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The Association between Neighborhood Walkability, Type 2 Diabetes, and Socioeconomic Status in Residents of Eight Ohio Counties

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Abstract

Objective: Regular physical activity is beneficial in preventing type 2 diabetes. Walking, either for recreation or to travel to a destination, is an inexpensive way to meet physical activity guidelines. Disadvantaged populations with low socioeconomic status (SES) have a higher prevalence of type 2 diabetes and are more likely to live in unwalkable neighborhood.

The purpose of this study was to determine the association between SES and neighborhood walkability in eight Ohio counties with highest prevalence of type 2 diabetes in the state.

Methods: Using data from the 2010 Ohio Behavioral Risk Factor Surveillance System (BRFSS) survey and walk scores from iPad Walk Score® (n.d.) application, multivariate logistic regression was used to assess the influence of walk score on diabetes prevalence. A Chi-squared test was used to analyze the association between diabetes and SES. Analysis of Variance (ANOVA) was used to assess association between walk scores, income level, and metropolitan statistical area (MSA). An additional walkability score was calculated using a modified version of the Systematic Pedestrian and Cycling Environmental Scan (SPACES) audit instrument. The walk scores were compared using Spearman's correlation coefficient.

Results: In a multivariate analysis, walk score was not significantly related to diabetes ($p=0.49$). Diabetes prevalence was almost twice as high in low SES populations ($p>0.001$), and average walk score was highest in the center city of a MSA in low SES ($p<0.001$). Walkability assessed via SPACES audit was correlated to the Walk Score® (n.d.) for destination ($p=0.04$), but was not correlated with walking for recreation ($p=0.424$).

Conclusion: When considering the relationship between SES, neighborhood walkability, and diabetes; the results were varied. Future research should assess walkability using a combination of perceived and objective measures of the built environment.

The Association between Neighborhood Walkability, Type 2 Diabetes, and Socioeconomic Status in Residents of Eight Ohio Counties

One of the most important benefits of regular physical activity is the prevention of chronic, life threatening diseases such as type 2 diabetes. Physical activity can prevent or delay the onset of diabetes or play a significant role in controlling blood glucose levels of a diabetic patient (Miller & Dunstan, 2004). Unfortunately, Americans continue to be inactive and the rates of type 2 diabetes continue to rise (CDC, 2011c). In regards to physical activity, specific targets set by Healthy People 2020 (HP2020) include reducing the percentage of adults who engage in no leisure time physical activity from 36.2% to 32.6% and increasing the percentage of adults who meet the weekly physical activity guidelines from 43.5% to 47.9% (U.S. Department of Health and Human Services, 2011a).

There are several ways to engage in physical activity during the day, but one simple and inexpensive way is to walk; either for recreation or to reach a destination. Persons who live in neighborhoods with available infrastructure to support walking as a form of physical activity have an advantage over those who live in unwalkable neighborhoods. Poorer or socioeconomically disadvantaged populations are more likely to live in neighborhoods that are perceived to be unwalkable (Kelly, Schootman, Baker, Barnidge, & Lemes, 2007; Macionis & Parrillo, 2010; Neckerman et al., 2009). In addition to living in an environment that is not conducive to walking, poorer segments of the population also have a higher prevalence of type 2 diabetes (Agardh, Allebeck, Hallqvist, Morad, & Sidorchuk, 2011).

The relationship between walkability, type 2 diabetes, and socioeconomic status is important for public health practitioners to understand when planning and implementing healthier lifestyle interventions. This study aimed to answer the following question: What is the association between socioeconomic status and neighborhood walkability in residents of eight counties in Ohio that had the highest prevalence of type 2 diabetes in the state?

Literature Review

Physical Activity

In 2008, the United States Department of Health and Human Services' (HHS) published new physical activity guidelines for Americans. The guidelines stressed the important health benefits of physical activity and indicated that taking part in some form of physical activity daily would be more beneficial than being completely inactive. The recommendation for adults was to participate either in at least 150 minutes of moderate intensity or 75 minutes of vigorous intensity aerobic physical activity weekly to gain significant health benefits. The duration of the activity should be for at least 10 minutes (HHS, 2008a). The physical activity objectives of Healthy People 2020 were written directly from the *Physical Activity Guidelines for Americans* (HHS, 2011b).

HHS has recognized two forms of bodily movement: baseline activity and health enhancing physical activity. Baseline activities are bodily movements performed during light intensity, everyday activities, and are not long enough in duration to count toward the recommended weekly total. Individuals who perform only baseline activities are considered inactive. Health enhancing physical activities include brisk walking, yoga, lifting weights, dancing, and climbing on playground equipment (HHS, 2008a). Research has concluded that performing activities such as these, on a regular basis, can promote weight loss, lower the risk of early death, improve cardiorespiratory and muscular fitness, reduce depression, and prevent the development of several chronic diseases. Specifically, there is a lower risk of having a stroke, coronary heart disease, high blood pressure, high cholesterol, colon cancer, and type 2 diabetes (HHS, 2008a).

While the health benefits of physical activity are tremendous, there are personal, social, economic, and environmental factors that can be barriers to participation in physical activity (HHS, 2008a). An environmental factor that plays a significant role in the ability to meet the physical activity guidelines is an individual's built environment. The built environment encompasses the physical structures engineered and built by humans to include homes, roads, food sources, and recreational facilities. People live, work, learn, and play within these environments (Sallis & Glanz, 2006).

Realizing the role the built environment plays in an individual's ability to participate in physical activities, public health officials and urban planners have taken an interest in determining what makes a community walkable. If neighborhoods could be designed so that residents can walk an additional kilometer per day, there is evidence that the likelihood of obesity could be reduced by as much as 4.8% (Frank, Andresen, & Schmid, 2004).

Walkability studies have used both macro-level and micro-level scales to assess a variety of neighborhood types. A macro-level approach to determining walkability comprises objective observations that measure variables such as city-wide net residential density, intersection density, land use mix, and retail floor area ratio (Cutts, Barby, Boone, & Brewis, 2009; Frank et al., 2010; Neckerman et al., 2009). The use of macro-level walkability indices have value in contributing to the growing research on built environments and walkability. For example, using their walkability index, Frank et al., (2010) found that the percentage of residents walking to work in high income, high walkability neighborhoods was 4-6% higher than in high income, low walkability neighborhoods. Similarly, the percentage of residents in low income, high walkability neighborhoods walking to work was 4-7% higher than in low walkability neighborhoods (Frank et al., 2010).

Micro-level variables consider the residents' perceptions of their neighborhood and the quality of neighborhood resources (Cutts et al., 2009). The variables most often considered in micro-level walkability studies were land path quality, path context, and safety (Southworth, 2005). McGinn, Evenson, Herring, Huson, and Rodriguez (2007) assessed both perceived and objective measures of walkability and concluded that when the measures were combined, they better described the relationship between the built environment and physical activity. Macro-level and micro-level variables frequently observed in combination within the literature include land use mix, connectivity of the path network, path quality, path context, and safety (Frank, Engelke, & Schmid, 2003; Frank et al., 2010; Southworth, 2005).

Neighborhoods with a mix of residential and commercial uses within the acceptable walking distance have been linked to increased walking activity (Frank et al., 2003). Americans will walk on average no more than 400 m to complete daily tasks (Aultman-Hall, Roorda, & Baetz, 1997). Popular commercial land uses include destinations such as grocery stores, schools, parks, work place, banks, cafes, fitness centers, libraries, and retail shops (Moudon et al., 2006; Southworth, 2005). The commercial destinations available to residents varies based on the location of the neighborhood.

In a historical context, when comparing traditional, pre-World War II neighborhoods and newly built suburban neighborhoods, it was found that residents of traditional neighborhoods have on average more businesses within 400 m of their homes. On average, suburban residents had to travel 557 m to the nearest establishment where residents of traditional neighborhoods had to travel an average of 247 m (Handy, Cao, & Mokhtarian, 2006). Jobs, stores, and schools left the inner cities and migrated toward the traditional and urban neighborhoods outside the confines of the once thriving metropolitan areas (Frumkin, 2002). Areas, such as East New York, that are mostly inhabited by low income African Americans and Latinos, have been plagued with the issue of poor quality food at high prices due to a lack of neighborhood full-service grocery stores. They are relegated to buying groceries at local convenience stores, delis, bodegas, or traveling further distances to find a full service grocery store (Munoz-Plaza, Filomena & Morland, 2007). Having a variety of uses for the land in a community that includes access to healthy food is influential in a resident's decision to walk instead of drive.

The presence of sidewalks, the density of intersections, and block sizes are all considered in determining the connectivity of the path network of a neighborhood. An important aspect of a connected neighborhood is the presence of sidewalks on at least one side of the street. This alone has been associated with an increase in destination walking behavior (Alfonzo, Boarnet, Day, McMillan, & Anderson, 2008). Block size and intersection density are equally important measures to consider. When a neighborhood has numerous intersections and small block sizes, there is an assumption that there is a high degree of connectivity. This offers the residents more route choices. The presence of cul-de-sacs, dead end streets, and high traffic intersections, often associated with new suburban neighborhoods, serve to limit connectivity and accessibility (Southworth, 2005). Residents of neighborhoods with a high degree of street connectivity have been found to be 1.2 times less likely to be overweight and 1.1 times less likely to be obese (Bodea, Garrow, Meyer, & Ross, 2009).

While connectivity is important, poor quality neighborhood streets and unpleasant community aesthetics dissuade residents from walking for leisure or travel. Important to path quality are the presence of street lights, crosswalks, and level paved sidewalks. Closely related to path quality, is the quality of the path context (Southworth, 2005). Higher income neighborhoods are able to invest more tax revenue in the physical upkeep and cleanliness of their streets and have monies budgeted toward the improvement of neighborhood aesthetics in the way of planted trees, benches, sidewalk cafes, landmark building, and even street art (Kelly et al., 2007). Realizing the impact of quality paths and aesthetics on walkability, the Seattle Housing Authority redesigned the physical environment of one of their public housing communities to promote walking activity; specifically recreational walking. The designers added 21 acres of open spaces in the way of ponds, a central park, and multiple smaller parks; the neighborhood was redesigned on a grid; trails were added; sidewalks were widened; and trees were planted. Additionally, walking groups were formed to improve the social environment as well. Residents reported that the total minutes they walked daily increased, and they also reported having more opportunities to walk for exercise and to complete errands (Krieger, Rabkin, Sharify, & Song, 2009).

The final common attribute of walkable neighborhoods is safety. Safety can be considered from two perspectives; the safety of pedestrians who share the road with automobiles, and the security of pedestrians from criminal activity. According to Southworth (2005), pedestrian safety was influenced by the presence of traffic calming techniques such as speed bumps, raised crosswalks, narrowed streets, and roundabouts. Additionally, the condition of sidewalks as well as the sidewalk width, slower posted speed limits, crossing signals, and night lighting were all significant in a resident’s perception of neighborhood pedestrian safety. Women in urban environments who felt their neighborhood was unsafe traveled 1100 fewer steps during the day as compared to those who felt safe (Bennett et al., 2007). In a walkability study examining 11 California neighborhoods of varying characteristics, safety concerns were the most important characteristic of the built environment that impacted an adult's decision to walk (Alfonzo et al., 2008).

The intentions of the HHS physical activity guidelines and the physical activity objectives of Healthy People 2020 are clearly stated; Americans must become more active to improve their health (HHS, 2011b). One of the easiest ways to be active is to walk in and around one's own neighborhood, either for recreation or for travel to a destination. Characteristics of the built environment such as land use mix, connectivity of the path network, path quality, path context, and safety can contribute to the perception of the walkability of a neighborhood.

Diabetes

One of the many chronic diseases that can be prevented by participating in regular physical activity is diabetes. Due to continued physical inactivity combined with high calorie diet intake, the prevalence of diabetes remains high. In the United States, diabetes is currently the seventh leading cause of death (CDC, 2011c). The prevalence of diagnosed and undiagnosed (pre-diabetes) cases of diabetes in 2010 was 11.3% in adults aged 20 to 65, and 26.9% in adults 65 years of age or older (CDC, 2011c).

Diabetes is characterized by high blood glucose levels that are a result of defects in either insulin secretion or insulin action or both. Glucose is produced in the body by the liver and muscles or it comes from the foods that are ingested. Insulin, a hormone produced by the beta cells of the pancreas, is responsible for carrying the glucose to the cells throughout the body. Without insulin, the glucose will remain in the blood causing elevated blood glucose levels (CDC, 2011a). The symptoms of diabetes include frequent urination, extreme thirst and hunger, unexplained weight loss, blurred vision, increased susceptibility to infections, tingling or numbness in hands or feet, fatigue, and dry skin (American Diabetes Association [ADA], 2010; CDC, 2011a).

The three common forms of diabetes are type 1, type 2, and gestational diabetes. Type 1 diabetes is most often diagnosed in children, teenagers, or young adults and occurs when the beta cells of the pancreas are attacked and destroyed by the body's immune system. Gestational diabetes is observed in women who, in the late stages of pregnancy, develop a shortage of insulin (HHS, 2008b). Blood glucose levels return to normal after giving birth, but these women have a 35% to 60% higher chance of developing type 2 diabetes in the next 10 to 12 years (CDC, 2011c). Type 2 diabetes is often diagnosed in adulthood and is characterized by insulin resistance which occurs when fat, muscle, and liver cells do not use insulin properly (HHS, 2008b). It is the most common form of diabetes and accounts for 90% to 95% of all diagnosed cases (CDC, 2011c). Common tools for managing and controlling blood glucose levels for diabetics include healthy eating, physical activity, insulin injections or oral medications, and regular blood glucose testing (CDC, 2011a).

When diabetes remains uncontrolled or undiagnosed, the long term complications are life threatening. Uncontrolled blood glucose levels can lead to poor cardiovascular health. In addition, diabetics can develop a condition known as metabolic syndrome; putting them at higher risk of having a stroke or dying as a result of heart disease. Metabolic syndrome is characterized by having at least three of the following conditions: excess weight situated around the waist, a high triglyceride level, low levels of high density lipid protein (HDL), high blood pressure, or a high fasting blood glucose level (CDC, 2011b).

Diabetic neuropathy, another significant complication of diabetes, occurs when the blood vessels that bring oxygen to the nerves are damaged. Neuropathy can cause problems with gastrointestinal and genitourinary systems and result in sexual dysfunction. Nerve damage to the arms and legs, also known as peripheral neuropathy, puts diabetes at risk for food ulcers and amputations and is most often seen in older adults who are overweight. Finally, those with uncontrolled blood glucose levels are at risk for blindness and diabetic nephropathy which often leads to renal failure (ADA, 2010; CDC, 2011b).

Common factors that increase the risk of developing type 2 diabetes include obesity, a high percentage of body fat around the abdominal region, lack of physical activity, older age, family history, and race/ethnicity (ADA, 2010). In a study of 16,884 overweight or obese adults, there was an increase in the prevalence ratio of type 2 diabetes with an increase in body mass index (BMI) (Must et al., 1999). The American Diabetes Association (2011) reported that a lifestyle intervention that increased physical activity that produced a 5% to 10% loss of total body weight combined with the use of medication has been shown to prevent or delay the development of diabetes.

If an individual's blood glucose level is elevated, but not to the point of having a diagnosis of diabetes, he or she can be classified as having pre-diabetes. Several studies have indicated the importance of physical activity in slowing or stopping the advancement of pre-diabetes to type 2 diabetes. In adults with pre-diabetes, the addition of a physical activity component to lifestyle interventions decreased the progression to type 2 diabetes by 31% to 63% in four clinical trials (Hayes & Kriska, 2008). In a meta-analysis of 14 controlled trials assessing the effects physical activity interventions had on controlling blood glucose levels, the weighted average blood glucose level at the end of the intervention was significantly lower in the exercise groups than in the control groups (Miller & Dunstan, 2004). Another national prevention study of people at high risk for developing diabetes showed that lifestyle intervention to lose weight and increase physical activity reduced the development of type 2 diabetes by 58% during a 3-year period and by 71% among adults aged 60 years or older (CDC, 2011c).

Socioeconomic Status

Socioeconomic status (SES) is a hierarchical ranking of an individual within his or her social structure often measured by income, education, occupation, and place of residence (Macionis & Parrillo, 2010). Modern sociologists have developed a variety of systems that stratify society according to a three tier structure: upper, middle, and lower class. Theorists differ in regards to the subcategories within these classes. In general, the upper class is composed of a small percentage of the total population who live in expensive neighborhoods, is highly respected in the community, and has substantial political clout. The largest percentage of the population is considered middle class, but this class is often subdivided into an upper middle class and lower middle class. In middle class population, those at the upper end of the spectrum live in suburban homes; work in prestigious, professional occupations; and have additional income to invest and send children to college. Further down on the spectrum are white collar workers and highly skilled blue color workers. The proportion of society that is considered lower middle class, or "working class," has an annual income of $30,000 to $50,000 annually. Their employment opportunities offer few benefits, they often own their own homes, but they have little means to acquire wealth. Finally, those in the lower class are considered the "working poor." Often located in inner cities and rural areas, this population consists mainly of poor whites and poor racial and ethnic minorities. Usually, this population carries no medical insurance and 12% to 13% receive welfare (Macionis & Parrillo, 2010).

Low income urban areas are frequently in the city's oldest districts that were once middle or upper class communities. Additionally, these communities are characterized by having a high population density and rental units that are considered substandard (Macionis & Parrillo, 2010). These neighborhoods are also perceived as having poor walkability. When considering only macro-level measures of walkability, high income and low income neighborhoods are often considered equally walkable. An inequity exists between communities of varying levels of SES when micro-level walkability features of the built environment are taken into consideration. In their comparison of poor and non-poor neighborhoods in New York City, Neckerman et al. (2009) found that the poorer communities had fewer trees, clean streets, sidewalk cafes, higher rates of felony complaints, narcotics arrests, and vehicular crashes.

Kelly, Schootman, Baker, Barnidge, and Lemes (2007) found a disparity between the investments in infrastructure in African American communities. Specifically, census blocks in the St. Louis metropolitan area that were predominately African-American and low income were 30 times more likely to have sidewalks with a lot of unevenness and 15 times more likely to have physical obstructions prohibiting the use of sidewalks (Kelly et al., 2007). In a comparison of high and low income neighborhoods of equivalent walkability scores, higher income neighborhoods scored higher in areas of pedestrian safety characteristics. High income neighborhoods had lower speed limits and narrower streets, and less motor vehicle accidents (Neckerman et al., 2009). Lower income neighborhoods have been found to be plagued with criminal activity and characteristics such as lack of street lighting, abandoned or rundown buildings, graffiti, and undesirable land use that give residents the perception that their neighborhood is unsafe (Alfonzo et al., 2008).

The prevalence of type 2 diabetes is disproportionately higher in socioeconomically disadvantaged neighborhoods. According to the CDC's 2008 statistics, the prevalence of low income adults diagnosed with diabetes was 11.7 cases per 100 people while the prevalence for high income adults with diabetes was 5.5 cases per 100 people (Beckles, Zhu, & Moonesinghe, 2011). In a meta-analysis determining the association between type 2 diabetes incidence and SES, it was determined that those with a low level of education, low level occupational status or low income have a 45%, 31%, and 40% increased risk of developing type 2 diabetes (Agardh et al., 2011).

A review of the literature indicates that those who live in lower income neighborhoods have negative built environment characteristics that are perceived as barriers to walking within their neighborhoods for recreation, for the completion of daily errands, or for commuting to work. Those at a lower SES are also diagnosed with type 2 diabetes at a higher prevalence. Since physical activity is important in the prevention and control type 2 diabetes, those in unwalkable, lower income neighborhoods are at a disadvantage as it relates to opportunities to improve their health status.

This study aimed to explore the association between socioeconomic status and neighborhood walkability in residents of eight counties in Ohio that had the highest prevalence of type 2 diabetes.

Methods

Data Sources

Data collection comprised of three aspects; diabetes prevalence and covariates were gathered from the Ohio Behavioral Risk Factor Surveillance System (BRFSS) survey (CDC. 2010); walkability was assessed through an iPad Walk Score® (n.d.) application (App); and additional walk scores were calculated using a modified version of the Systematic Pedestrian and Cycling Environmental Scan (SPACES) instrument.

Diabetes prevalence and covariates gathered from CDC's 2010 Ohio BRFSS. Eight Ohio counties with the largest frequency of respondents who answered the question, "Have you ever been told by a doctor that you have diabetes?" were chosen for analysis. The counties selected were Cuyahoga (n = 672), Franklin (n = 654), Hamilton (n = 687), Lucas (n = 706), Mahoning (n = 689), Montgomery (n = 676), Stark (n = 685), and Summit (n = 678); with 5,447 total respondents. The data was weighted to reflect the sampling strategy.

Walkability assessed through an iPad Walk Score® (n.d.) App. Data related to walkability was collected using the Walk Score® App downloaded to an Apple iPad (Front Seat LLC, 2009). This commercial software application was developed to identify and promote walkable neighborhoods. For all zip codes within each of the eight selected counties, the walk score was ascertained using this App.

Walk Score® (n.d.) developed an algorithm that incorporated the physical parameters related to walkability of a neighborhood including street intersection density, average block length, and a weighted score representing the type of amenity within 0.25 miles of a residence. The types of amenities considered in the algorithm were restaurants, grocery stores, retail stores, coffee shops, schools, parks, and banks. The score represents the ease to travel without the use of an automobile; the higher the score the more walkable the neighborhood (Walk Score®, 2011a).

Systematic Pedestrian and Cycling Environmental Scan (SPACES) instrument. An additional walkability score was calculated for two zip codes within six of the eight Ohio counties using a modified version of the Systematic Pedestrian and Cycling Environmental Scan (SPACES) instrument. Pikora et al. (2002) developed this physical activity audit instrument to evaluate the built environment using a combination of field observations, geographic information systems (GIS) technology, and published pollution and traffic reports.

The SPACES tool categorizes the factors that influence walking into four features: functional, safety, aesthetic, and destination: a) *The functional features* are related to the physical attributes of the walking path and street that characterize the structural features of the built environment. The functional elements in the SPACES tool are walking surface, streets, traffic, and permeability; b) *Safety elements* include personal and traffic safety; c) *The aesthetic features* include items considered visually appealing to walkers that include neighborhood cleanliness and maintenance and building diversity; d) *The destination features* considered the availability of community and commercial facilities in the neighborhood. (Measures of traffic or industrial pollution which were part of original SPACES audit by Pikora et al. (2002) were not assessed in the current study). The detailed tool used to complete the virtual audit can be found in Appendix A.

This present study collected data via a virtual audit using both Google Street View (Europa Technologies, 2011b), Google Earth (Europa Technologies, 2011a), and ArcGIS Explorer (ESRI, 1996). Badland, Opit, Witten, Kearns, and Mavoa (2010) tested reliability of replacing physical audits with virtual audits using the SPACES and concluded that virtual audits were a reliable alternative.

Within the Ohio counties of Cuyahoga, Hamilton, Montgomery, Lucas, Summit, and Franklin; two zip codes were chosen to represent both an area within a major metropolitan city and an area outside the metropolitan city. The zip codes chosen also represented locations within these areas that had the greatest frequency of respondents to the diabetes question on the BRFSS.

Google Street View was not complete for the counties of Mahoning and Stark therefore these counties could not be evaluated.

All observations for the SPACES items were collected using Google Street View and Google Maps with the exception of the following questions: 1) Is the distance between intersections short, and 2) Is there a buffer between the path and traffic? These items required measurements that were completed using ArcGIS.

Steps to collect the data. When a zip code was inputted into the iPad Walk Score® (n.d.) App, the program calculated a walk score for a designated location within the zip code. This walk score was previously used to access neighborhood walkability. In order to maintain consistency, this same location was used for the SPACES audit. Using ArcGIS, a 400 m buffer zone was created around the residence at this location (Handy et al., 2006; Pikora et al., 2002). If the exact location from Walk Score® (n.d.) was not a residence, the nearest residence was chosen as the point of study. Within each 400 m buffer zone, four street segments were chosen to assess using Google Street View. The streets were chosen based alphabetically on the first letter of the street. For example, the first four streets of the first zip code would begin with the letters A through D and the first street of the second zip code would begin with the letter E.

Calculating the walk score. As mentioned in the methods, walk score was adapted from Pikora et al.'s (2006) study of neighborhood environmental factors using SPACES. Within each zip code, the proportion of road segments in each neighborhood that exhibited a certain characteristic was calculated. This proportion was then multiplied by a value between 0 and 1 based on that item's value in increasing neighborhood walkability. A value of 1 indicates a more desirable attribute of walkability. The score for each item within an element was then summed to give a raw aggregate score. Each aggregate score was multiplied by a Delphi weight to calculate the final walk score. As reported in literature, the Delphi weight was developed by a panel of experts representing urban planning, local government, transportation, public health, and pedestrian, cycling, and disability advocacy groups (Pikora, Giles-Corti, Bull, Jamrozik, & Donovan, 2003). A Delphi weight was assigned to each element as it relates to walking for transportation and walking for recreation (see Table 1). In the end, two scores for walkability were derived from the SPACES instrument; a score related to the ease of walking to a destination and walking for recreation.

Table 1. *SPACES Delphi Weights*

Factors	Delphi Weight		Description
Functional	Recreation	Destination	
Walking/cycling surface			
Path type	0.39	0.28	Is there a path suitable for walking?
Surface Type	0.24	0.17	What material is the path made of?
Path Maintenance	0.19	0.11	Is the path well maintained?
Path Continuity	0.18	0.33	Does the path form a useful, continuous and cohert route?
Direct route		0.11	Does the path form a direct route to destination
Streets			
Width of street	1.00		How wide is the street/road?
Traffic			
Volume	0.43		How heavy is the weekday traffic volume?
Speed	0.35	0.50	What is the posted traffic speed?
Management/control devices	0.22	0.50	Are there devices that slow or restrict traffic?
Permeability			
Street design	0.26	0.30	Is the street design conducive for walking?
Intersection design	0.20	0.20	Is the distance between intersections short?
Intersection distance	0.16	0.20	Are the intersections designed to allow more choice of route?
Other access points	0.38	0.40	Are there other routes available that provide alt ways
Safety			
Personal			
Lighting	0.48	0.50	How well lit is the neighborhood?
Surveillance	0.52	0.50	Can others observe pedestrians through passive surveillance
Traffic			
Crossing	0.35	0.40	Are the devices available to assist in safely crossing street
Crossing aids	0.33	0.40	Are there pedestrian aids available to assist in safely crossing
Verge width	0.32	0.20	Is there a buffer btwen the path and traffic?
Aesthetics			
Streetscape			
Trees	0.20		Are there trees along the street/road?
Garden Maintenance	0.11		Are the gardens in the neighborhood well maintained?
Street Maintenance	0.17		Is the streetscape well maintained?
Cleanliness	0.18	0.50	Is the neighborhood free of litter, rubbish, graffiti?
Pollution	0.18	0.50	Are the traffic or industrial pollution levels low?
Parks	0.16		Is there a part in the neighborhood?
Views			
Sights	0.56		Are there diverse, interesting and different sights in the neighborhood?
Architecture	0.44		Are there diverse and interesting architectural designs in the neighborhood?
Destination			
Facilities	1.00	1.00	
Parks	0.60		Is there a park in the neighborhood?
Shops	0.40	0.30	Are there shops in the neighborhood?
Services		0.25	Are there services in the neighborhood? (i.e. schools)
Local facilities		0.15	Are there local facilities in the neighborhood? (i.e. post boxes)
Vehicle parking facilities		0.10	Are there a restricted number of car parking facilities at destination?
Public transport		0.20	Is there access to public transport in the neighborhood?

Data Analysis

Statistical analysis was conducted using IBM Statistical Package for Social Sciences (SPSS) for Windows, version 19 (IBM, 2010). The normality distribution of all variables was checked. Normally distributed sample means were compared using 2-sample t-test or one way analysis of variance (ANOVA). Non-normal variables were analyzed using the Mann-Whitney or Kruskal-Wallis nonparametric tests. Associations between categorical variables were analyzed using Chi-squared test. Two sided significance was considered at $p<0.05$.

The diabetes variable was categorical (yes/no). The influence of each independent variable (age [continuous], sex [categorical, reference: male], race [categorical, reference: Caucasian], BMI [continuous], employment status [categorical, reference: employed], education level [categorical, reference: college graduate], marital status [categorical, reference: married], income level [categorical, reference: more than $50,000], general health [categorical, reference: good health], level of physical activity [categorical, reference: active], and walk score [continuous]) on diabetes was measured using logistic regression. As decided a priori, model building comprised of adjusting for age first. The next model was adjusted for age, sex, race, BMI, income level, and general health. The final model was additionally adjusted for walk score.

Secondary analysis was carried out that included a Chi-squared test to analyze the association between diabetes status and income level. An ANOVA compared the walk score mean to the four metropolitan status codes (MSC). The MSCs were categorized as a) a center city of a metropolitan statistical area (MSA), b) outside the center city of an MSA but inside the county containing the center city, c) inside a suburban county of the MSA, and d) in an MSA that has no center city. MSA are used mainly by the census bureau to identify areas with a high population density. MSC have varying income levels and features of the built environment. Within the MSC, the walk score means were compared to income level.

Spearman's correlation coefficient was used to assess if walk scores from the iPad App and from the SPACES instruments were correlated. In order to compare the walk scores, the values were standardized. Each value was divided by maximum walk score for that measure of walkability. For Walk Score® (n.d.), that value was 100, for SPACES-Destination it was 6.40, and for SPACES-Recreation it was 8.82. These values were then graphed in a scatterplot.

Results

The descriptive characteristics of the overall study population and categorized by sex are presented in Table 2. Mean age was 48 years, however men were on average two years older than female in this study ($p<0.001$). BMI and education were not significantly different between men and women. African American men comprised a higher proportion of the study participants versus women of the same race. Proportion of men who were not married was higher ($p<0.001$). Significantly more women were employed versus men. Compared to men, a higher proportion of women enjoyed good health, but men reported a higher percentage of daily physical activity. Overall, 74% of the study population reported being inactive.

Table 2. *Descriptives of Independent Variables*

Characteristics	Overall N= 5447 Mean ± sd, or n%	Males N= 2854 Mean ± sd, or n%	Females N= 2593 Mean ± sd, or n%	p-value†
Age (yrs) n = 5447	47.52 ± 17.47	48.73 ± 17.81	46.19 ± 17.0	< 0.001*
Race n = 5396				< 0.001‡
Caucasian	77.8%	75.4%	80.4%	
African American	15.9%	18.9%	12.6%	
Others	6.3%	5.7%	6.0%	
BMI (kg/m2) n = 5263	27.76 ± 6.16	27.61 ± 6.72	27.90 ± 5.50	0.087*
Income n = 4826				< 0.001‡
Less than $50,000	50.7%	53.2%	48.0%	
More than $50,000	49.3%	46.8%	52.0%	
Education Level n = 5440				0.057‡
Less than Grade 11	6.0%	6.0%	6.1%	
High School graduate/GED	27.8%	29.2%	26.3%	
College graduate	66.2%	64.9%	67.7%	
Marital Status n = 5438				< 0.001‡
Married	58.5%	55.7%	61.6%	
Not Married	36.2%	38.9%	33.2%	
Other	5.3%	5.4%	5.3%	
Employment Status n = 5435				< 0.001‡
Employed	57.4%	53.3%	61.8%	
Unemployed	42.6%	46.7%	38.2%	
General Health n = 5436				0.026‡
Good Health	85.0%	84.0%	86.1%	
Poor Health	15.0%	16.0%	13.9%	
Physical Activity n = 5441				0.004‡
Active	25.1%	26.7%	23.3%	
Inactive	74.9%	73.3%	76.7%	
Walk score n = 5447	30 (35)	38 (35)	37 (34)	0.004§

* 2-sample t-test assuming unequal variances
‡ Chi-square test
§ Mann-Whitney test
† Explains the difference between males and females

The independent variables and their association with diabetes are presented in Table 3. The mean age of diabetics was 59, but the mean of non-diabetics was 13 years younger ($p<0.001$). Gender was not significant between diabetics and non-diabetic participants. Caucasians comprised a higher proportion of diabetic study participants as compared to other races. The average BMI was 6 points higher among diabetics. There was a higher proportion of diabetes among college graduates, those who were married, and unemployed. Walk score was higher among diabetics.

Table 3. *Independent Variables and their Association with Diabetes*

Characteristics	Diabetes 9.9% Mean ± sd, or n%	Non-diabetic 90.9% Mean ± sd, or n%	p-value
Age (yrs) n = 5447	59.01 ± 16.18	46.26 ± 17.15	< 0.001*
Sex n = 5442			0.752‡
Male	51.8%	52.5%	
Female	48.2%	47.5%	
Race n = 5392			< 0.001‡
Caucasian	66.5%	79.1%	
African American	25.9%	14.8%	
Others	7.5%	6.2%	
BMI (kg/m2) n = 4824	32.64 ± 7.22	27.23 ± 5.79	< 0.001*
Income n = 4824			< 0.001‡
Less than $50,000	71.4%	48.6%	
More than $50,000	28.6%	51.4%	
Education Level n = 5435			< 0.001‡
Less than Grade 11	11.7%	5.4%	
High School graduate/GED	36.3%	26.9%	
College graduate	52.0%	67.8%	
Marital Status n = 5435			0.003‡
Married	52.2%	59.2%	
Not Married	42.9%	35.5%	
Other	4.8%	5.4%	
Employment Status n = 5432			< 0.001‡
Employed	32.0%	60.2%	
Unemployed	68.0%	39.8%	
General Health n = 5432			< 0.001‡
Good Health	57.4%	88.0%	
Poor Health	42.6%	12.0%	
Physical Activity n = 5439			< 0.001‡
Active	37.8%	23.7%	
Inactive	62.2%	76.3%	
Walk score n = 5447	42 (34)	37 (35)	0.005§

* 2-sample t-test assuming unequal variances
‡ Chi-square test
§ Mann-Whitney test

The distribution of above mentioned variables categorized by race are presented in Table 4. The study population had a significantly greater proportion of Caucasian participants than any other race. The mean age for Caucasians was 48 which was three years older than the average age of African Americans. The mean BMI in African Americans was greater than for Caucasians (p <0.001). Although a higher proportion of Caucasians reported being in good health, a higher percentage of African Americans was physically active. The mean walk score for African Americans was 48 while the average walk score for Caucasians was only 34. On average, Caucasians were more educated, had a higher family income, and were married.

Table 4. *Independent Variables Compared by Race*

Characteristics	Caucasian N= 4199 (77.8%) Mean ± sd, or n%	African American N= 856 (15.9%) Mean ± sd, or n%	Others N= 341 (6.3%) Mean ± sd, or n%	p-value
Age (yrs) n = 5396	48.53 ± 17.47	45.14 ± 16.53	40.27 ± 16.26	< 0.001*
BMI (kg/m2) n = 5219	27.39 ± 5.94	30.00 ± 6.85	28.86 ± 5.71	< 0.001*
Income n = 4795				< 0.001‡
Less than $50,000	45.3%	72.3%	60.8%	
More than $50,000	54.7%	27.7%	39.2%	
Education Level n = 5390				< 0.001‡
Less than Grade 11	4.8%	9.7%	9.7%	
High School graduate/GED	26.5%	35.3%	25.0%	
College graduate	68.7%	54.9%	65.3%	
Marital Status n = 5390				< 0.001‡
Married	62.4%	41.0%	55.6%	
Not Married	32.6%	52.1%	39.1%	
Other	5.0%	6.9%	5.3%	
Employment Status n = 5385				< 0.001‡
Employed	59.5%	51.9%	46.0%	
Unemployed	40.5%	48.1%	54.0%	
General Health n = 5384				< 0.001‡
Good Health	87.0%	76.3%	84.4%	
Poor Health	13.0%	23.7%	15.6%	
Physical Activity n = 5391				< 0.001‡
Active	23.6%	32.3%	25.8%	
Inactive	76.4%	67.7%	74.2%	
Walk score n = 5396	34 (34)	48 (28)	43 (37)	< 0.001§

* ANOVA
‡ Chi-square test
§ Kruskal-Wallis test

When these variables were subsequently categorized by income (low: <$50,000/year, high: >$50,000 /year) (Table 5), a higher proportion of the study population with high income were college graduates (42% [in high income] vs. 25 [low income]), were married, and were employed. The mean age of those with a family income less than $50,000 was 49 years; four years older than the average age of those with a higher income. The mean walk score was greater among those whose family income was less than $50,000 and this population reported being more physically active than those whose income was greater than $50,000. The proportion of those reporting good general health was greater in those with an annual family income greater than $50,000.

Table 5. *Independent Variables Compared by Income Level*

Characteristics	Less than $50,000 N= 2445 (44.9%) Mean ± sd, or n%	More than $50,000 N= 2380 (43.7%) Mean ± sd, or n%	p-value
Age (yrs) n = 4826	48.85 ± 18.90	44.88 ± 13.65	< 0.001*
BMI (kg/m2) n = 4700	28.31 ± 6.70	27.30 ± 5.56	< 0.001*
Education Level n = 4820			< 0.001‡
Less than Grade 11	10.1%	1.1%	
High School graduate/GED	39.9%	14.5%	
College graduate	50.0%	84.5%	
Marital Status n = 4821			< 0.001‡
Married	40.6%	79.4%	
Not Married	26.7%	16.3%	
Other	6.8%	4.4%	
Employment Status n = 4819			< 0.001‡
Employed	42.4%	78.2%	
Unemployed	57.6%	21.8%	
General Health n = 4819			< 0.001‡
Good Health	76.5%	94.8%	
Poor Health	23.5%	5.2%	
Physical Activity n = 4825			< 0.001‡
Active	32.7%	16.7%	
Inactive	67.3%	83.3%	
Walkscore n = 4826	43 (33)	32 (36)	< 0.001§

* 2-sample t-test assuming unequal variances
‡ Chi-square test
§Mann-Whitney test

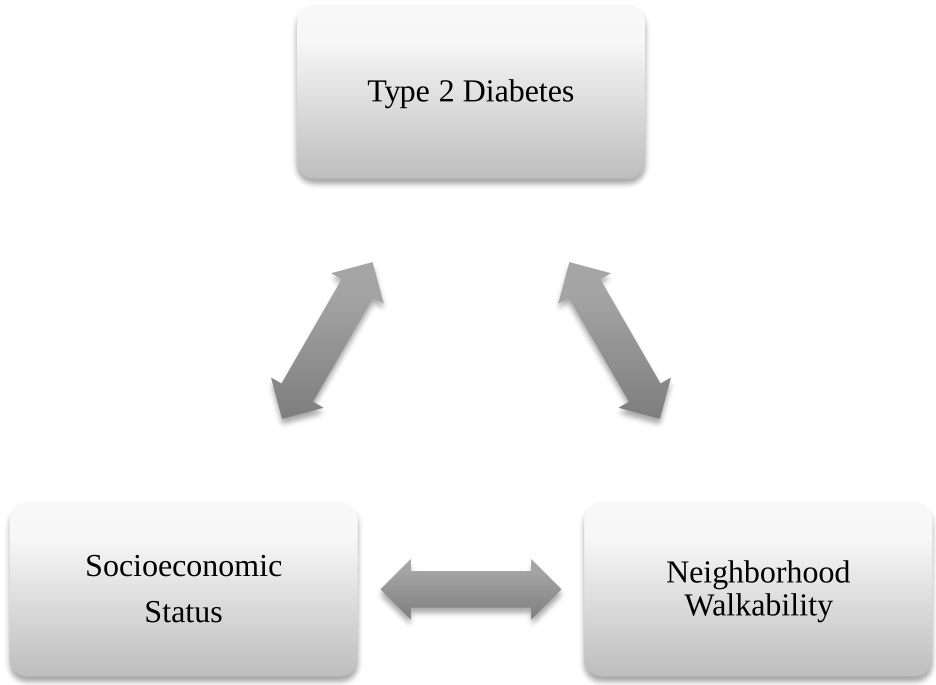

Figure 1. Relationship between diabetes, socioeconomic status, and walkability.

The model in Figure 1 was used to test the effects of relationships between type 2 diabetes, socioeconomic status, and neighborhood walkability independently.

Relationship between Diabetes and Neighborhood Walkability

Table 6 summarizes the influence of each independent variable has on the risk of diabetes in the eight Ohio counties. In bivariate analysis, general health had the greatest influence on diabetes prevalence. There was a fivefold higher odds of having diabetes in those with poor health as compared to those in good health (odds ratio, 95% confidence interval [OR: 5.47 {95% CI: 4.51, 6.61}]). Other variables that significantly predicted risk of diabetes were age, BMI, and walk score. The odds of having diabetes increased by 4.1% for each year increase in age, 12.1% for each unit increase in BMI, 0.4% for each unit increase in walk score. Those who had an annual family income of less than $50,000 were 62% less likely to have been told by a doctor that they have diabetes. Additionally, the odds of an African American having diabetes decreased by 31.3% over Caucasians.

Table 6. *Bivariate Analysis of Independent Variables and their Association with Diabetes*

Dependent Variable	Independent Variable	n	Beta	Standard Error of the Mean	p-value	Odds Ratio 95% CI
Diabetes	Age	5441	0.041	0.003	< 0.001	1.042 (1.037, 1.048)
	Sex	5441				
	Female‡					
	Male		0.029	0.091	0.746	1.030 (0.862, 1.230)
	Race	5380				
	Caucasian‡					
	African American		-0.376	0.177	0.034	0.687 (0.486, 0.971)
	Others		0.363	0.192	0.059	1.437 (0.987, 2.093)
	BMI	5214	0.114	0.007	< 0.001	1.121 (1.106, 1.136)
	Income Level	4708				
	More than $50,000‡					
	Less than $50,000		-0.965	0.110	< 0.001	0.381 (0.307, 0.472)
	General Health	5423				
	Good Health‡					
	Poor Health		1.697	0.098	< 0.001	5.457 (4.506, 6.607)
	Walk score	5441	0.004	0.002	0.033	1.004 (1.000, 1.008)

95% CI: 95% confidence interval
‡ Reference variable

The results of a multivariate analysis including age, sex, BMI, income level, general health, and walk score has on the prevalence of diabetes is shown in Table 7. Holding all other variables constant, those in poor health had the most significant influence on diabetes prevalence (OR 2.59). The odds of having diabetes increased for every one unit increase in BMI (13.3%) and age (5.3%), but walk score was no longer significant (p = 0.49).

Table 7. *Multivariate Analysis of Independent Variables and their Association with Diabetes*

Dependent Variable	Independent Variable	Beta	Standard Error of the Mean	p-value	Odds Ratio 95% CI
Diabetes	Age	0.051	0.004	< 0.001	1.053 (1.045, 1.060)
	Sex				
	Female‡				
	Male	0.117	0.117	< 0.001	0.635 (0.505, 0.799)
	Race				
	Caucasian‡				
	African American	0.599	0.143	<0.001	1.820 (1.374, 2.411)
	Other	0.867	0.232	<0.001	2.379 (1.510, 3.749)
	BMI	0.008	0.008	< 0.001	1.133 (1.114, 1.152)
	Income level				
	More than $50,000‡				
	Less than $50,000	0.356	0.131	0.007	1.428 (1.104, 1.847)
	General Health				
	Good Health‡				
	Poor Health	0.126	0.126	< 0.001	2.858 (2.235, 3.656)
	Walk score	-0.002	0.003	0.491	0.998 (0.993, 1.003)
	Constant	-9.098	0.395	< 0.001	0.00

95% CI: 95% confidence interval
‡ Reference variable

In the further analysis, within the race and sex categories the odds of having diabetes differed (data not shown). The odds of an African American being diagnosed with diabetes were 82.0% greater than that of a Caucasian in this analysis, odds of a female having diabetes increased by 3%.

The independent variable of interest in this study was walk score. Table 8 summarizes this variable’s influence on diabetes unadjusted, age adjusted, and in a multivariate adjusted model. While walk score is significant in a bivariate analysis ($p = 0.033$), it loses its significance as additional variables are added to the analysis ($p = 0.310$, $p = 0.491$).

Table 8. *Analysis of the Walk Score Variable*

Dependent Variable	Walk score	Beta	Standard Error of the Mean	p-value	Odds Ratio 95% CI
Diabetes	Unadjusted	0.004	0.002	0.033	1.004 (1.000, 1.008)
	Age Adjusted	0.004	0.002	0.310	1.005 (1.000, 1.009)
	MV*	-0.002	0.003	0.491	0.998 (0.993, 1.003)

* Further adjusted for sex, race, BMI, income level, and general health

Relationship between Diabetes and Socioeconomic Status

To evaluate the relationship between the diabetes and socioeconomic status, the results are displayed in Table 9. Diabetes prevalence was almost twice as high in low income population (p<0.001).

Table 9. *Prevalence of Diabetes Compared by Annual Family Income*

Diabetes	Income Level		Total	p-value
	Less than $50,000 n = 2445	More than $50,000 n = 2379		
Yes n = 437	71.4%	28.6%	9.1%	< 0.001§
No n = 4387	48.6%	51.4%	90.9%	
Total	50.7%	49.3%		

§ Chi-square test

Relationship between Neighborhood Walkability and Socioeconomic Status

Without considering income level, the mean walk score was highest in the center city and decreased in areas further from the center (see Figure 2). However, when walk score was categorized by income level and metropolitan status, the average walk score was not significantly different between income levels for those who lived inside a suburban county of a MSA. Those who lived in the center city of a MSA and had an income less than $50,000 had the highest average walk score, 45.29. Within a MSA, the average walk score was higher for those who made less than $50,000. The lowest average walk score, 9.09, occurred with family income less than $50,000 and lived in an area not in a MSA (see Figure 2). The overall p-value comparing mean walk score with MSA was significant (p < 0.001) (see Table 10).

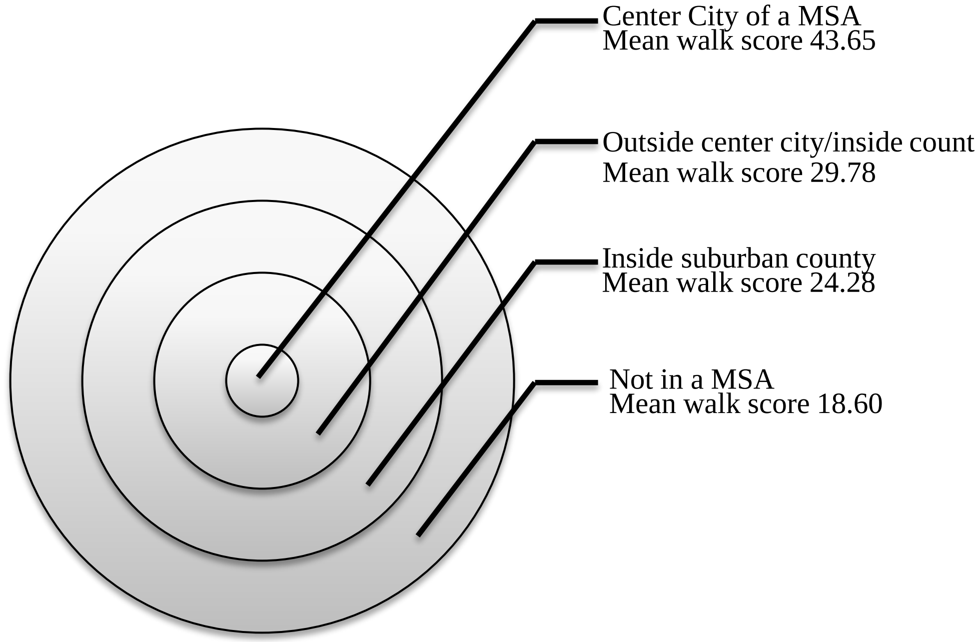

Figure 2. Mean walk score for Metropolitan Status Codes.

Table 10. *Mean Walk Score by Metropolitan Status and Income Level*

Metropolitan Status	Income Level		p-value
	Less than $50,000	More than $50,000	
Center City of a MSA	45.29	41.95	< 0.001§
Outside Center City/Inside County	32.73	27.38	< 0.001§
Inside Suburban County of MSA	26.81	21.94	0.234§
Not in a MSA	9.09	43.00	0.032§

MSA: Metropolitan Statisical Area (MSA)

§ Independent samples t-test assuming unequal variances

Comparison between Walk Score® **(n.d.) and SPACES Audit**

When the walk score value from the iPad Walk Score® App was compared to the SPACES walk score for destination walking, the values were moderately positively correlated (see Figure 3).

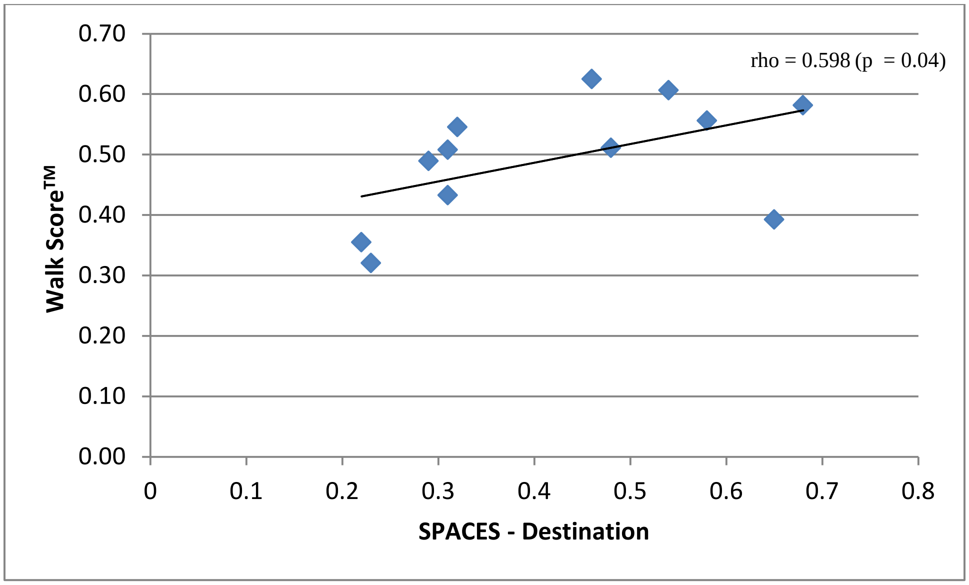

Figure 3. Walk Score® (n.d.) vs. SPACES – destination.

Conversely, when the walk score was compared to the SPACES walk score for recreation in Figure 4, the correlation was not significant (p=0.424).

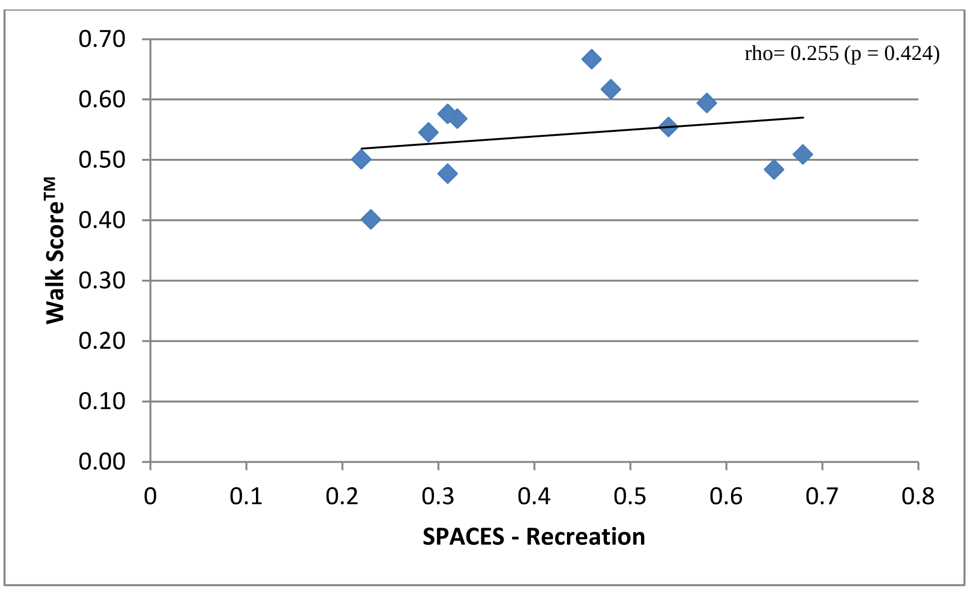

Figure 4. Walk Score® (n.d.) vs. SPACES – recreation.

Discussion

The aim of this study was to determine the association between socioeconomic status and neighborhood walkability in residents of eight counties in Ohio that had the highest prevalence of type 2 diabetes in the state. When considering the relationship between socioeconomic status neighborhood walkability, and diabetes, the results were varied. Without controlling for the variables of age, sex, race, BMI, income level, and general health; walk score was considered to be a significant predictor of diabetes. When these variables were added to the model, walkability lost its significance. In a summary of literature of the effectiveness of physical activity interventions for the treatment of type 2 diabetes, Miller and Dunstan (2004) highlighted two studies that supported walking as a means to lower HbA1C levels. HbA1C blood tests provide an average blood sugar level over the past six to 12 weeks. Since obesity is a common risk factor for diabetes, lifestyle interventions are encouraged that promote weight loss through physical activity and healthy eating (ADA, 2010). Frank et al. (2004) found that the odds of obesity decreased by 4.8% for each kilometer walked. Results from our study are similar to those reported by Berke, Koepsell, Moudon, Hoskins, and Larson (2007) who found no significant association between higher neighborhood walkability and the proportion of overweight or obese men and women.

Tang, Chen, and Krewski (2002) and Robbins, Vaccarion, Zhang, and Kai (2005) reported that lower SES was a risk factor for diabetes; similar to the results of this study. One caveat was that these studies found SES and diabetes association only significant in women. Gender differences were not examined in this study. In another study conducted by Connolly, Unwin, Sherriff, Bilous, and Kelly (2000), SES and diabetes prevalence was inversely related with strongest association occurring in adults between the ages of 40-69.

The final association of interest in this study was between neighborhood walkability and socioeconomic status. The mean walk score was more than 10 points greater for those whose annual family income was less than $50,000 compared to those with a higher income. In results similar to this study, Hoehner, Brannan-Ramirez, Elliot, Handy, and Bownson (2005), observed a relationship between neighborhood walkability and SES. Through telephone survey and neighborhood audit, residents in lower income areas of Savannah, GA and St. Louis, MO were found to meet physical activity guidelines by walking for activities of daily living, but not for recreation.

Further analysis of the relationship between socioeconomic status and neighborhood walkability within four MSC revealed that walkability was greatest within the center city of a MSA for both income levels; walkability still being higher for lower income residents. Of areas within a MSA, walk scores were lowest for suburban counties. Handy, Cao, and Mokhtarian (2006) also reported a relationship between neighborhood walkability and the built environment. The results of their study found that the average distance to the nearest establishment in a suburban neighborhood was more than two times greater than in a traditional neighborhood. Through the collection of survey data and objective measures of the built environment as well as self-reported and objective measures of physical activity; Forsyth, Oakes, Lee, and Schmitz (2009) concluded that high density areas create a more conducive environment to walking for the purpose of travel.

One final analysis of neighborhood walkability compared the walkability as assessed by Walk Score® (n.d.) with the SPACES audit. Not surprisingly, the walk score used in this study was correlated with the SPACES walk score for destination. These scores measured the proximity of parks, schools, work places, public services, and commerce to places of residence.

When the walk score value was compared to the SPACES for recreation score, these values were not correlated. Not considered in the Walk Score® (n.d.) algorithm but important to walking for recreation were pedestrian safety, sidewalk availability, and aesthetics (Walk Score®, 2011b). One study examined the relationship between walk score and objective and subjective measures of the built environment. Carr, Dunsiger, and Marcus (2010) concluded that walk score was strongly correlated to objective features of the built environment such as land use mix, street connectivity and residential density. A positive correlation was found between walk score and crime statistics. While Walk Score® (n.d.) was an excellent choice to ascertain a location's access to nearby services and facilities, it had clear limitations to its use.

Limitations

Several limitations of the study should be noted. First, by using walk scores that were based on zip code locations, neighborhood walkability was extrapolated to individual respondents of the BRFSS study. Using Walk Score® (n.d.) as a measure of walkability only described the relationship between neighborhood walkability and diabetes and income as it related to destination walking. The characteristics of a built environment that were related to walking for recreation were not part of the walk score. A further limitation of this study was the use of objective observations alone to assess the walkability of the built environment. A study by McGinn et al. (2007) concluded that both objective and perceived measures of a neighborhood most accurately measured the relationship between walkability and the built environment. The final limitation of this study was that this research relied on self-reported measures of diabetes, general health, and income.

Ideally, this study should be repeated using survey methods to collect data to evaluate participants' perceived walkability of the neighborhood in addition to the objective measurements of the environment. Objective measures of neighborhood walkability should include features of the built environment that promote or hinder walking to a destination or recreation.

There are several strengths of this study. A population based sample was used that was representative of demographic characteristics of eight Ohio counties, and our sample size comprised of more than 5000 participants. We used advanced technical apps and GIS tools to assess walk scores. We objectively assessed walkability by modifying and tailoring SPACES audit for use in the United States. Finally, a comparison of the SPACES audit and Walk Score® (n.d.) results indicated a distinction in built environment features that objectively measured walking for recreation or for traveling to a destination.

Conclusion

The aim of this study was to determine the association between socioeconomic status and neighborhood walkability in residents of eight counties in Ohio that had the highest prevalence of type 2 diabetes in the state. It was determined that the relationship between walkability and diabetes was significant before controlling for BMI, age, sex, race, income level, and general health. Lower socioeconomic status was associated with a higher prevalence of diabetes, but walk scores were highest in lower income areas in the center of the city. Despite the limitations associated with using Walk Score® (n.d.) to objectively identify walkable neighborhoods within the counties, the SPACES audit measuring walking with the intent of traveling to a destination was correlated with the Walk Score® (n.d.) measure of walkability. The SPACES audit measuring walking for recreation was not correlated. Future research should study neighborhood walkability using perceived measures of the built environment with more inclusive objective measures of a neighborhood to include crime rates.

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Appendix A

Modified SPACES Walkability Audit

Functional

Walking surface

1. Is there a path suitable for walking?
   1 No path
   2 Sidewalk
   3 Shared path with markings
   4 Shared path with no markings
2. What material is the path made of?
   0 No path
   1 Continuous concrete
   2 Concrete slabs
   3 Paving bricks
   4 Gravel
   5 Bitumen
   6 Grass or sand
   7 Under repair
3. Is the path well maintained? (even surface, smooth with no holes, cracks, weed, or tree root intrusions)
   0 No path
   1 Poor (a lot of bumps, cracks, holes)
   2 Moderate (some bumps, cracks, holes)
   3 Good (very few bumps, cracks, holes)
   4 Under repair
4. Does the path form a useful, continuous and coherent route through the neighborhood?
   0 No path
   1 Path is continuous
   2 Path is not continuous
5. Does the path form a direct route to destinations?
   0 No path
   1 Path is direct
   2 Path is not direct

Streets

6. How wide is the street/road?
   1 1 lane
   2 2 or 3 lanes
   3 4 or 5 lanes
   4 6 or more lanes

Traffic

7. How heavy is the weekday traffic volume? (Collected as AAWT)
   1 Low
   2 Medium
   3 Heavy

8. What is the posted traffic speed?
    1 Less than 25mph
    2 26-40 mph
    3 41-45 mph
    4 46-50 mph
    5 More than 50 mph
9. Are there devices that slow or restrict traffic?
    1 Roundabouts
    2 Speed bumps or humps
    3 Chicanes, chokers, curb extensions or lane narrowing
    4 Traffic signals
    5 None

Permeability

10. Is the street design conducive for walking?
    1 Grid
    2 Cul de sac
    3 Modified Grid
11. Is the distance between intersections short?
    1 Less than 240 meters
    2 More than 240 meters
12. Are the intersections designed to allow more choice of route?
    1 4 or more way
    2 3 way
13. Are there other routes available that provide alternate ways around the neighborhood?
    1 Lane
    2 Access lane through cul de sac
    3 Path through park
    4 None

<u>Safety</u>

Personal

1. How well lit is the neighborhood?
    1 Streetlights present that cover path
    2 Streetlights present but do not cover path
    3 No streetlights
2. Can others observe pedestrians through passive surveillance? (Includes, observation from window, veranda, porch or garden)
    1 Observed from greater than 75% of buildings
    2 Observed from 50%-74% of buildings
    3 Observed from less than 50% of buildings

Traffic

3. Are the devices available to assist in safely crossing busy streets/roads?
    1 Crosswalk
    2 Traffic signals
    3 Bridge/Overpass
    4 Underpass
    5 None

4. Are there pedestrian aids available to assist in safely crossing busy streets/roads?
    1 Median Refuge
    2 Curb extensions
    3 None
5. Is there a buffer between the path and traffic?
    1 Next to road
    2 Within 1 meter of curb
    3 Between 1 and 2 meters of curb
    4 Between 2 and 3 meters of curb
    5 More than 3 meters from curb

<u>Aesthetics</u>
Streetscape
1. Are there trees along the street/road?
    1 1 or more per house block
    2 Approximately 1 tree for every 2 house blocks
    3 Approximately 1 tree for every 3 house blocks
    4 No trees
2. Are the gardens in the neighborhood well maintained? (trim and clean; look kept up; free of weeds, lawns mowed)
    1 More than 75% well maintained
    2 Between 50%-74% well maintained
    3 Less than 50% well maintained
3. Is the streetscape well maintained? (verges, trees, gardens are well cared for)
    1 More 75% well maintained
    2 Between 50%-74% well maintained
    3 Less than 50% well maintained
4. Is the neighborhood free of litter, rubbish, and graffiti?
    1 No or almost no trash
    2 Some trash
    3 Lots of trash
5. Is there a park in the neighborhood (for aesthetics)?
    1 Yes
    2 No

Views
6. Are there diverse, interesting and different sights in the neighborhood?
    1 Urban (houses, household garden)
    2 Commercial (shops, offices)
    3 Water (river, ocean)
    4 Nature (reserves, parks where level of care differs)
    5 Tended nature (parks, “looked after” gardens)
7. Are there diverse and interesting architectural designs in the neighborhood?
    1 All building designs are similar
    2 Range of different designs
    3 Not applicable (no buildings)

<u>Destination</u>

Facilities

1. Is there a park in the neighborhood?
   1 Yes
   2 No
2. Are there shops in the neighborhood?
   1 Yes
   2 No
3. Are there services in the neighborhood? (i.e. schools)
   1 Yes
   2 No
4. Are there local facilities in the neighborhood? (i.e. post boxes)
   1 Yes
   2 No
5. Are there a restricted number of car parking facilities at destination?
   0 0
   1 1-20
   2 21-50
   3 51-70
   4 More than 71
   5 Not applicable
6. Is there access to public transport in the neighborhood?
   1 Bus stops
   2 Train stops
   3 No public transportation

Appendix B

Public Health Competencies

Domain #1 Analytic Assessment Skill

- Defines a problem
- Determines appropriate uses and limitations of both quantitative and qualitative data
- Selects and defines variables relevant to defined public health problems
- Identities relevant and appropriate data and information sources
- Evaluates the integrity and comparability of data and identifies gaps in data sources
- Applies ethical principles to the collection, maintenance, use, and dissemination of data and information
- Makes relevant inferences from quantitative and qualitative data
- Obtains and interprets information regarding risks and benefits to the community
- Applies data collection processes, information technology applications, and computer systems storage/retrieval strategies
- Recognizes how the data illuminates ethical, political, scientific, economic, and overall public health issues

Domain#2: Policy Development/Program Planning Skills

- Collects, summarizes, and interprets information relevant to an issue

Domain #3 Communication Skills

- Communicates effectively both in writing and orally, or in other ways
- Solicits input from individuals and organizations
- Effectively present accurate demographic, statistical programmatic and scientific information for professional and lay audiences

- Listens to other in an unbiased manner, respects points of view of others, and promotes the expression of diverse opinions and perspectives

Domain #4: Cultural Competency Skills

- Identifies the role of cultural, social, and behavioral factors in determining the delivery of public health services
- Understands the dynamic forces contributing to cultural diversity

Domain #5: Community Dimension of Practice Skills

- Identifies community assets and available resources

Domain #6: Basic Public Health Sciences Skills

- Identifies the individual's and organization's responsibilities within the context of the Essential Public Health Services and core functions
- Defines, assesses, and understands the health status of populations, determinants of health and illness, factors contributing to health promotion and disease prevention, and factors influencing the use of health services
- Identifies and applies basic research methods used in public health
- Applies the basic public health sciences including behavioral and social sciences, biostatistics, epidemiology, environmental public health, and prevention of chronic and infectious diseases and injuries
- Identifies and retrieves current relevant scientific evidence
- Identifies the limitations of research and the importance of observations and interrelationships
- Develops a lifelong commitment to rigorous critical thinking