INTRODUCTION

In the late-20th century, a key public health debate in the United States (U.S.) began to focus on health outcomes associated with automobile-oriented built environments characterized by low-densities and segregated land uses. Research began establishing links between low-density developments, resulting automobile dependence and reduced moderate activity levels among the American population (Cao 2010; Berrigan *et al*. 2014). Associated with the sedentary lifestyles, relationships also were drawn to increases in obesity and a variety of other adverse health outcomes, including poorer mental health, cardiovascular disease, cancer, diabetes and chronic obstructive pulmonary disease (Lopez 2004; Sturm & Cohen 2004). By the mid-1990s, with evidence linking sedentary lifestyles, obesity and increased mortality rates, physical activity—including moderate activity such as walking—became a essential national health objective (USDHHS 1996).

Within this research, scale emerged as an important dimension. Studies utilizing higher geographic scales, such as counties, emphasized the importance of urban form in shaping inactivity and obesity. In contrast, neighborhood level studies emphasized socioeconomic factors, such as poverty, as being important in influencing health outcomes, including obesity (Scott *et al.* 2009; Vojnovic *et al.* 2014). This research also was consistent with existing studies concluding that the highest obesity levels were evident among marginalized populations (Wang & Beydoun 2007; Flegal *et al.* 2012).

More recently, researchers have focused on the relationship between the neighborhood food environment and public health outcomes. Studies have found that the composition of the neighborhood food environment can shape dietary intake and alleviate one's risk for obesity (Chen *et al.* 2010; Boone-Heinonen *et al.* 2011). Individuals whose access is restricted to fast food establishments or food outlets that lack affordable, nutritious and culturally relevant food

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staples have poorer diets and higher risks of diet related diseases than individuals who have access to full-service supermarkets (Zenk *et al.* 2009; Gustafson *et al.* 2013).

Yet the relationships between the neighborhood food environment and public health outcomes are complex and nuanced (Hutchinson *et al.* 2012; LeDoux & Vojnovic 2014). Evidence is growing that neighborhood and store perceptions, nutritional knowledge, transportation networks and time constraints shape dietary outcomes and affect obesity risks (Kumar *et al.* 2010; Walker *et al.* 2011; Chen & Yang 2013). Moreover, there is a mounting recognition that studies examining the relationship between neighborhood food environments and health outcomes need to track whether or not respondents actually utilize such environments (Zenk *et al.* 2011**;** Matthews 2012).

Against these growing complexities, this study examines the relationships between the neighborhood food environments, **mobility and obesity outcomes among residents from the** lower eastside neighborhoods of Detroit, Michigan, a low-income, minority community facing extreme disinvestment and decline. **With the recognition that socioeconomic variables and mobility constraints can influence neighborhood health outcomes—including obesity—this article scrutinizes the interplay between neighborhood food environments, weight status as measured by the body mass index while controlling for pedestrian mobility, socioeconomic status and whether or not individuals utilize their neighborhood food stores.** By so doing, this study adds an important contribution to the current discourse by explicitly incorporating **store utilization** to test further the associations between neighborhood food environments and obesity.

URBAN FORM, PEDESTRAIN ACTIVITY, NEIGHBORHOOD FOOD AND OBESITY

Starting in the 1960s and continuing into the 1980s, considerable criticism focused on the environmental and socioeconomic impacts of the growing low-density, automobile-oriented form of U.S. cities (Preston 1967; Otterstrom 2003). Critics worried about the increasing energy and material requirements necessary to sustain these built environments as well as the growing inequity between older inner cities and their rapidly developing suburbs.

During the 1990s and 2000s, a new attack on low-density developments became focused on public health. With obesity increasing nationally, considerable interest was placed on examining how the characteristics of the built environment and associated physical activity (both moderate and vigorous) influence health outcomes. Research revealed that pedestrian-oriented neighborhoods (characterized by higher densities, mixed land uses and connected street networks based on the grid) promoted walking, and thereby increased physical activity (Handy *et al.* 2002; Cao 2010). In contrast, automobile-oriented suburban developments (characterized by low-densities, segregated land uses and disconnected street systems based on curvilinear streets) encouraged residents living within these neighborhoods to travel by car.

Research also began to question issues beyond urban form in shaping local health outcomes, including the role of socioeconomic, ethnic and cultural variables. The prevalence of overweight and obesity among under-privileged sub-group populations—including low-income groups, the less educated, women and visible minorities—introduced a new dimension to this research. Analysis began to focus on the health dimensions of marginalized communities and urban form, an area of inquiry recognized as being under-represented in the planning and health literature (LaMonte *et al.* 2002; Vojnovic 2006; Vojnovic *et al.* 2006). Studies began to recognize "the burdens of place" associated with neighborhoods characterized by extreme socio-

economic stress, where many of the traditional relationships between urban form, travel behavior, physical activity and health do not hold (Vojnovic *et al.* 2013).

Neighborhood food environments also are an important component of the built-environment that potentially can shape public health outcomes—including obesity. Research has shown that low-income and minority community residents who rely on local food environments devoid of affordable nutritious foods had significantly higher BMIs than residents do of similar communities who shopped in higher quality food environments outside their neighborhood (Inagami *et al.* 2006). Consequently, residents living in neighborhoods lacking full-service supermarkets or disproportionately composed of convenience stores and fast food establishments have been found to be at a greater risk for obesity (Morland *et al.* 2006; Mehta & Chang 2008; Bodor *et al.* 2010). Yet some studies have found no strong associations between the neighborhood food environment and BMI levels (Hattori *et al.* 2013; Gase *et al.* 2014), while others have shown modest affects among different age groups (Pruchno *et al.* 2014; Williams *et al.* 2014). Despite these incongruities, there is still a potential that improvements to **obesogenic** environments might promote better public health outcomes (**Swinburn and Egger 2002;** Boone-Heinonen *et al.* 2013). The Detroit neighborhoods that are the focus of this research—neighborhoods experiencing disinvestment and decline for over five decades—emerge as ideal case studies for exploring the associations between the local food environment and obesity.

DISINVESTMENT IN DETROIT

Detroit is a city that shows many of the effects of poverty and inaccessibility to public services as well as private goods such as health care and fresh food. The current distressed state of the city is due, in large part, to population decline and a fiscal crisis resulting from a long period of decentralization, deindustrialization, abandonment and regional fragmentation (Thomas

1997; Galster 2012). The outcome is evident in the emergence of a predominantly African-American city, with high rates of poverty and unemployment, where basic needs for urban and social services go unmet.

City population declined 25% between 2000 and 2010; one of the steepest drops in U.S. central cities during that period (U.S. Census 2000, 2010a). By 2010, the city of Detroit's total population had declined by 1.1 million people (61.4%) since its 1950 population peak year. Such population loss left large swatches of vacant residential and commercial areas and a reduced ability to support a wide variety of community services. This drastically-altered urban spatial configuration—which some call "shrinkage" and others call abandonment of the central city (Dewar & Thomas 2013)—has led to the need to examine the effects of accessibility or lack thereof on the health and well-being of citizens remaining in the distressed city.

Depopulation had certain specific characteristics. For generations, because of suburban patterns of racial segregation and exclusion (Darden *et al.* 1987), those leaving the city were largely middle-class or working-class Whites, but after 2000, increasingly, middle-class African American families began to leave. Overall, this massive exodus aggravated problems of central-city poverty, since those leaving were more mobile financially than those remaining. In 2010, Detroit's families were experiencing a 32.3% poverty rate (U.S. Census 2010b). At the same time, the city remained majority-African American at 82.7% and metropolitan Detroit continued to be one of the most racially segregated regions among major U.S. metropolitan areas.

The middle-class flight along with growing poverty among remaining city residents brought complicated social, economic and physical changes to the city of Detroit. Decreasing numbers of middle-class children in neighborhoods and schools jeopardized the educational experience of remaining students and faltering finances and decreasing school quality drove even

more middle-class families away. In terms of infrastructure, an increasing proportion of residents unable to afford automobiles relied on notoriously inefficient city and suburban bus transit systems, but city routes grew worse as the city depopulated and jobs spread regionally outward into automobile-centric territory (Grengs 2010).

The economic crisis of 2007 exacerbated these conditions for the city and region. The mortgage crisis led to a wave of foreclosures across metropolitan Detroit, but particularly in vulnerable areas such as the city's residential neighborhoods. This led to more housing vacancies and eventually, if the city was able to raze the site, vacant land. Mortgage lenders foreclosed mortgages for 63,150 homeowners between 2005 and 2011 in the city of Detroit (Detroit Office of Foreclosure 2011).

All of this had a devastating effect on the city's spatial fabric. Some neighborhoods collapsed altogether, leading to residential blocks with few standing houses, or with a large number of vacant ones, and nearby commercial strips no longer had a purpose as they were designed originally to serve coterminous neighborhoods. The Detroit Residential Parcel Survey, carried out in 2009 by a local consortium, documented 91,488 vacant residential lots in Detroit (Detroit Data Collaborative 2010). Overtime, this massive disinvestment and decentralization, combined with another major restructuring occurring with neighborhood food suppliers created an adverse food environment.

The decline of Detroit's retail food environment was a product of many forces, some local but many that were much broader. These included the loss of population and wealth to suburbs, planning decisions in which urban renewal and highways caused the demolition of public markets and stores within predominantly African American neighborhoods and shifts in the supermarket industry as it globalized and suburbanized. Stores predictably followed wealthy

customers whose needs and tastes formed the basis of the typical inventory found in the stores. As chains perfected big box models in greenfield locations supplied by trucks on highways, the larger footprint—harder to replicate in built-out inner cities—soon became the norm. The 1980s and 1990s also saw significant consolidation and vertical integration with mergers, buyouts and strategic partnerships, so that fewer corporations now control a greater portion of the flow of products from farm to fork (Guptill & Wilkins 2002; Wrigley 2002).

During these broader economic changes, major chains neglected or divested from the smaller, older store base in inner cities. Left behind, low-income and minority communities were faced with fewer choices and higher prices (Pothukuchi 2005). Shifts in the industry also led to the decline of wholesale grocery trade on which smaller independent and specialty grocery stores depended. In Detroit, wholesale trade in grocery and related products dropped from 629 establishments in 1967 doing more than $11.8 billion in sales to 101 businesses doing around $2.9 billion forty years later, both in 2012 dollars (U.S. Census 1967, 2007).

As older, independent grocers closed down in the years following the civil disturbances, few community efforts to attract new stores existed. It was not until 1998, when the first Kmart store—developed in partnership with Hartford Memorial Baptist Church—opened at 7 mile and Meyers. The store lasted only about five years. A second opened at Telegraph and 8 Mile in 2001, but was among a series of closures for the chain in 2014 (Kmart 2001; Snavely 2014). The same year, Kroger opened in northeast Detroit, but it lasted only about three years (Brooks 2001). Prospects for national chains in Detroit seemed bleak; although well-regarded independent stores, such as Honeybee Market, E&L Supermercado, Mike's Fresh and previously the city's only black-owned Metro Foodland, operated successfully in Detroit.

By early-2000s, Farmer Jack, the last major retail supermarket chain in the city, was struggling to compete with the newer and larger suburban formats of Meijer, Kroger and Wal-Mart as well as lower-price urban formats such as Save-A-Lot. In 2007, A&P shuttered all metro Detroit Farmer Jack stores. As the first decade of the 21st century ended, the severe disinvestment and decline in Detroit created a local food environment dominated by convenience, liquor and dollar stores and fast-food restaurants. It is against this backdrop of severe disinvestment in the city and the retail food environments that we examine the connections between neighborhood food stores and obesity.

DATA AND RESEARCH AREA

The analyses presented are from a larger on-going project examining the relationship between the built-environment and health outcomes in Metropolitan Detroit. A random mail survey implemented over the latter half of 2008 and the beginning of 2009 was sent to 2,514 households in low-income, African American neighborhoods on the lower eastside of Detroit, Michigan (Figure 1). Overall, 258 households returned the survey, for a final response rate of 10.3 percent. While such rates are within expectations in socially and economically marginalized communities (Groves & Couper 1998; Siegel 2002), the level of economic deterioration was unforeseen. The response rates in the Detroit neighborhoods were impacted drastically by the subprime mortgage crisis in the city of Detroit. Roughly 700 occupied residences identified in the sample were vacated within three months.

The 8-page survey ascertained information on participants' sociodemographics, diet, travel behavior, mobility and physical activity levels. **Information collected on travel-included weekly food stores visited, frequency of store trips, trip distances and travel mode (walking, public transit or automobile).** With the surveys coded, all respondent addresses

were geocoded. In addition, with store destinations addresses provided and verified through site surveys when necessary, all end-point destinations also were geocoded.

<Figure 1: Study Area Map>

The survey respondents tend to be overwhelming African American (82%) and low-income (50% of respondents report an annual household income of below $20,000). In addition, roughly one-third of respondents lack a private vehicle and only 18.5% of respondents 25 years or older possess a college degree. Such sociodemographics are representative of the broader census tract population within the research neighborhoods. According to the U.S. Census American Community Survey 2006-2010 5-year estimates, the study area consists of a population that is more than 93.5% black, with a median household income of $20,822 and with only 6.4% of the residents having a university degree. The research area also consists of a high percentage of female-headed households and single mothers. Only 17.7% of the residents within these neighborhoods were married (U.S. Census 2010c).

The lower eastside Detroit neighborhoods constitute an approximately 27 square kilometer area that is characterized by extreme class and racial segregation. The neighborhoods surveyed are experiencing a process of disinvestment and decline similar to the broader city. From the surveys, high levels of fear from crime and violence were reported within the study area and particularly among women.

The loss of residential density in the study area reveals the scale of decline. In the 2010 Census, the neighborhoods making-up the study area averaged about 1,580 people per square

kilometer, a decline from 2,622 people per square kilometer in the 2000 Census. In addition to the population loss of some 22,000 people over the decade, these neighborhoods also have experienced a widespread closure of stores, services, industries and public amenities, including schools (Figures 2 and 3).

<Figure 2: Abandoned Store>

<Figure 3: Abandoned Factory>

Despite the ongoing and large-scale disinvestment, which has been taking place for over half-a-century now, the study area still contains retail, commercial and industrial activity. While convenience and liquor stores litter the neighborhood landscape, the study area does contain an Aldi's discount supermarket and a number of other large independent supermarkets, where many of the residents shop, and particularly the lowest-income earners who do not have access to a car. The ongoing function of these neighborhoods, in spite of the widespread decline, was an important reason for selecting these neighborhoods for the study (Figures 4 and 5). Unlike many other lower-income Detroit neighborhoods, which have simply been abandoned, these neighborhoods have continued to function despite the extensive population and investment exodus, making them ideal for a study into the condition of residents in communities experiencing extreme decline.

<Figure 4: Neighborhood blocks consist of extensive housing abandonment>

<Figure 5: Liquor and party stores dominate the local retail landscape>

Given the current emphasis placed on **urban form**, automobile dependence and the importance of walking on public health outcomes, the analysis here has been focused on physical activity associated with walking. Recent studies have drawn association between low urban densities, low levels of pedestrian activity and high BMI values (Sturm & Cohen 2004; Berrigan *et al.* 2014). One important aspect of this research is to explore in greater detail the association between mobility and public health outcomes. With large segments of the population within the lower eastside Detroit neighborhoods not owning a car, the analysis allows a unique control of the built environment, and a more nuanced exploration into how variations in access to food sources, pedestrian activity and socio-economic variables affect obesity outcomes.

DATA MEASURES

Dependent variable - The dependent variable was an individual's **weight status as measured by their** body mass index (BMI). BMI values were calculated **(weight (kg) / height (m)^2)** from self-reported height and weights. These BMI values were used to create a dichotomous variable, not obese (BMI < 30) and obese (BMI ≥ 30). The median BMI value for survey respondents was 28.71, a classification of overweight (Table 1). Given that **74.49%** of respondents analyzed were overweight or obese, the choice to use a dichotomous variable over a categorical variable was chosen.

<Table 1>

Independent variables - Socioeconomic status has long been a predictor of obesity. In particular, higher rates of obesity have been observed among individuals of low socioeconomic status and education levels (McLaren 2007). These impacts have been more pronounced in females (especially African American) than in males (Ogden *et al.* 2013). In line with these past

findings, sociodemographic data employed in the analysis included gender, age, household income and education attainment. Gender and educational attainment are operationalized as dichotomous variables. Here educational attainment captures whether or not a respondent has a college degree.

Two dichotomous variables are included to capture whether or not a respondent owned a private vehicle **and if a respondent predominately walks to any of the retail food stores utilized.** It is believed that increased mobility through private vehicle ownership might allow respondents to have more control over the food environments utilized but also decrease the likelihood of walking to closer establishments. The walking measure **captures whether or not a respondent walks to their destinations, which is a reflection of the walkability of their neighborhood and their physical ability**. Walking, whether as a leisure or destination activity, is considered the most frequently engaged in physical activity among a wide spectrum of the population. Walking is accessible and considered acceptable even among subgroups who generally engage in limited physical activity, including the elderly and minority populations (Booth *et al.* 1997; Giles-Corti & Donovan 2002). However, past research has shown that health benefits from older neighborhood built environments that promote walking have been offset by severe urban decline and poverty (Zick *et al.* 2009; Vojnovic *et al.* 2013, 2014).

Last, the food and beverages one consumes can affect **body weight outcomes**. Moreover, research has shown that food environments might influence the types of foods available for consumption, which can influence dietary intake patterns (Boone-Heinonen *et al.* 2011). Consequently, four dietary variables were included, the monthly servings of soda & juice, sweets, salty snacks and fruits & vegetables. **These measures were calculated from survey questions that asked respondents to record their daily and weekly consumption of**

each group. Serving sizes reflect the portion of food consumed in relationship to the nutritional label for the product.

Food environment variables - A series of cumulative opportunity and minimum distance accessibility measures were calculated from the respondents' home addresses to full-service supermarkets, convenience stores and fast food establishments. Convenience stores included corner groceries, party, dollar and liquor stores that had limited availability of affordable nutritious food sources. Fast food establishment represented major U.S. chain franchises such as McDonalds. The local food environment data was derived from the Michigan Department of Agriculture's retail food-licensing database, an independent supermarket database from the Detroit Economic Growth Corporation as well as entries from telephone and internet business directories. **All stores within the larger study area were field verified to ensure proper classification and location. Field visits also occurred to capture any stores not listed in the above datasets. All stores frequented by respondents outside the study area also were visited or called to ensure their existence.**

The cumulative opportunity measures (Cumulative Supermarkets, Cumulative Convenience and Cumulative Fast Food) capture the immediate spatial proximity and can be viewed as a respondent's **overall** neighborhood food environment. Two sets of cumulative opportunity measures, 805 and 1609-meters, were calculated in order to examine how the gradual enlargement of a neighborhood food environment might influence outcomes. **The first opportunity measure captures a reasonable walking distance to purchase food in the absence of a private vehicle (USDA 2009). The second opportunity measures captures the U.S. federal government's distance criteria utilized to identify "food deserts."** The shortest distances measures (MinDist Supermarkets, MinDist Convenience and MinDist Fast Food)

capture the closest store within each category to a respondent. All distances used in the accessibility measures were calculated over a road network using ESRI Network Analyst in ArcMap 10.1 (ESRI 2011). **Last, in order to capture whether or not respondents actually utilize the food environments around them, two dummy variables (805m Shop (0N | 1Y) and 1609m Shop (0N | 1Y)) that tracked whether or not a respondent shopped at a supermarket, convenience or fast food establishment within the previously defined cumulative accessibility zones were created. Here respondents identified the stores that they utilized on a weekly basis which was cross referenced against the larger neighborhood food environmnet.**

Statistical analysis - A binary logistic regression framework was used to estimate the influence of the neighborhood food environment on the potential that a respondent was obese controlling for individual level sociodemographics, **mobility and whether or not respondents utilized their neighborhood food environment.** The model parameters were estimated using maximum likelihood estimation. All statistical analyses were conducted in R 3.1.1 (R Development Core Team 2014). Prior to the data analysis, 11 households were removed due to insufficient data, e.g. no height and weight data recorded. Initial models that included the dietary intake measures found that such factors were not statistically significant and their inclusion was found to influence negatively the fit of the overall models. Consequently, dietary variables were dropped and the results below focus on the pedestrian activity and food environment components.

RESULTS

<Table 2>

The results (Table 2) provide mixed support for the role that the neighborhood food environments play in shaping **weight status** outcomes. In terms of spatial proximity, there are no associations between the 805m cumulative accessibility measures and BMI; nor does walking to a retail food store have any impact on obesity prevalence. At this level, traditional sociodemographics dominate the model. Age and household income have a statistically significant negative relationship with **weight status** while car ownership has a positive relationship. Low-income households were significantly more likely to be obese (OR .99, 95% CI .99 to .99) than higher income households. **Younger respondents tended not to be obese (OR .97, 95% CI .95 to .99) in comparison to older respondents.** In contrast, individuals who owned a private vehicle had a greater likelihood of being obese (OR 3.38, 95% CI 1.39 to 8.57) than respondents who do not own a private vehicle. Overall, respondents' immediate neighborhood food environment had no statistically significant relationship to obesity incidences once socioeconomic status was controlled.

As the neighborhood food environment is expanded, the role of the fast food environment becomes salient. The1609m cumulative fast food accessibility measure has a positive relationship with obesity. The greater number of fast food establishments within 1609m of a respondent's home, the significantly greater the likelihood of being obese (OR 1.24, 95% CI 1.05 to 1.50). Car ownership continues to exhibit a statistically significant positive relationship with **weight status** and household income continues to have a negative relationship.

The inclusion of the **805m store utilization** control variable reveals a statistically significant positive relationship between respondents' utilizing their neighborhood food environment and **weight status**. Respondents who utilize the neighborhood food environment within 805m of their home have a higher chance of obesity (OR 4.10, 95% CI 1.33 to 13.66) than

residents who do not shop within the immediate food environment. At this level, the role of household income and car ownership remain but the saliency of age disappears. The neighborhood food environment variables continue to show no relationship with the dependent variable. Cumulative accessibility measures for the fast food establishments at 1609m remain relevant even when accounting for **whether or not respondents' utilize their neighborhood food environment.** The role of car ownership also remains salient but the role of household income fades while the remaining neighborhood food environments continue to show no relationship.

Regarding the shortest distance measures, respondents who travel larger minimum distances to national, regional or independent supermarkets are more likely to be obese (OR 1.001, 95% CI 1.00 to 1.00) than respondents who have to travel smaller minimum distances. Conversely, residents who have to travel shorter minimum distances to fast food establishments are also more likely to be obese (OR .99, 95% CI .99 to .99) even after household income and car ownership rates are controlled.

DISCUSSION

This study examined the relationships between the neighborhood food environment and weight status among low-income, minority residents living in neighborhoods facing extreme disinvestment and decline in Detroit, Michigan. Socioeconomic status, pedestrian mobility and actual neighborhood food environment utilization were controlled. Overall, the results show mixed results for the role of neighborhood food environments in explaining weight status outcomes such as obesity.

The results from the analysis show that the presence of national, regional or discount supermarkets within 805 and 1609-meters of a resident's home had no relationship with obesity.

Residents surrounded by a greater number of supermarkets were no more likely to have lower obesity levels than residents lacking such options were. **These results are similar to past studies in the U.S. that have failed to demonstrate a significant association between supermarkets, food access and obesity (Hattori *et al.* 2013; Gase *et al.* 2014).** Such findings should not come as a surprise as the presence of a supermarket does not necessary indicate that respondents who utilize such establishments purchase nutritious food staples or lead active life styles.

While national, regional and independent supermarkets are a source of affordable nutritious food sources, they also are a source of affordable unhealthful foods. Consequently, household dynamics such as nutritional knowledge and structural conditions such as concentrated poverty and unemployment could influence respondents' interactions with such establishments. This is supported further by the lack of significant relationship between **weight status** and **the proximity of convenience stores.** The **preferences, knowledge and attitudes** of shoppers along with important sociospatial experiences can also work to prevent respondents from visiting and purchasing unhealthful items at such stores despite their convenience or being, in some cases, the only immediate option. These trends hold even when the actual store **utilization** of respondents are included into the model.

Results indicating higher obesity likelihood for respondents utilizing neighborhood food stores within 805m of their homes could indicate that the most disadvantaged bear the burden of restricted accessibility and poor food environments. **Bromley and Thomas (1993) noted long ago that** residents who do not have the resources to overcome the temporal and fiscal constraints required to shop at more affordable distant stores are much more reliant on the stores nearest them. In contrast, residents whose coping strategies revolve around avoiding

the neighborhood food environment have a lower likelihood of being obese, despite the additional temporal and fiscal burdens.

Overall, these findings indicate the need for studies to document where people shop rather than assuming individuals choose to minimize distance in their shopping preferences. Past studies have shown that residents' food activity spaces often go beyond their immediate neighborhood food environment and in many cases do not begin or end at the home (Zenk *et al.* 2011). In addition, improved accessibility to large-scale retail supermarkets do not necessary translates into changes in food shopping patterns (Cummins *et al.* 2014). Moreover, as recent research has shown, food prices might be more crucial than distance to stores in explaining obesity **prevalence** (Ghosh-Dastidar *et al.* 2014). Thus, people struggling to make ends meet might not be able to afford to consume nutritious diets even when they are present. Furthermore, assuming residents shop at the nearest retail food store ignores the crushing burden placed on marginalized communities by the additional travel costs associated with their efforts to find better food options outside their immediate neighborhood. Similarly assuming that all trips are single purpose, originate from the home and occur during the day ignores the challenges and constraints often faced by the working poor (Chen & Cark 2013).

The fast food cumulative accessibility measure at 1609m is the only spatial proximity food measure that plays a role in explaining **weight status.** Such results confirm past findings that show the negative impact of fast food establishments on diet related outcomes and obesity even when sociodemographic variables are controlled (Maddox 2004; Inagami *et al*. 2009**;** Boone-Heinonen *et al.* 2011).

Findings indicating that greater distances to supermarkets play a role in explaining the likelihood of obesity suggest that as distance to supermarkets increase a heavier

reliance on automobile travel occurs. Similarly, it also signifies potentially greater travel costs for households lacking a vehicle, which might limit one's ability to purchase more nutritious food staples. Likewise, outcomes showing that shorter distances to fast food outlets shape weight status outcomes reveal how relatively nearby cheap energy-dense food can serve as a coping mechanism in the absence of viable options. While such findings are similar to other studies (Michimi and Wimberly 2010; Reitzel *et al.* 2014), caution is needed in placing too much emphasis on the role of distance in the models since the odd ratios are close to one.

The lack of significance for the walking measure in influencing body weight reveals that walking should be viewed as one element in a broad strategy to promote physical activity, which should include various types of moderate and vigorous exercise (such as gardening, hiking, jogging and swimming). Besides physical activity, a healthy body weight also will be influenced by diet, a variable that should be considered as important as physical activity in reducing overweight and obesity. In turn, both physical activity and diet are variables that are influenced by age, socioeconomic status and gender.

The role of class emerges within this research, and reaffirms that the traditional relationship between urban form, physical activity and public health, including obesity, might not hold in communities experiencing severe disinvestment and decline. Socioeconomic variables can override the importance of the built environment in shaping health outcomes. This is not to imply that race does not matter. Race and class are intricately intertwined especially in Detroit. The lower eastside Detroit neighborhoods are approximately 93% African American and they are the product of a broader legacy of racial residential segregation that economically

stratified the region. **Moreover, one should avoid giving too much weight to the role of household income in the results as the odd ratios are very close to one.**

While the focus of this study was on obesity, a sensitivity analysis in which the non-obese respondents were broken into two groups normal and overweight was conducted. Findings from this nested dichotomy found two significant differences between the groups. The likelihood of a respondent being overweight increased as the number of supermarkets within 1609m increased. Similarly, the likelihood of being overweight increased as respondents aged in the shortest distance models.

Several limitations affect the research findings. First, the study relied on self-reported height and weight measurements to calculate BMI levels. While considerable research supports the legitimacy of self-reported measures in public health research, self-reported responses can lead to measurement, reliability and validity issues (Brener *et al.* 2003). Second, the cross sectional nature of the study design only captures one point in time, which limits the generalizability of the study. Third, the sample size is modest and the overall response rate of the sampling frame was low. While the overall composition of the sample is **relatively** representative of the underlying neighborhood census demographics, care should be taken not to extrapolate beyond the lower eastside neighborhoods of Detroit. **Moreover, it should be noted that the survey returned a slightly higher educated sample than the underlying population.** Despite these limitations, there appears to be mixed support for the role of the neighborhood food environment on influencing obesity, even when sociodemographics and pedestrian mobility and neighborhood store utilization are controlled. In particular, fast food establishments appear to play a significant role in shaping public health outcomes.

CONCLUSION

Over the last few years, fresh food retail in Detroit's neighborhoods has expanded in response to the extreme disinvestment in the city's food environment. The city of Detroit now boasts more than ten seasonal neighborhood farmers markets and several food-buying collectives. Eastern Market, the region's largest produce market, sponsors 18 seasonal, weekly farm stands in various neighborhood and employment locations. Other initiatives, such as monthly, low-cost Fresh Food Share produce boxes distributed at 35 community locations and local sourcing by restaurants, increasingly support small-scale food enterprises. Despite their importance, many of these initiatives are fragile given their newness and labor-intensiveness, reliance on outside support, smaller scale and seasonality and experience modest revenues due to their "alternative" formats. Moreover, such initiatives also face an uncertain future as national and regional retail outlets open nearby and boutique markets catering to high-income earners move into the city.

Whole Foods opened its doors to national media fanfare in 2013 in midtown, with public subsidy at a level that few other stores in the city can claim to have received (Sadovi 2013; Stock 2013). Large-scale investments and subsidies are being made to create a giant open-air food marketplace for the city's young professionals at Cadillac Square. At the same time, the large-scale regional supermarket chain Meijer opened a 17,652 sq. m. store at Woodward and 8 Mile, the city's northern boundary and are in the process of building a new store in northwest Detroit. Like Whole Foods, Meijer is receiving public subsidies that many of the historic and minority owned independent supermarkets in the city fail to receive (Zemke 2011).

Yet as the results of this study show, the relationship between neighborhood food environments are complex and often mediated by larger structural issues and sociocultural conditions. While improving accessibility to sources of affordable nutritious food sources is

imperative on grounds of equity, such strategies must seriously tackle the structural conditions underlying the economic and racial stratification occurring in the region and broader food system. However, as noted in this study, there might be some benefit to such interventions among the subpopulations that are forced to rely on their immediate neighborhood food environment.

This study has found that certain dimensions of the neighborhood food environment contribute to weight status outcomes such as obesity. Such dimensions play out at different scales. Residents who heavily rely on their immediate neighborhood food environment (805m) have a higher likelihood of being obese than residents who do not utilize the stores around them. At a larger scale of 1609m, lower eastside Detroit residents with a greater concentration of fast food establishments around them have a higher possibility of being obese than residents with fewer fast food restaurants around them. Yet not all dimensions of the neighborhood food environment have been found to be influential. Traditional access to neighborhood food stores whether a full-service supermarket or a convenience store are not found to explaining weight status outcomes in residents on the lower eastside of Detroit.

The salience of the fast food environment warrants additional attention in terms of public health interventions. The additional burdens placed on residents to escape their neighborhood food environment for weekly provisions may encourage their reliance on fast food establishments to help stretch food dollars during the month. When combined with the erosion of basic food preparation knowledge within households and schools and targeted fast food marketing in inner city environments, it can lead to the creation of a "toxic food environment" (Brownell 2004). Moreover, older homes hosting poorer families also may have less reliable

kitchen equipment, water and electrical/gas power. Such complexities warrant further examination and should be incorporated into future policy strategies to ameliorate public health outcomes in Detroit.

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Table 1: Model variables with descriptive statistics

Variable	n	Min	Max	Mean	Median	Std Dev
BMI[1]	247	16.95	61.10	30.06	28.71	7.41
Obese	106	30.10	61.10	36.73	34.83	6.04
Overweight	78	25.00	29.90	27.44	27.46	1.36
Non-Overweight	63	16.95	24.96	22.07	22.20	1.95
Age	247	18.00	94.00	52.27	53.00	16.33
College Degree (0N | 1Y)	239					
Yes	46	-	-	-	-	-
No	193	-	-	-	-	-
Household Income	215	5000	135000	28767	20500	27164
Gender (0F | 1M)	246					
Male	64	-	-	-	-	-
Female	182	-	-	-	-	-
Car Ownership (0N | 1Y)	222					
Yes	139	-	-	-	-	-
No	83	-	-	-	-	-
Walk (0N | 1Y)	191					
Yes	66	-	-	-	-	-
No	125	-	-	-	-	-
Dietary Intake (monthly servings)[2]						
Soda & Juice	245	2.00	360.00	62.03	28.00	68.25
Sweets	243	1.00	180.00	18.31	6.00	29.25
Salty Snacks	241	1.00	180.00	17.95	6.00	50.64
Fruits & Vegetables	246	2.00	360.00	62.00	36.00	66.05
Cumulative Opportunity Supermarkets (805m)	247	0.00	2.00	0.42	0.00	0.56
Cumulative Opportunity Supermarkets (1609m)	247	0.00	4.00	1.79	2.00	1.08
Cumulative Opportunity Convenience (805m)	247	0.00	13.00	4.25	4.00	2.46
Cumulative Opportunity Convenience (1609m)	247	6.00	14.00	18.13	18.00	5.14
Cumulative Opportunity Fast Food (805m)	247	0.00	6.00	0.85	0.00	1.36
Cumulative Opportunity Fast Food (1609m)	247	0.00	9.00	3.55	3.00	2.42
MinDist Supermarkets (m)	247	150.20	1996.00	1001.00	974.80	439.07
MinDist Convenience (m)	247	63.02	1081.00	452.80	442.70	196.21
MinDist Fast Food (m)	247	144.70	2347.00	1047.00	997.80	490.49
805m Travel (0N | 1Y)	191					
Yes	35	-	-	-	-	-
No	156	-	-	-	-	-
1609m Travel (0N | 1Y)	191					
Yes	84	-	-	-	-	-
No	107	-	-	-	-	-

N = 255

[1] BMI = weight (kg) / height (m)^2

[2] A serving size for food consumed was referenced to the portion of food consumed in relationship to the nutrition label.

Table 2: Logistic regression results

				95% CI		
805 Meters	B	SE	OR	2.50%	97.50%	
(Intercept)	0.243	0.771	1.275	0.280	5.863	
Age	-0.024	0.011	0.977	0.954	0.999	*
College Degree (0N | 1Y)	0.491	0.487	1.634	0.635	4.342	
Household Income	-1.85E-05	8.01E-06	0.999982	0.999965	0.999996	*
Gender (0F | 1M)	-0.315	0.415	0.730	0.318	1.635	
Car Ownership (0N | 1Y)	1.219	0.460	3.385	1.398	8.579	*
Walk (0N | 1Y)	-0.431	0.408	0.650	0.289	1.443	
Cumulative Opportunity (Supermarkets)	-0.165	0.345	0.848	0.427	1.665	
Cumulative Opportunity (Convenience)	0.057	0.080	1.059	0.906	1.240	
Cumulative Opportunity (Fast Food)	0.277	0.172	1.320	0.951	1.873	

R^2 = 0.121 (Hosmer-Lemeshow), 0.152 (Cox-Snell), 0.205 (Nagelkerke)

Model $X^2(9)$ = 25.58

* $p < 0.05$

n = 155

				95% CI		
1609 Meters	B	SE	OR	2.50%	97.50%	
(Intercept)	-0.845	0.993	0.429	0.059	2.963	
Age	-0.018	0.012	0.982	0.960	1.005	
College Degree (0N | 1Y)	0.511	0.496	1.667	0.635	4.498	
Household Income	-1.66E-05	8.43E-06	0.999983	0.999966	0.999999	*
Gender (0F | 1M)	-0.368	0.428	0.692	0.294	1.588	
Car Ownership (0N | 1Y)	1.236	0.465	3.441	1.408	8.790	**
Walk (0N | 1Y)	-0.635	0.423	0.530	0.227	1.204	
Cumulative Opportunity (Supermarkets)	-0.073	0.213	0.930	0.607	1.407	
Cumulative Opportunity (Convenience)	0.027	0.039	1.027	0.951	1.111	
Cumulative Opportunity (Fast Food)	0.223	0.090	1.249	1.050	1.500	*

R^2 = 0.143 (Hosmer-Lemeshow), 0.176 (Cox-Snell), 0.238 (Nagelkerke)

Model $X^2(9)$ = 30.06

* $p < 0.05$, ** $p < 0.01$

n = 155

				95% CI		
805 Meters Travel Controlled	B	SE	OR	2.50%	97.50%	
(Intercept)	0.387	0.780	1.472	0.319	6.924	
Age	-0.022	0.012	0.978	0.955	1.000	
College Degree (0N | 1Y)	0.753	0.495	2.122	0.814	5.746	
Household Income	-1.81E-05	8.06E-06	0.999982	0.999965	0.999997	*

Gender (0F | 1M)	-0.067	0.418	0.935	0.408	2.121	
Car Ownership (0N | 1Y)	0.980	0.469	2.665	1.076	6.842	*
Walk (0N | 1Y)	-0.518	0.427	0.596	0.254	1.368	
Cumulative Opportunity (Supermarkets)	-0.747	0.416	0.474	0.202	1.044	
Cumulative Opportunity (Convenience)	0.029	0.081	1.029	0.877	1.207	
Cumulative Opportunity (Fast Food)	0.250	0.180	1.284	0.909	1.848	
805m Travel (0N | 1Y)	1.413	0.588	4.107	1.336	13.667	*

R^2 = 0.142 (Hosmer-Lemeshow), 0.176 (Cox-Snell), 0.237 (Nagelkerke)

Model $X^2(10)$ = 30.03

* $p < 0.05$

n = 155

				95% CI		
1609 Meters Travel Controlled	B	SE	OR	2.50%	97.50%	
(Intercept)	-0.954	1.007	0.385	0.051	2.716	
Age	-0.017	0.012	0.983	0.960	1.006	
College Degree (0N | 1Y)	0.529	0.499	1.697	0.642	4.612	
Household Income	-1.57E-05	8.40E-06	0.999984	0.999967	1.000	
Gender (0F | 1M)	-0.361	0.431	0.697	0.294	1.610	
Car Ownership (0N | 1Y)	1.192	0.467	3.292	1.339	8.447	*
Walk (0N | 1Y)	-0.781	0.455	0.458	0.183	1.102	
Cumulative Opportunity (Supermarkets)	-0.120	0.219	0.887	0.572	1.359	
Cumulative Opportunity (Convenience)	0.030	0.040	1.030	0.954	1.116	
Cumulative Opportunity (Fast Food)	0.214	0.091	1.239	1.040	1.489	*
1609m Travel (0N | 1Y)	0.387	0.416	1.472	0.652	3.360	

R^2 = 0.147 (Hosmer-Lemeshow), 0.181 (Cox-Snell), 0.244 (Nagelkerke)

Model $X^2(10)$ = 30.93

* $p < 0.05$

n = 155

				95% CI		
Minimum Distance	B	SE	OR	2.50%	97.50%	
(Intercept)	0.634	0.861	1.885	0.351	10.451	
Age	-0.019	0.012	0.981	0.959	1.004	
College Degree (0N | 1Y)	0.718	0.510	2.050	0.766	5.759	
Household Income	-1.87E-05	8.26E-06	0.999981	0.999964	0.999997	*
Gender (0F | 1M)	-0.263	0.415	0.769	0.336	1.727	
Car Ownership (0N | 1Y)	0.954	0.458	2.595	1.071	6.516	*
Walk (0N | 1Y)	-0.648	0.412	0.523	0.230	1.165	
MinDist Supermarkets	0.001	0.001	1.001	1.000	1.003	*
MinDist Convenience	0.001	0.001	1.001	0.999	1.003	
MinDist Fast Food	-0.002	0.001	0.998	0.997	0.999	**

R^2 = 0.135(Hosmer-Lemeshow), 0.167 (Cox-Snell), 0.225 (Nagelkerke)

Model $X^2(9) = 28.33$

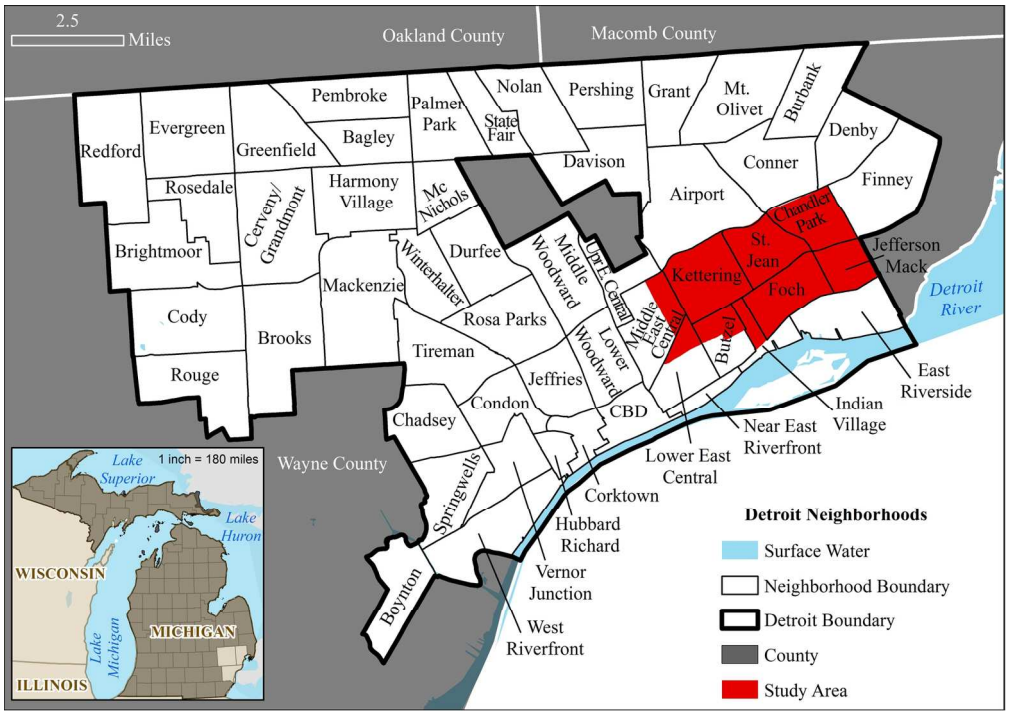
* $p < 0.05$, ** $p < 0.01$

n = 155

B - regression coefficient, SE - standard error, OR - odds ratio, CI - confidence interval

Weight Status (BMI) is the outcome variable

Numbers shown were rounded to the third decimal place



Study Area Map
160x112mm (300 x 300 DPI)

Abandoned Store
135x90mm (300 x 300 DPI)

Abandoned Factory
135x90mm (300 x 300 DPI)

Neighborhood blocks consist of extensive housing abandonment
320x240mm (180 x 180 DPI)

Liquor and party stores dominate the local retail landscape
135x90mm (300 x 300 DPI)