PERSONAL SERVICE AND LEISURE TRAVEL IN THE CITY OF DETROIT AND ITS SUBURBS: EXPLORING INDIVIDUAL- AND NEIGHBORHOOD-LEVEL VARIABILITY

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ABSTRACT

PERSONAL SERVICE AND LEISURE TRAVEL IN THE CITY OF DETROIT AND ITS SUBURBS: EXPLORING INDIVIDUAL- AND NEIGHBORHOOD-LEVEL VARIABILITY

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The ability to travel is essential for people to participate in society, acquire resources and services, and engage in daily life. Trips for personal service and leisure constitute a significant share of total travel, more than one-third of all trips, but the distinct patterns of these journeys have often been overlooked in the existing literature. Also, daily travel in high-poverty, declining urban neighborhoods experiencing disinvestment is less studied and is not well understood. Focusing on the city of Detroit and its suburbs, this dissertation examines daily travel patterns – the one-way trip distance (length of journey to the destination), weekly trip frequency and total distance traveled, and mode of travel – for personal services and leisure activities, and how they vary by individual sociodemographic characteristics and different neighborhood environments. The results show that personal service and leisure travel have distinct patterns in terms of trip distance and mode selection. Also, the effects of the neighborhood environment and individual sociodemographic characteristics on travel vary significantly by the purpose of the journey (personal service versus leisure). In particular, the effect of aging varies by neighborhood context and trip purpose. Seniors in declining urban neighborhoods have significantly fewer leisure trips, indicating challenges they face in leisure activity participation. Moreover, the typical association of high-density built environments and shorter trip distances do not hold in the declining urban Detroit neighborhoods. In fact, residents in such neighborhoods experience unique burdens in travel and have to travel longer distances to reach amenities despite living in a high-density built environment, due to the extreme disinvestment within the city of Detroit. Lastly, focusing on an essential type of personal

services – pharmacies, it is shown that residents in declining urban neighborhoods actually bypass local independent stores within the neighborhood and travel longer distance to shop at more distant national chain pharmacies.

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Chapter 1. Introduction

Daily travel is essential for people to participate in society and acquire resources and services. It has been extensively studied by geographers, planners and policy makers to facilitate and influence how people move in urban spaces. Many studies on travel behavior consider trips of all purposes together, or at best distinguish between work and non-work trips. For studies that focus on specific types of trips, the attention is often given to work trips. However, people also travel to visit personal service providers, such as banks, churches, pharmacies, doctors and dry cleaners, and to enjoy leisure activities, such as interactions with friends and family members, going to a movie or strolling in the mall. These trips are important for people's welfare and also constitute a significantly large proportion of the total amount of travel (Mcguckin and Fucci 2018; Ohnmacht, Götz, and Schad 2009). Despite their importance, trips for both personal services and leisure activities are underexplored in the existing literature.

Some evidence indicates that travel patterns and the effects of various factors can vary among trips for different purposes. Leisure trips are found to be longer in one-way trip distance than personal service trips on average and both are shorter than trips for work (Schmöcker et al. 2005; Vojnovic et al. 2014). Also, some noted that the effects of the built environment characteristics have a stronger impact on total distance traveled for work and service than for leisure (Elldér 2014). In addition, the effects of some individual sociodemographic variables were found to be contingent on the purpose of the trip. For example, higher incomes are associated with greater distances traveled for work trips, but weaker or no effects were found for trips for shopping and social activities (van den Berg, Arentze, and Timmermans 2011; Dieleman et al. 2002; Horner and Schleith 2012). Some studies also indicate that aging results in shorter one-way distances for most

trips, but has no effect on travel for recreation or social activities (van den Berg et al. 2011; Schmöcker et al. 2005).

These findings indicate that travel decision making mechanisms could vary across trips for different purposes. Næss (2006) explained that destination choice and the resulting one-way trip distances are the compromise of two competing incentives - the shortest distance (or time) needed to travel and the best quality of the facility. The balance between these two incentives differs depending on the trip purposes. This means the effects of factors on travel will vary by trip purpose. Further, Elldér (2014) argued that work trips are most constrained by space and time and therefore more subject to the influence of the local built environment, while trips taken during free time, such as to leisure destinations, are much less likely to be affected because people have more freedom to choose where and when to go.

Therefore, general findings on travel behavior for all purposes or for work cannot be automatically assumed to apply to travel characteristics for other needs, including personal services and leisure activities. In the current literature, there is limited evidence on how people's travel patterns may differ for different purposes. Also, the existing research is not conclusive when it comes to some of the relationships influencing travel. For instance, while some found a positive effect of aging on the total frequency of leisure trips, other studies identified a negative effect of aging to these same destinations (van den Berg et al. 2011; Pettersson and Schmöcker 2010; Schwanen, Dijst, and Dieleman 2001). A more nuanced examination of the different types of personal service and leisure trips and the associations with individual sociodemographic characteristics and neighborhood environments would provide additional insight, and a more complete understanding, of travel behavior.

In this dissertation, I will study travel for personal services and leisure activities, with a focus on the Detroit region. In the early twentieth century, the city of Detroit emerged as one of the leading industrial centers of the U.S. and the capital of automobile production. Detroit would flourish over the next half century, reaching its population peak of 1.85 million in 1950. However, with racial and class tensions, suburbanization, neoliberal policies, and economic restructuring (Darden and Thomas 2013; Sugrue 2014; Vojnovic 2009; Vojnovic and Darden 2013), the city of Detroit has experienced severe decline over the last six decades. Detroit has a disproportionate concentration of minority and low-income populations. Many residents and businesses have abandoned the city, leading to a breakdown of local services and infrastructure, and generating severe municipal financial stress (Alexander 2013). Despite signs of improvement in the Downtown and Midtown areas, the city as a whole is still economically struggling (Reese et al. 2017; Vojnovic et al. 2016). Local residents, many of whom live in poverty, have poor access to basic amenities for meeting daily needs (Vojnovic et al. 2014). In contrast to the city, the suburban jurisdictions surrounding Detroit have been relatively vibrant, with active local economies and a rich provision of public services. In fact, some of the suburbs in the Detroit region, such as Birmingham and Ann Arbor, are considered among the best places to live in the US (NICHE 2018). The spatial distribution of wealth, businesses, as well as public services are highly unbalanced across the Detroit region. The sharp contrast of the urban and suburban areas makes the region valuable for understanding access and realized daily travel to amenities across neighborhoods of different built environments and social conditions.

Highly segregated, low-income minority urban neighborhoods confronting severe disinvestment and decline are generally understudied in the existing travel behavior literature. Evidence has shown that neighborhood socioeconomic conditions can affect how residents travel. It was found

that neighborhood median income levels affect the amount of active travel (walking and biking) even after controlling for individual-level sociodemographic characteristics (Freeman et al. 2013). Research focusing specifically on Detroit has also shown that compared with middle- and high-income white suburban residents, lower-income urban Detroit residents who are mostly African Americans have to travel longer distances to reach various amenities (LeDoux and Vojnovic 2013, 2021). While trips to various types of food options have been examined for Detroit (Eckert and Vojnovic 2017; LeDoux and Vojnovic 2013, 2014), trips to personal services and leisure destinations, which constitute more than a third of total travel by frequency, have yet to be investigated in detail.

To capture travel patterns for personal services and leisure activities by residents in neighborhoods of the Detroit region, including declining low-income urban neighborhoods underrepresented in the existing travel behavior literature, this dissertation examines the variability of daily trips for personal services and leisure activities[1], including one-way trip distances, weekly frequencies and

[1] The personal service trips explored in this dissertation include maintenance (e.g., cleaners and barbers), financial services, health services, pharmacy, postal office, religious place, and retailing (e.g., bookstores, video stores, office stores, electronics stores, music stores and clothes stores). Leisure travel trips here is limited to short daily trips for recreational and social purposes, excluding long-distance tourism. These include social visits, bars and coffee shops, leisure education, hobby (e.g., golfing, bowling, playing cards, and choir), library, mall, physical activity, performance, recreation (e.g., parks and museums), and other miscellaneous leisure trips. Note that personal service and leisure trips studied here do not include food trips of grocery shopping and restaurant visits, which have been explored in a series of papers using the same dataset (Eckert and Vojnovic 2017; LeDoux and Vojnovic 2013, 2014).

total distance traveled and travel mode, and how these patterns are influenced by individual-level and neighborhood-level attributes. In addition, spatial accessibility and trips to pharmacies – an essential type of personal services – will be examined to understand how people access and utilize pharmaceutical services in different neighborhoods.

The study area includes six Detroit neighborhoods - two urban neighborhoods in eastside Detroit, two high-density suburban neighborhoods in Ann Arbor and Birmingham, and two low-density suburban neighborhoods in West Bloomfield and Bloomfield Hills. These neighborhoods vary in terms of the built environment and racial and socio-economic composition, which enables comparisons of travel behavior for personal service and leisure at both the individual and neighborhood levels. Data from an NSF survey on health and travel behavior, which was collected in 2008 from these six neighborhoods, are used to examine personal service and leisure travel. In addition, land use data from site surveys of these neighborhoods are employed to map the different built environments. ReferenceUSA 2008 historic business data are also used to map the spatial distribution of pharmaceutical services across the Detroit region.

In this dissertation, I propose the following research questions:

Question set 1: How do individual sociodemographic characteristics and neighborhood environments influence one-way trip distances for personal services and leisure activities? Also, how do individual sociodemographic characteristics and neighborhood environments influence weekly frequency and total distance traveled and mode use for personal services and leisure activities?

Question set 2: what is the spatial distribution and accessibility to pharmacies in the Detroit region and is there any variation across different neighborhoods? What are the travel patterns to

pharmacies and how are they influenced by accessibility, personal attributes and neighborhood environments?

To address these questions, the remaining components of this dissertation consist of seven remaining chapters. Chapter 2 examines the current literature and identifies the need to examine travel for leisure and personal service purposes in disadvantaged urban communities. Chapter 3 offers a detailed review of the history of Detroit and explains how the study region has evolved into the current spatial structure, characterized by a declining urban core surrounded by Low-density Suburbs, largely comprised of wealthy and white population subgroups.

Chapter 4 describes the datasets used in this dissertation in detail, including the travel survey, site survey and the ReferenceUSA historic business database. It also explains how the data on travel behavior have been processed. In the original data, 3,307 trip destinations for various personal services and leisure activities were reported. A three-level classification system was used to categorize these trips into different activity types and then into the two general purposes of personal service and leisure travel, resulting in 1,364 leisure trip destinations and 1,507 personal service trip destinations. Then, the chapter describes basic neighborhood characteristics and trip patterns observed based on descriptive statistics.

Different sets of data analyses and findings are reported in Chapters 5 to 7. Chapters 5 focuses on the one-way trip distances for leisure and person service travel. The impacts of factors at three levels – trip purpose, neighborhood type, and individual sociodemographic variables – and their interaction effects were analyzed. OLS regressions were used to explore the separate effect of each factor and multilevel models were used to model the combined effects of all relevant factors with a consideration of within-individual variation. The results show that trip distance is primarily

determined by trip purpose and neighborhood type. The effects of individual sociodemographic factors of income, age and gender are much weaker and are shown to be contingent on the purpose of the trip and the neighborhood context.

Chapter 6 examines the weekly frequency and total distance traveled by different transport modes. Negative binomial regressions were performed to model weekly frequency and OLS regressions were used to model weekly total distance traveled. The results show that the travel mode for leisure and personal service trips is affected by the trip purpose, neighborhood contexts and individual-level variables of income (for High-density Suburbs and Urban Detroit only) and age. Weekly trip frequencies vary by individual-level sociodemographic characteristics, but the effects depend on the trip purpose and neighborhood contexts – a negative effect of aging on leisure trips for Urban Detroit only and a positive effect of being female on leisure trips for Low-density Suburbs specifically.

Chapter 7 focuses on travel for a specific personal service – trips to pharmacies – and examines the accessibility and travel patterns of Detroit Region residents to pharmaceutical services. ReferenceUSA business data were used to map the spatial distributions of pharmacies and calculate accessibility levels to different types of pharmacies (including national chains, local independent pharmacies and supermarket pharmacies). Travel patterns were then modeled with logistic regressions for whether or not people use pharmacies and for travel mode choices, OLS regressions for one-way trip distance and ordered logistic regressions for the rank of the chosen destination pharmacy among all available options in terms of distance from the respondents' home (destination choice). The findings indicate that access to pharmacies is unequal across different neighborhoods and that Urban Detroit residents have particularly low accessibility to national chain pharmacies and travel long trip distances due to both low accessibility and the need to shop

around for preferred pharmaceutical services. This complements the findings in Chapter 5 and further illustrates how accessibility to amenities affects trip distances.

Chapter 8 summarizes the findings and discusses the merits of the study and future directions that could be pursued beyond this dissertation.

Chapter 2. Literature Review

Travel activities originate from people's daily needs. People move across space to obtain resources and participate in various activities to live their daily lives. Thus, demand for travel is often considered derivative. Following a trip-based approach, travel behavior can be understood as consisting of four separate stages – trip generation, destination choice, mode choice, and route choice (McNally 2007). To measure travel behavior, there are many indicators that reflect the multiple dimensions behind such a complex process. Some common indicators include one-way trip distance (trip length), total vehicle miles traveled (VMT), travel time, frequency of trips, and mode choice.

People make daily trips for three types of activities – work (subsistence), personal services (maintenance necessities) and leisure activities (discretionary) (Ås 1978; Reichman 1976; Stopher, Hartgen, and Li 1996). This dissertation focuses on nonwork trips for personal services and leisure activities. I will review the current literature related to personal service and leisure travel and examine two major factors that influence travel behavior – built environment characteristics and personal attributes.

2.1. Personal service travel

From the 2008 Detroit NSF survey used in this study, personal service trips – such as travelling to a bank, a doctor, a dentist and/or pharmacy – account for 17.2% of all travel. Despite the significance of these trips, personal service travel has been underexplored in the travel behavior literature. In the existing studies, personal service trips were often examined as part of total, or non-work travel, together with trips for other purposes. Some studies did include and examine personal service trips as a separate category of travel along with trips for other purposes, but the

focus was not specifically on the details of personal service trips (Haugen and Vilhelmson 2013; Kotval-K and Vojnovic 2016; Lee, Vojnovic, and Grady 2018). In particular, the unique patterns of personal service travel and whether and how individual- and neighborhood-level factors affect personal service travel in ways that might be different from travel for other trip purposes is underexplored in the existing literature.

Among various personal services, pharmacies are especially important since they are an essential part of health care provision. There have been some research efforts on evaluating spatial accessibility to pharmacies and identifying pharmacy deserts at local, regional and national scales (Erickson and Hirshorn 1996; Erickson and Workman 2014; Ikram, Hu, and Wang 2015; Pednekar and Peterson 2018; Qato et al. 2014, 2017). Neighborhoods with concentrations of visible minority populations, and high poverty and unemployment rates, have been found to have lower access to pharmaceutical services. However, actual travel to pharmacies is generally overlooked in the existing literature. It is necessary to go beyond an evaluation of access and examine pharmacy travel, since it reflects how people actually utilize available pharmaceutical services, under the influences of various factors including spatial accessibility, community cultural norms and values, and personal needs, preferences and financial resources. Having a pharmacy nearby does not necessarily mean the person will actually use it even when s/he need pharmaceutical services. Evidence in grocery shopping in Detroit has demonstrated that people in inner-city low-income neighborhoods bypass nearby opportunities to shop at more distant grocery locations for better quality of products and cheaper prices (LeDoux and Vojnovic 2013). A similar pattern might also apply in travel for pharmacies.

2.2. Leisure travel

Leisure travel in this dissertation refers to daily travel activities for leisure purposes. A large body of literature in tourism has examined leisure travel for long-distance tourism. The focus of the research here is placed on short daily trips for recreational and social purposes.

Compared with other types of travel activities, such as commuting or shopping, leisure travel has received limited attention in the past. Meanwhile, leisure activity participation has been increasing throughout the second-half of the 20th century due to reduction in work hours, increasing incomes and better accessibility to leisure destinations (Schlich et al. 2004). As evidence from multiple countries has shown, distance traveled for leisure trips actually makes up a large proportion of total distance traveled. For instance, the travel related with leisure activities in the Netherlands constituted 44% of the total distance traveled in 2005 (Ettema and Schwanen 2012), and leisure trips made up 26 percent of all trips in Switzerland in 2005 (Ohnmacht et al. 2009). Leisure travel is also prominent in the US. According to the 2017 National Household Travel Survey by the US Federal Highway Agency, social and recreational travel involved 866 person trips and 4,327 vehicle miles traveled per household annually; it is the most frequent among the trips for various purposes and involves a high percentage of vehicle miles traveled, only second to commuting for work (Mcguckin and Fucci 2018). Therefore, understanding leisure travel is important for the understanding of daily travel patterns.

Since 2000, there have been increasingly more studies focusing on leisure travel. Personal attributes (sociodemographic variables and personal lifestyles and preferences), household structure, and built environment characteristics were found to impact the frequency, distance and modal share of leisure trips (Lanzendorf 2002; Ohnmacht et al. 2009).

Compared with regular travel activities such as commuting and grocery shopping, leisure travel has a unique characteristic – variety (novelty) seeking (Kemperman, Borgers, and Timmermans 2002; Schlich et al. 2004; Stauffacher et al. 2005). As European evidence has shown, while the majority of leisure destinations was habitual, a small yet substantial share of the leisure destinations visited daily were new places never visited before and this percentage was higher for men and younger people, and it was higher over weekends as compared to the weekdays (Schlich et al. 2004; Stauffacher et al. 2005).

In general, most of the existing leisure travel studies focus on the European context. Undertaking research in a major U.S. regional center – the Detroit Region within this dissertation – will provide an important leisure travel behavior study in a North American context. In addition, the focus on a major city experiencing disinvestment and decline, as in urban Detroit, will add an important dimension to leisure travel behavior research.

2.3. Factors influencing travel behavior

Travel behavior could be influenced by various factors, including neighborhood characteristics of the built environment and the sociodemographic composition, individual sociodemographic characteristics, household structure and intra-household decision making (Gliebe and Koppelman 2002), availability of parking (Christiansen et al. 2017; Manville 2017; Shoup 2006), weather (Böcker, Dijst, and Faber 2016; Cools et al. 2010), and social influence (Maness, Cirillo, and Dugundji 2015). Figure 2-1 below provides a conceptual framework demonstrating the association of the neighborhood built environment, neighborhood sociodemographic composition and individual sociodemographic characteristics with travel behavior, with a more detailed discussion of these relationships being reviewed over the coming pages.

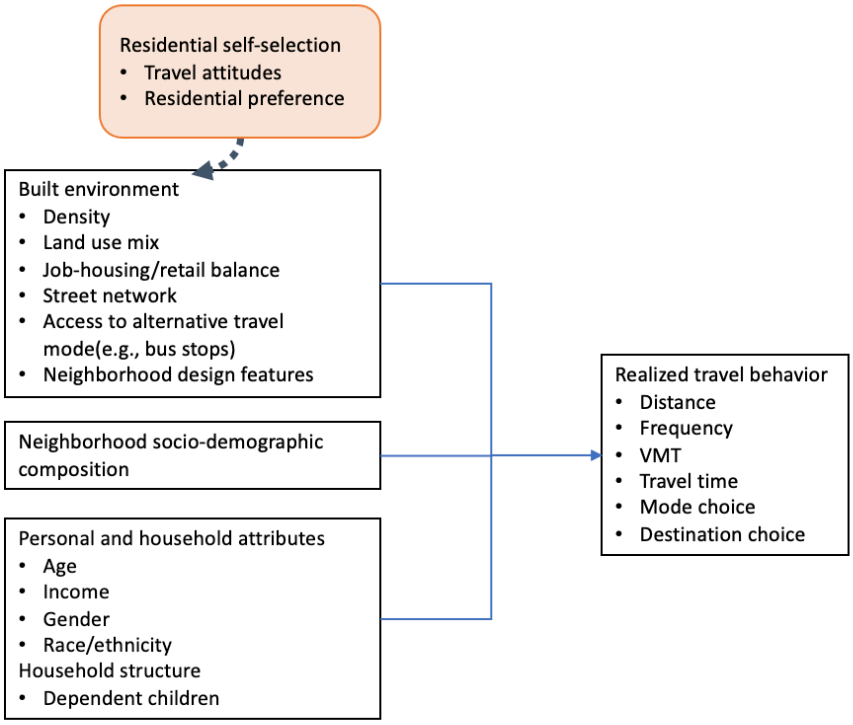


Figure 2-1. A general framework for travel behavior and influencing factors

2.3.1. Built environment and travel behavior

The built environment plays a significant role in shaping travel behavior. According to Cervero and Kockelman (1997), the built environment refers to "*physical features of the urban landscape (i.e. alterations to the natural landscape) that collectively define the public realm, which might be as modest as a sidewalk or an in-neighborhood retail shop, or as large as a new town*" (p. 200). The built environment largely consists of three components (Handy et al. 2002): land use activities (where residents live and the spatial arrangement of destination opportunities); transport systems (road networks and public transit infrastructure); and neighborhood design elements (including sidewalks, bike lanes, and building setbacks). Land use patterns will shape the physical distances between potential destinations and origins. Land use patterns and transport systems jointly

determine the accessibility to various opportunities, which then impact the distance, mode and frequency of trips. Neighborhood design, alongside the other two components, can shape people's selection of transport modes and make non-auto transport modes more desirable by making it easy and comfortable to travel by walking or cycling.

Features of the built environment and travel behavior

Density

One feature of the built environment that is considered important in shaping travel is density. Density is commonly measured by the concentration of population/households, employment, or dwelling units per given area of land (Ewing and Cervero 2010). Dense urban development can lead to shorter distances between origins and destinations, and is empirically associated with shorter trip distance, less automobile use, and lower VMT (Ewing and Cervero 2001, 2010; Ewing and Hamidi 2015; Stevens 2017).

Land use mix

The land use mix captures another important aspect of built environment that is considered critical in shaping travel, the level of diversity in land uses (residential, commercial, public, industrial) within a block, neighborhood or across a specific urban area. The land use mix is an indicator that measures the simultaneous and balanced presence of different land uses within a given area. The amount of different land uses is often measured by the land area, floor area, and/or employment (Ewing and Cervero 2010), based on which some metric is then calculated to reflect the extent of land use mix. Neighborhoods with mixed land uses enable the residents to access various amenities within a short distance and fulfil multiple needs without having to travel far. Mixed land use decreases the distance of trips. It also enables people to do various activities within one location,

thus increasing the likelihood of trip chaining and reducing the total amount of travel. It also promotes walking by enriching pedestrian experiences. Various empirical studies have confirmed the association of mixed land uses with reduced vehicle miles traveled and increases in non-motorized modes of travel, such as walking and public transit (Ewing and Cervero 2010; Stevens 2017). A common measure of land use mix is the entropy-based index (Frank and Pivo 1994). For a given geographical unit (e.g., a census tract, a traffic analysis zone, or within a quarter mile of the household), the entropy value (H) of this specific area is measured by the equation below:

$$H = -\sum (P_j * ln\, P_j)$$

where P_j represents the percentage of each land use type j within the area. When operationalizing land use mix, the size of the geographical units defined and the types of land use considered are important and can influence the strength of association found between land use mix and travel (Duncan et al. 2010).

Spatial distribution of opportunities relative to the population

Another important dimension of the built environment is the spatial distribution of opportunity locations relative to the population. Proximity to destinations is associated with shorter trip distances and encourages non-automobile transport modes. Some measures include job-housing ratio, distance to downtown/central business district, and distance/gravity-based access to jobs and retail stores (Ewing and Cervero 2010). Also, when job-housing balance is coupled with good access to retail opportunities, it increases chances of trip chaining, such as a small detour along the way from work to home to pick up a loaf of bread, and results in further reduction in the total distance traveled (Cervero and Duncan 2006).

Street network connectivity

The connectivity of the street network impacts the actual distance that people have to travel. Compared with a dense grid network in a traditional urban neighborhood, a suburban curvilinear system with loops, curves, and cul-de-sacs will significantly increase trip distances. With the transition from traditional dense grid streets to the curvilinear system, non-auto modes are also inhibited. A common measure of street network connectivity is the density of intersections and 4-way intersections in particular, which is often associated with reduced annual household VMT and more walking and biking trips (Ewing and Cervero 2010; Ewing and Hamidi 2015).

Access to transit

Better access to bus stops and rail stations makes it convenient to utilize public transit and is found empirically to be associated with higher frequency of trips by public transit and lower VMT (Ewing and Cervero 2010). Access to public transit is often measured as the distance from home to bus stops or subway stations, or the distance from public transit stations to the workplace.

Neighborhood design

Additionally, elements of neighborhood design influence travel through promoting alternative transport modes to the car, specifically walking and cycling, by creating a safe, comfortable and pleasing environment. Continuity of sidewalks and bicycle lanes, minimal barriers, small building set-backs, street lighting, and attractive places such as park trails, greenery, and architectural diversity can influence the extent to which people will walk, bike and/or spend time in public spaces (Vojnovic 2006).

Overall, different features of the built environment are not independent from each other, but rather highly correlated (Ewing and Cervero 2001; Handy 2017; Krizek 2003). High density, mixed land use, highly connected streets, good public transit service and pedestrian-friendly design are often found simultaneously in traditional, pedestrian-oriented urban neighborhoods. Given the coupling nature of various built environment features, instead of measuring different features independently, some studies compare types of neighborhoods directly, e.g. urban vs suburban, pedestrian- and transit-oriented vs auto-oriented, and high-density urban vs high-density suburban vs low-density suburban (Ewing and Cervero 2001; Vojnovic et al. 2014). In traditional urban neighborhoods, trip distances tend to be shorter, and residents are less reliant on the car (Ewing and Cervero 2001).

Meta-analyses of empirical studies have shown that each feature's individual effect on travel behavior tends to be small or marginal (Ewing and Cervero 2010; Stevens 2017). Yet, this does not mean the built environment is not important for travel. The different features of the built environment are often co-present in neighborhoods and hard to isolate (Ewing and Cervero 2001). Some features enhance each other in their effects on travel behavior - for example, the effects of mixed land use tend to be more pronounced in high-density settings (Ewing and Cervero 2001). Thus, the aggregated effects from changes of the built environment on travel behavior can be substantial (Ewing and Cervero 2010; Handy 2017).

While the relationship between travel behavior and the built environment has been extensively studied, these studies were typically conducted in economically robust and dynamic urban areas. Segregated, declining inner-city neighborhoods in the U.S tend to be under-represented in travel behavior research. The mechanism of how the built environment affects travel behavior may not apply to these places due to the unique challenges of decline and disinvestment faced by local communities.

Causality and self-selection

A contested issue about the influence of built environment on travel is causality. It has been confirmed by empirical studies that all else being equal, residents living in neighborhoods with higher levels of density, land-use mix, connectivity, and transit accessibility tend to drive less than residents living in neighborhoods characterized by lower residential and employment densities, single-use zoning, disconnected street networks, and absence of transit (Cervero and Kockelman 1997; Ewing and Cervero 2010; Milakis, Efthymiou, and Antoniou 2017; Stevens 2017). However, this only demonstrates correlation, rather than causality. According to Singleton and Straits (2005), the establishment of causality involves not only statistical association, but also non-spuriousness, time precedence, and causal mechanism.

A challenge to establishing causality is that the statistical association between built environment and travel behavior may be due to the spurious effect of residential self-selection. Residential self-selection means that residents choose to live in certain types of neighborhoods where the built environment enables their pre-existing travel habits and preferences. In this sorting process, people who like biking or walking and prefer proximity to various amenities, live in high-density, mixed-use urban neighborhoods, while people who prefer to drive are likely to select housing in Low-density Suburbs, where the built environment is designed to accommodate car use. Thus, it is possible that travel attitudes, personal values and preferences shape travel, and thus changes in the built environment will not induce changes in travel patterns despite the statistical association between the two.

To address the self-selection problem, researchers have employed various methods, including controlling for variables of personal attitudes and residential preferences with cross-sectional data,

longitudinal/quasi-longitudinal studies that incorporate time dynamics, or qualitative interviews (Naess 2012). Empirical studies across different urban contexts have shown that changes in built environment do induce changes in travel patterns, even after controlling for the effect of self-selection. Ultimately, both self-selection and built environment are influential on travel behavior, but the built environment is recognized as maintaining a separate and significant impact on travel and pedestrian activity (Aditjandra, Cao, and Mulley 2012; Cao, Mokhtarian, and Handy 2009b; Goddard et al. 2006; Handy, Cao, and Mokhtarian 2005). Some have further argued that self-selection is in itself a demonstration of the influence of built environment on travel behavior and built environment here serves as an enabler for people to fulfill certain travel patterns (Næss 2014).

2.3.2. Neighborhood sociodemographic composition and travel behavior

The built environment is not the only neighborhood-level factor affecting travel behavior. The sociodemographic composition of a neighborhood could also be important in defining the unique residential environment the residents experience, which shapes their daily travel patterns.

Spatial mismatch theory argues that the suburbanization of jobs and the concentration of low-income racial minorities in inner-city neighborhoods has resulted in a separation of low-skilled jobs from low-income, black-majority urban neighborhoods, leading to longer commuting distances by the residents in these neighborhoods (Gobillon, Selod, and Zenou 2007; Kain 1992). Additionally, evidence has shown that disinvestment and decline in the city of Detroit also caused a spatial mismatch of the low-income black urban neighborhoods from daily amenities such as grocery stores and healthy restaurant options, increasing the amount of nonwork travel by residents living in such neighborhoods (Eckert and Vojnovic 2017; LeDoux and Vojnovic 2013; Vojnovic et al. 2014).

Moreover, the effect of the built environment on travel behavior could vary across neighborhoods with different sociodemographic compositions. Freeman et al. (2013) found that in terms of the amount of active travel (walking and cycling), residents living in high-income neighborhoods are more responsive to changes in neighborhood built environment than residents in lower-income neighborhoods. This holds even after controlling for individual-level sociodemographic characteristics.

2.3.3. Individual sociodemographic characteristics and travel behavior

Since the 1980s, researchers began to systematically explore the association between various dimensions of travel behavior and individual sociodemographic characteristics. One of the early attempts is Hanson and Hanson (1981). They examined the influence of sociodemographic factors on travel, by using disaggregated travel-diary data to generate a variety of measures of the individual's complex travel-activity pattern and then determining which sociodemographic characteristics are related to each of these dimensions of travel using regression analysis (Hanson and Hanson 1981).

Later, as more researchers focused on the impact of the built environment on travel, sociodemographic characteristics were typically included in such studies together with built environment features to explain travel (Cervero and Kockelman 1997; Dieleman et al. 2002; Ewing et al. 2015; Hong, Shen, and Zhang 2014; Sun, Wilmot, and Kasturi 1998). Sociodemographic characteristics were generally found to significantly influence travel patterns even after controlling for built environment characteristics. After extensive reviews of empirical evidence, Ewing and Cervero conclude that 1) trip frequency was primarily influenced by socio-economic characteristics and then to a lesser extent by the built environment, 2) mode choice and

VMT were affected by both socio-economic characteristics and the built environment, and 3) trip length was primarily influenced by the built environment (Ewing and Cervero 2001, 2010).

As the issue of transport disadvantage and the resulting social exclusion began to receive attention during the 2000s, researchers began to focus more specifically on sociodemographic characteristics to examine travel patterns by vulnerable population sub-groups, such as the elderly, women, low-income earners, minorities, and the disabled (Lee et al. 2018; Lucas 2012; Lucas et al. 2016; Pyrialakou, Gkritza, and Fricker 2016). The goal of such studies is typically to understand the travel behavior and transport needs of the vulnerable and to inform policymakers to ensure a broader meeting of transport needs, whether by infrastructure provision or regulation. For example, how do lower-income groups travel, what are their preferred transport modes, and do these vary by neighborhood context? Answers to these types of questions can help policy makers decide whether to provide more public transit service, in what areas specifically, or are there other needs in infrastructure provision or regulation to ensure efficient and equitable mobility (Mercado et al. 2012). In addition, some researchers - who focus on public health, physical activity and active travel (such as walking and biking) - emphasize the importance of encouraging active lifestyles among particular population sub-groups, such as the elderly (Winters et al. 2015) and children (McDonald 2008), to reduce obesity and promote travel safety.

One sociodemographic characteristic commonly included in travel behavior studies is income. Having a higher household income was found to be associated with more trips, longer trip distance, and more car use in the North American and UK contexts (Dieleman et al. 2002; Giuliano and Narayan 2003; Holtzclaw et al. 2002; Lucas et al. 2016; Roorda et al. 2010). Meanwhile, higher income people have a greater propensity to take social and leisure trips, compared with other trip purposes (Lucas et al. 2016).

Another factor that influences travel behavior is age. Some studies found that as people transition into adulthood, the frequency of trips and the total miles traveled increase, but as they enter old age, the frequency of trips and the total miles traveled drop (Mcguckin and Fucci 2018; Morency et al. 2011; Roorda et al. 2010).

The gender gap in travel behavior is prevalent and "extends across differences in income, marital status, age, housing tenure, parenthood, and location within the metropolitan area, and across occupation as well" (Crane 2007, p. 309). Empirical evidence in North America and the UK shows that when compared with men, women tend to make shorter trips in general; they also make fewer work commutes and leisure trips, while making more trips for shopping as well as personal and family care (Crane 2007; Lee et al. 2018; Lucas et al. 2016; Mcguckin and Fucci 2018). Once they start a family, women tend to bear more household responsibilities such as shopping for the family and chauffeuring the children, which tends to reflect traditional gender roles. Women with dependent children have more complex trips and tend to do more trip chaining due to their greater household responsibilities, which makes the access to a car and driving more important (Lee et al. 2018; Rogalsky 2010). Yet, lower-income women are more likely to take public transit than drive, due to the lack of access to a car (Lee et al. 2018; Mercado et al. 2012).

Race and ethnicity have not been as commonly discussed as other sociodemographic variables like age, gender and income in travel research, and it is not typically included even as a control variable. However, race and ethnicity, particularly in the US, are closely associated with socio-economic status and residential location, thus indirectly influencing travel behavior. Minority populations are more likely to have lower incomes, which in turn is associated with less travel and lower car ownership rates. Also, in the US context, and specifically the Midwest, due to the influence of suburbanization and historical patterns of segregation, lower-income minorities are more likely to

concentrate in declining urban cores, where they have poor access to amenities and have to travel longer distances to reach necessary daily destinations, as has been found to be the case in the city of Detroit (Vojnovic et al. 2014; Vojnovic and Darden 2013).

2.4. Summary

A review of the existing literature demonstrates that personal service travel and leisure travel are relatively underexplored in the travel behavior literature, and particularly in the context of segregated, declining urban neighborhoods in the U.S. Existing findings on how neighborhood-level built environment and individual sociodemographic factors impact travel behavior may not apply in these specific urban contexts. For a more complete understanding of travel behavior, there needs to be a thorough evaluation of the complex nature of personal service and leisure travel in the specific context of declining urban neighborhoods.

Chapter 3. A Background Introduction to the Detroit Region

The bankruptcy of the city of Detroit in 2013 captured international attention. The world's motor city, home of some of the biggest global automobile corporations, collapsed economically. For decades, the Detroit region has been dealing with pressures associated with the economic decline of the core, racial segregation, and extreme suburbanization since the 1950s. This section will briefly review the history of Detroit, analyze major factors behind its decline – including racial discrimination, class conflicts, suburbanization, and economic globalization – and then examine the current conditions across the region.

3.1. A brief history of Detroit and its suburbs

During the 1900s and 1910s, with the rise and clustering of major automobile companies – such as Ford, GM, and Chrysler – Detroit became a world center of the automobile industry. Responding to the labor demand and the economic boom being experienced in the North, Americans from the South, and particularly large numbers of African Americans, migrated to Detroit for job opportunities. This Great Northern Migration of blacks from the South started in the 1920s and continued for the following several decades (Sugrue 1996). This migration would supply Detroit with a labor force that would enable it to reach its pinnacle as an industrial powerhouse during the 1940s. During World War II, Detroit received great amounts of funds from the US government for defense manufacturing. Detroit's manufacturing industries prospered, and the local economy peaked during wartime and in the immediate post-WWII years (Sugrue 1996).

However, throughout the second-half of the 20th century, Detroit suffered from economic decline and racial and class conflicts. In the 1950s and 1960s, due to the automation of auto industries, the decline in the demand for military production, and the relocation of factories to the suburbs in

pursuit of lower taxes and cheaper labor and land, the demand for labor, especially low-skilled labor, dropped significantly in the city of Detroit (Sugrue 1996). This created a class of unemployed, mainly African Americans, in the city (Sugrue 1996). Long-time racial segregation in the housing market and discrimination in hiring trapped the City's African American population throughout its declining neighborhoods (Sugrue 1996). The tension between poor urban blacks and well-off white urban residents broke out and resulted in the 1967 riot (Sugrue 1996). Triggered by the riot, large groups of white upper- and middle-class residents left the city for the suburbs, a process that became known as "white flight" (Sugrue 1996). This suburbanization throughout the 1960s was also facilitated by highway construction and FHA policies which supported suburban housing mainly occupied by whites (Vojnovic and Darden 2013). While the Detroit suburbs prospered during the post-World War II period, the city rapidly declined, facing concentrations of high poverty, crime and unemployment rates (Sugrue 1996). In the 1970s and 1980s, Detroit's economy was further impacted negatively by globalization processes and the ongoing industrial restructuring across the American rustbelt. As a result, Detroit continued to experience extensive job losses as manufacturing left the city, the state and even the country.

With its historical burden of racial and class segregation, combined with a significant loss of tax base due to the urban disinvestment, the city struggled for decades before finally filing for bankruptcy in 2013. Once among the richest places in the US, Detroit now stands out as a city with high poverty and unemployment rates (Darden and Thomas 2013, Sands 2015). After the bankruptcy, there have been public and private efforts to revive the city and positive improvements have been made (Reese et al. 2017). However, while the downtown and midtown areas have seen improvements, the city overall is still suffering from continued decline (Reese et al. 2017; Vojnovic et al. 2016).

With tremendous population loss, a concentration of poverty, vacant urban lands, and reductions in tax revenues, the city is now unable to maintain the basic municipal amenities in a sparsely populated urban area. Retailing and other commercial businesses have also left, leaving fewer jobs and less access to amenities for basic daily needs for the local residents (Vojnovic et al. 2014).

Looking at the city's demographic trends, the urban disinvestment and the decline experienced in the city of Detroit is coupled with high concentrations of visible minorities, and particularly African Americans, since the 1950s (Figure 3-1). In 2010, the population shrank to only a fraction of what it used to be, with a loss of over a million people since its population high point, which was reached around 1950. The drop in the percent of white population reveals the scale of white flight out of the city into the suburbs. In contrast to the decline of the city of Detroit, the surrounding suburbs still fare relatively well in terms of population (Figure 3-2). The suburban population has been increasing steadily since 1950, coinciding with the population flight from the city of Detroit. This is just one of the many cases of the American population exodus from the cities to the suburbs, which was evident nationally in the post-WW II years, but Detroit could be considered as the quintessential example (Muller 2004), with a tremendous population drop and extreme racial/class segregation evident across the region.

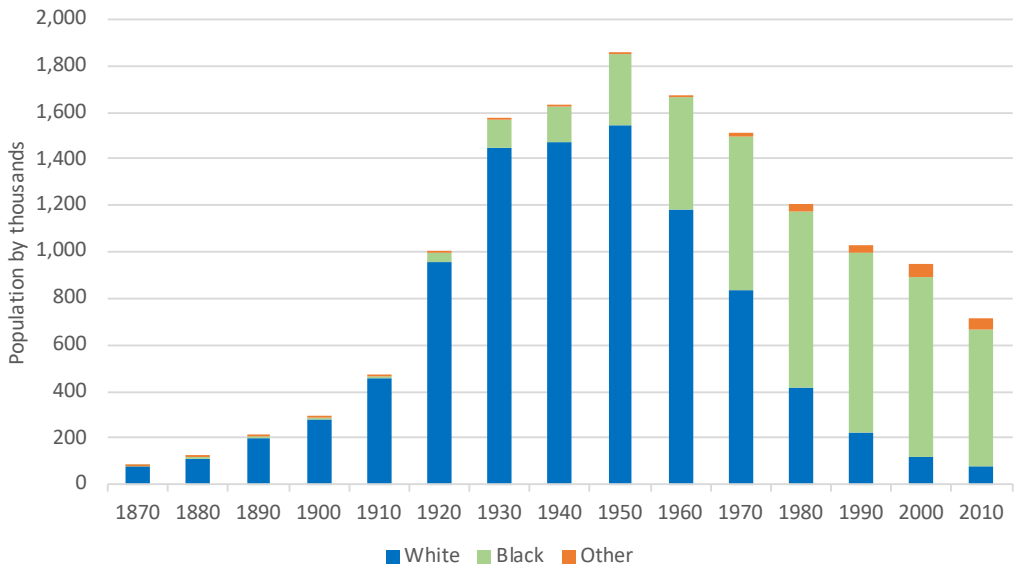


Figure 3-1. Demographic changes in the city of Detroit from 1870 to 2010

Source: US Census

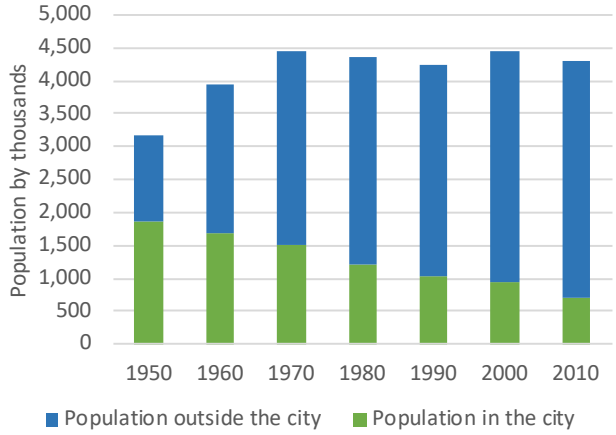


Figure 3-2. Population changes of Metropolitan Detroit (Detroit-Warren-Dearborn MSA)

Source: US Census

3.2. Factors behind the decline of the city of Detroit

Many forces contributed to the urban disinvestment and decline in the city of Detroit. Here I will analyze three major factors, including suburbanization, historical racial discrimination, and global economic restructuring. These factors resulted in a rapid population loss, especially of whites, and

an associated tax base exodus out of Detroit, leading to the decline of the city. Here I will discuss each of these processes separately, recognizing that these forces are closely intertwined in the shaping of Detroit's history.

3.2.1. Suburbanization

Suburbanization in Detroit resulted in the migration of population, mostly white middle-class, from the city of Detroit to the suburbs. Suburbanization itself is a complex process driven by various factors. The first factor driving the suburbanization process is the mobility provided by the wide diffusion of affordable automobiles. In 1913, Ford Motor Company developed the auto assembly line and began to produce automobiles on a much larger scale and at much lower cost. Cars began to enter the daily life of working-class American families. The greater mobility facilitated the decentralization of the population from the urban core.

But the decentralization didn't happen at a large scale until the post-WWII era, when the federal government started the massive construction of the interstate highway system after 1945 (Vojnovic 2009). With the highway system, it became much easier and faster to commute between the city and the suburbs. As a city dominated by the auto industry, Detroit was ahead of the process of road infrastructure construction. Detroit began as a leading city with its road construction for automobiles in the early twentieth century (Martelle 2012). Beginning in late 1940s, the city of Detroit had highway construction projects at the expense of razing black neighborhoods, believing that it would facilitate urban development (Sugrue 1996). Along with the increasing wealth of households, and the drop in the real price of gas, massive outflow of population into suburbs ensued (Vojnovic 2000, 2009; Vojnovic and Darden 2013).

Another important factor in facilitating rapid post-World War II suburbanization is federal government housing policies. Before the suburbanization experienced during the second-half of the 20th century, cities suffered from over-crowding, insufficient housing and poor living conditions. The post-WWII baby boom and increasing income intensified the demand for single-family housing. The government was motivated to ease congestion within the urban core and accommodate the increasing housing demand. The federal government agency for housing – Federal Housing Agency (FHA) was set up to subsidize house mortgages in the 1930s. The 1949 Housing Act further expanded the FHA's influence by providing federally supported mortgage insurances. FHA policies favored suburban development and enabled many, including working-class families, to purchase homes in the suburbs (Vojnovic 2000, 2009). Suburban infrastructure was also subsidized to support the low-density housing (Vojnovic 2000, 2009). The relative abundance of cheap rural land also facilitated these rapid suburban development patterns (Vojnovic 2009).

Yet another crucial factor in shaping suburbanization across the Detroit region are the local racial and class tensions. Triggered by slowing economic growth in the South and the great success of the economy in Detroit, large numbers of African Americans, who were often poor and less educated, came to Detroit to seek new opportunities (Sugrue 1996). The influx of blacks competing for jobs and housing generated resistance from the whites in the city, eventually leading to the 1967 Detroit Riot, which accelerated the white flight from the city (Sugrue 1996). With cheap access to automobiles, and efficient road systems connecting the suburbs and the city, white upper- and middle- class residents readily moved to the suburbs of Detroit to enjoy their upscale suburban enclaves, which maintained a generally more homogenous racial and class composition, and lower tax rates, while at the same time, some continued to hold on to their jobs in the city (Darden et al.

1987; Darden and Thomas 2013; Sugrue 1996). The particular nature of white flight means that minority populations and the poor are left behind – or more appropriately, trapped – in the city.

3.2.2. Racial and class discrimination

The suburbanization process across the Detroit region did not have equal impacts among the white and black populations. Due to residential segregation in the early and mid-twentieth century, the black population had limited access to suburban housing. First, discriminative lending practices by both public and private sectors denied blacks, and other minorities, access to mortgages and opportunities for home ownership; even after the 1968 Fair Housing Act was enacted, subtle discrimination with pronounced impacts persisted (Vojnovic and Darden 2013). Second, it has been recorded that when some black families tried to move into certain white neighborhoods, strong resistance came from local residents who wanted to keep a racially homogenous neighborhood (Sugrue 1996). Third, suffering from discrimination in education and employment, Detroit's black population had generally lower incomes and resources, creating an interaction of disadvantages due to race and class. Most of the city's black population were not able to purchase suburban homes and had limited housing choices. In the suburbs, exclusionary zoning was also practiced to keep the properties more expensive than what low-income earners could afford (Vojnovic and Darden 2013).

Therefore, while the whites moved to the suburbs, the city's black population was left behind in the city. Consequently, as the second-half of the 20th century progressed, black neighborhoods with high poverty rates, low levels of home ownership, and substandard housing conditions began to increasingly characterize the city, in large part as a result of discrimination and racial and class segregation practices (Sugrue 1996). The divide between white power in the suburbs and black

political power in the city limited progress in racial integration and the potential to solve urban problems (Darden and Thomas 2013).

3.2.3. Economic restructuring

As implied by its nickname, the 'motor city', the economy of Detroit was powered by the automobile industry. Automobile manufacturers enjoyed tremendous success during the golden years of the industry. But the heavy reliance on the automobile sector made the city vulnerable to shifts in the industry and to the precarious global market, particularly following the growing acceptance of neoliberalism, and its push for policies promoting deregulation and free trade. The shifts in the auto and broader manufacturing industries resulted in large job losses, and a resulting tax revenue erosion, which greatly contributed to the decline of Detroit.

Widespread automation in the auto industry eliminated large amounts of low-skilled jobs. Motivated to reduce production costs and the vulnerability to unions and labor strikes, Ford and other auto makers had been exploring the introduction of highly automated machinery since the 1940s (Sugrue 1996). The transition from assembly line to automation during late-1940s and into the 1950s enabled a few large auto makers to produce more with fewer workers. This automation also forced many suppliers and small auto makers out of business, leading to additional job losses in the auto sector (Sugrue 1996).

In addition, over time, factories had relocated from the City of Detroit to the suburbs, then to other regions across the US – such as the South, with weak unions – and eventually even out of the country, in pursuit of cheaper lands and labor (Sugrue 1996). This resulted in an extremely high unemployment rate within the city, which was historically highly dependent on this one industry. But conditions became even worse with the growth of foreign competition. During the 1970s,

Detroit auto makers began to face strong competition from foreign auto makers, and particularly from Japan. The oil crisis made American cars unattractive compared to Japanese cars, which maintained better fuel economy. Responding to foreign competition, Detroit auto makers survived by cutting costs at the expense of workers (Darden and Thomas 2013). When manufacturing jobs dropped, it impacted Detroit much more than other northeastern areas such as Chicago and Pittsburgh, whose economies were much more diversified (McDonald 2014). Over the decades that the auto manufacturers remained dominant in the region, Detroit failed to develop new industries that would serve as a stimulus for new growth (Farley et al 2000, p. 59).

Lastly, federal and state policies also facilitated the economic decline of Detroit city. In the 1950s, the defense funding for manufacturing left Detroit for the South (Sugrue 1996). The important role of defense contracting can be exemplified by economic growth in the states of Texas, Arizona, and California. Also, the federal and state governments had reduced financial help for the city over the decades. At the national level, the Reagan government curtailed urban programs and reduced aid to cities (DiGaetano and Klemanski 1993; Vojnovic 2007). Regionally, the state government had also enacted significant cuts of its public funding to the city of Detroit, leaving the city relying on its own dwindling resources (Sugrue 1996).

Today, GM's and Chrysler's headquarters remain in the city, but the number of jobs offered by the management section is small compared to the large labor force the auto industry used to employ in the city in the immediate post-WWII years. The Detroit region as a whole still has a large concentration of global and regional headquarters for auto design, engineering and management, but most of them located in the Detroit suburbs, and not the city (Sturgeon, Biesebroeck, and Gereffi 2008). To name a few, Ford's headquarters sit in Dearborn, Toyota has a regional center for Design and R&D in Ann Arbor, and Nissan's regional technical center is in Farmington Hills.

They provide well-paid professional jobs in the suburbs. This further contributes to the sharp divide between the city and its periphery.

Throughout the different periods and processes of economic restructuring, the city of Detroit's black population was particularly heavily impacted. They were among the first to be laid off when the companies made decisions to cut the labor force (Sugrue 1996). In addition, automation and the relocation of factories heavily reduced the middle-income manufacturing positions within the city. The loss of employment opportunities severely crippled the city's increasingly pronounced, and trapped, black population.

3.3. Concluding commentary

The coupling impacts of suburbanization, racial and class discrimination, and economic restructuring have led to a tremendous loss in Detroit's population, leading to highly concentrated poverty, unemployment, abandoned houses and vacant lands, and drastically reducing the city's tax revenues. Facing these challenges, the city has had increasing difficulties delivering even basic public services, such as education, police protection, fire control, street lighting and snow removal.

The process of decline itself is self-catalyzing (McDonald 2014). As the city began to decline, more people began to leave Detroit, at least the whites. The sharp drop in the urban core left empty houses behind. Property values fell by 77% in constant dollars in the half century since 1960s (Sugrue, 2014, p.xvi). The erosion of tax base means the city is now unable to maintain the basic municipal amenities in a sparsely populated urban area. Retailing and other commercial businesses have also left, leaving fewer jobs and less access to amenities for basic daily needs for the local residents (Vojnovic et al. 2014). This caused more people to leave and in turn led to more disinvestment and deterioration.

The background of urban decay, and the sharp contrast between the city and the suburbs across the Detroit region, make it a valuable case for examining travel across neighborhoods with different built environments and sociodemographic compositions. It is recognized in the existing research that the planning and design of low-income communities, and the understanding of the interrelationship between the urban built environment and travel behavior – and particularly when it comes to personal service and leisure travel – is underrepresented in existing research (Lee et al. 2018; Vojnovic 2006; Vojnovic et al. 2014). The study focused on personal service and leisure travel across the Detroit region in this dissertation will help fill this gap.

Chapter 4. Study Site and Data

4.1. Study site

The study site of this dissertation includes six neighborhoods across the Detroit region (Figure 4-1). There are multiple ways to define the extent of the Detroit region, which covers the city and the surrounding areas that maintain functional relationships. In this study, I employ the definition of the region by the Southeast Michigan Council of Governments (SEMCOG), which consists of seven counties of Wayne, Oakland, Macomb, Monroe, St. Clair, Washtenaw, and Livingston. Within this region, six neighborhoods are selected to represent three distinct types of built environments.

The selected six neighborhoods are two lower-income and high-density urban neighborhoods in Detroit city (Detroit 1 and Detroit 2), two upper-income high-density suburban neighborhoods in Ann Arbor and Birmingham, and two upper-income and low-density suburban neighborhoods in West Bloomfield and Bloomfield Hills (Figure 4-1). Each of the six neighborhoods is around 4 square miles.

These neighborhoods vary from each other in terms of built environment characteristics and racial and socio-economic composition. The selection of these neighborhoods enables comparisons of travel behavior for personal services and leisure destinations between urban and suburban communities consisting of both high-density and low-density neighborhoods. The selection also includes highly segregated lower-income communities confronting severe disinvestment and decline, which are relatively underexplored in the literature of community design and travel behavior.

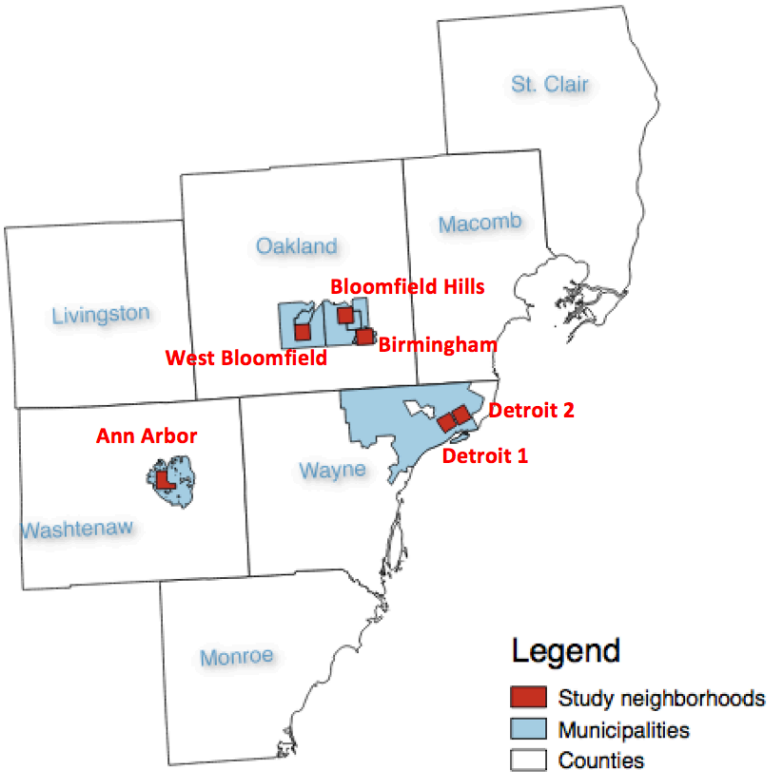


Figure 4-1. The six neighborhoods surveyed in the Detroit region as defined by SEMCOG

4.2. Data collection

A stratified random mail survey collected data on travel behavior and health among residents in the six selected neighborhoods in the Detroit region. It was conducted during the second half of 2008 with responses collected into early 2009. In total, 1,191 survey responses were received, a 20% response rate, which is considered good for a mail out survey to the general population (Sommer and Sommer 1997). The two high-density urban neighborhoods in eastside Detroit yielded the lowest response rates, compared with the other four neighborhoods. It is not a surprise given that these two neighborhoods have high poverty and high crime rates, lower education levels, and have generally shown distrust of public institutions. Considering a similar response rate of 19.8% for the 2009 National Household Travel Survey (Federal Highway Administration 2011),

a 20% response rate in this survey of travel behavior is good. Nonetheless, with the relatively low response rate, caution should be used when generalizing the results to the whole population. It should be recognized, however, that the data were validated by comparing the survey data with data from 2010 census tracts that contained the study neighborhoods in terms of demographic characteristics, with the sources showing comparable demographic compositions (LeDoux and Vojnovic 2013).

The survey asked the participants various questions regarding sociodemographic characteristics, travel behavior, diet, health, and perception of their neighborhoods. As to travel behavior, the survey specifically asked about a respondent's travel activities in a typical week. This reduces the instability of responses due to week-to-week variance. By asking people about their trips in a typical week, this dataset has the strength of preserving regular trips which are important to the individual and providing a picture of what people typically do. For example, spending two weekends a year on Lake Michigan would, in all likelihood, not be captured in the survey.

Since the household addresses of respondents were known, the starting points of trips were known. In addition, while participants were asked for perceived distances between destinations, names of destinations and addresses or major intersections were also collected. All the destination locations were found through site surveys and mapping programs and then recorded. This allowed all starting and end points of trips to be identified, a total of well over 15,000 weekly trips. Having starting and end points of trips allowed all trips to be referenced through Google Maps that determined the shortest time route distance. By geocoding all households and their end-point destinations, this approach to calculating distance reduced errors associated with self-reported distances, which were significant. This practice was seldom carried out in travel behavior research

at the time of data collection and is not always used even today. It provided improved accuracy of distances traveled than only relying on self-reported distances traveled.

This dissertation uses the part of the survey on travel behavior for personal services and leisure activities, along with the associated sociodemographic data. In the section for personal service trips, the survey asked what personal services the respondent went to in a typical week. Some examples of personal services were listed to give a sense of what counts as services, including dry cleaner, beauty salon, church, pharmacy, and so on. In the section for leisure trips, the survey also asked where the respondent go most often in a typical week, in their free time, such as coffee shop, bar, mall, friend's house, and so on. For each trip, the purpose, location, distance from home, and frequency by travel modes were recorded. From the survey, personal service and leisure travel constituted a significant share of total travel (37.4% by frequency) among residents across the Detroit region.

Since the data collection in 2008, people nowadays use online banking and shopping more often and take less trips to banks/ATMs and local stores, especially among younger and higher-income population groups. Thus, the relationship between the frequency of shopping and banking trips with individual factors might have changed since 2008 and thus should be interpreted with some caution. Travel behavior for services other than banking and shopping, such as health and social services, pharmacies, maintenance, or religious places, as well as leisure activities, should not be impacted as much by the growth of internet and mobile apps, since these activities often require physical presence. Therefore, the 2008 Detroit survey data should still bring valuable insights to the current understanding of travel behavior and serve the purpose of this dissertation sufficiently.

One limitation of the data from the Detroit travel survey is that information on trip chaining was not collected. This means that if someone made a stop for pharmacy on her/his way to grocery shopping, these would be captured as two separate trips in the data. To collect information on trip chaining, travel diaries which detailed the daily trajectory of the respondent would be needed. This would be difficult to practice with Urban Detroit residents, who maintain a high institutional distrust. Instead, the survey asked for destinations visited in a typical week, without asking the residents to record every single move throughout the week in detail. This was a necessary trade-off in order to collect enough information on travel patterns of residents in disadvantaged communities, who were less likely to respond to on surveys.

Besides the mail-in survey on travel behavior and health, site surveys were also carried out in the neighborhoods, collecting data on building types (single family homes, duplexes, apartments, and factories), land uses (residential, commercial, retail, and industrial), and abandoned buildings. All were recorded and mapped, see **Error! Reference source not found.**. The site surveys show that urban Detroit neighborhoods and the high-density mixed use suburban neighborhoods of Ann Arbor and Birmingham have comparable high levels of building and road intersection density, while the low-density suburban neighborhoods of Bloomfield Hills and West Bloomfield have much lower building and road intersection density (Table 4-1).

Table 4-1. Land use density in the six neighborhoods in the Detroit region

	Detroit 1	Detroit 2	Ann Arbor	Birmingham	Bloomfield Hills	West Bloomfield
Buildings per sq. mi.	1794.3	1196.5	1690.8	1509.5	491.1	775.5
Intersections per sq. mi.	77.7	49.2	31.1	41.4	5.2	5.2

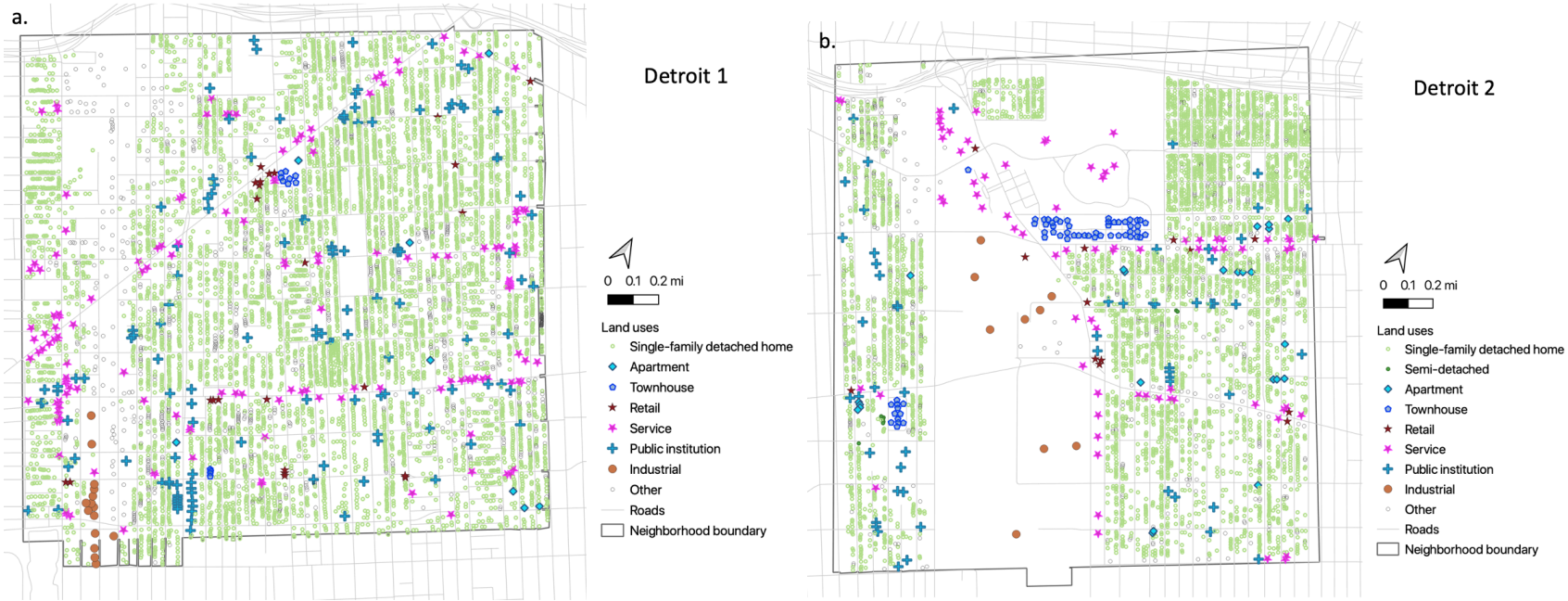


Figure 4-2. Land uses in the six neighborhoods of the Detroit region

Figure 4-2. (cont'd)

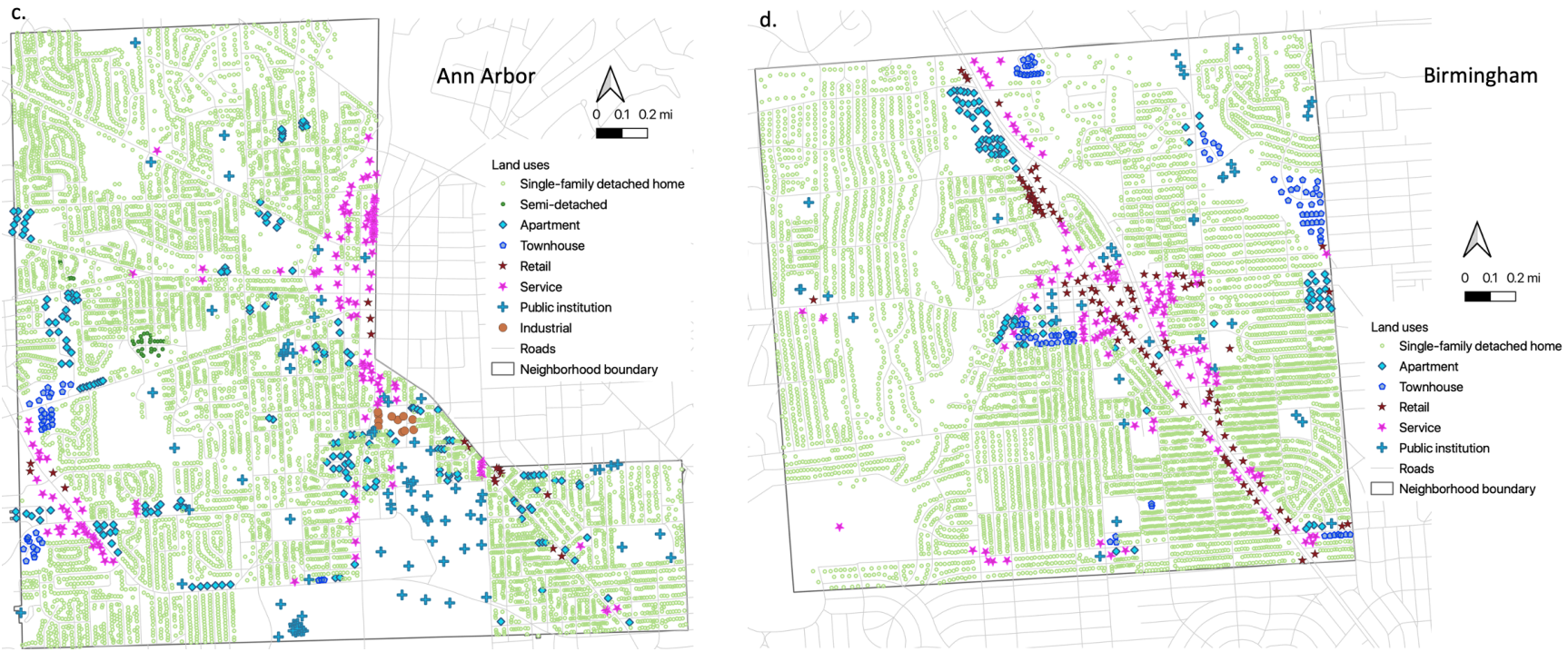


Figure 4-2. (cont'd)

In addition, a list of all pharmacies in the Detroit region was compiled based on the ReferenceUSA Historic Business data for the year 2008 (Data Axle 2008). After cleaning, the final data contain 1087 pharmacies. This will be used to map the spatial distribution and accessibility to pharmacies, a key personal service, across the Detroit region.

4.3. Classification of trips by purpose

This study focuses on trips for personal services and leisure activities. While trips can be classified by the nature of the activity into three distinct purposes of work (mandatory, contracted), service (committed but flexible) and leisure (optional) (Ås 1978; Reichman 1976; Stopher et al. 1996), the boundary between service trips and leisure trips in reality is not always clear. Different respondents had different ideas about whether a trip was service or leisure, and this was reflected in their different decisions on what trips to list in the personal service trip section and in the leisure trip section. For example, some respondents put trips to church, library or the gym as personal service while others classified these trips as leisure. A consistent standard is needed to separate trips for personal service and for leisure. In addition, a classification system is necessary to further break these down into different types of personal service and leisure trips and compare the characteristics of each type of trip. For example, it would be important to distinguish personal service trips for health from those for personal care, such as going to a barber or a spa.

In the existing travel literature, there has yet to be a standard classification scheme for daily trips. There are multiple approaches evident in the existing studies. One common approach is to categorize by trip destinations using industrial classification systems such as SIC or NAICS and make modifications when needed (Chudyk et al. 2015; Scott and He 2012; Winters et al. 2015). Another approach is to categorize by trip destination solely based on the researchers' personal

judgment and the purpose of the study (Schlich et al. 2004); this makes cross-study comparisons difficult. A third approach is to define the types of trips by subjective motives such as enjoyment or maintenance, given that people attach different values to the same type of destinations. For instance, some visit the gym for enjoyment, while others might go there to maintain health. However, after reviewing previous classifications, Mokhtarian et al. (2004) argued that, in travel behavior studies, it is not always practical or necessary to account for the psychological differences and classify trips by subjective motives.

In this study, I adopted the first approach above and classified the purposes of trips based on the destinations, using an industrial classification system modified to accommodate travel behavior. I built a three-level classification system using the latest version (2017) of the North American Industry Classification System (NAICS). NAICS was designed and advanced as a better classification system to replace the SIC code during the late-1990s. Using the principle that similar production processes should be grouped together, it provides a consistent framework for the collection, analysis, and dissemination of industrial statistics (Executive office of the President and Office of Mangement and Budget 2017).

Trips were classified bottom up based on three levels. First, to what industry the trip destinations belonged to in the NAICS (level 1), then to what sector they belonged to in the NAICs (level 2), and then to the two main types of trips studied in this dissertation – personal service and leisure (level 3). At level 1, each trip was coded according to the nature of the trip destination and what industry it belonged to in NAICS. Each type of trip corresponded to an industry in NAICS. At level 2, trips were classified into broader groups based on what sector the trip destination belonged to, as specified in NAICS. Most trips were classified as such using NAICS. At level 3, the Level-2 broad groups were further sorted into two categories, personal service and leisure destinations.

The rationale of this distinction was that, in contrast to personal services, leisure activities are optional and not necessarily done for basic daily needs – they are free from work or other duties such as doing household chores or acquiring goods and services (Ås 1978; Stopher et al. 1996). Leisure is intended as relaxation, fun, or life enrichment. Therefore, among the level 2 broad groups, trips to financial service, health and social service, retail service, post office, maintenance, religious place and pharmacy were considered as personal service trips; other groups of trips, such as trips to the mall, library, drink and beverage, leisurely education activities, fitness, hobby, performance, recreation, and family and friends were considered leisure trips.

The NAICS classification, developed as an economic tool, does not serve the purpose of travel behavior studies perfectly. Therefore, some modifications were made to develop a classification scheme to better reflect the actual purposes of various trips. Modifications on the NAICS classification at level 1 are as follows. First, some trip destinations belonged to different industries in NAICS, but these trips were classified as one single type of trip, because the distinction of the industries was trivial for the purpose of this study. For instance, pet care visits and vet visits were simply coded as pet care. Second, the industry of 'Fitness and Recreational Sports Centers' covered all kinds of amenities for sports and is too broad for the study of leisure physical activity trips, so the trips that fell into this industry were coded into multiple types, e.g., trips for swimming were distinguished from trips for yoga. Third, some trips did not involve a specific economic activity, such as visiting a friends' home or dropping kids to school, and thus did not belong to any industry in NAICS. In these cases, specific codes were created based on the nature of these trips.

As to modifications on the NAICS classification at level 2, some sectors were too broad for grouping trips, and thus were broken down into finer groups. Instead of being grouped together, the trips that fell into the NAICS sector of 'Arts, entertainments & recreation' were divided into

four groups--1) fitness, 2) hobby, 3) performances and 4) recreation. Also, trips to religious destinations and to pharmacies were taken out from the NAICS sectors they belong to ("other service" sector and "retail trade" sector, respectively) and classified as two standalone groups, because of their special nature and dominant presence in the data. In addition, some trip types were joined to a group despite not being included in the corresponding sector in NAICS. This was done because the nature of these trips matched with the group from the consumption perspective. For example, movie theaters were listed in NAICS under the sector of information industries due to their specific production process, but for the purposes of this analysis, they were categorized into the group of trips for performances, which also included concerts, sport games and plays.

The entire classification system is described in Table A1 for personal service trips and Table A2 for leisure trips in the Appendix. The trips in the survey data were coded and classified accordingly. Some respondents gave no information for either personal service or leisure trips. These were excluded from the data as incomplete answers and not used in the analysis, unless a "N/A" was reported by the respondent, indicating a complete response with simply no personal service or leisure trips committed on a regular basis. After the classification, I got 1364 trip destinations for leisure and 1507 trip destinations for personal service journeys reported for a typical week by residents in the six sampled neighborhoods in the Detroit region.

4.4. Neighborhood sociodemographic composition

The six neighborhoods maintain considerable differences in demographic and socio-economic composition, as summarized in Table 4-2. In terms of gender, across all the six neighborhoods, there were more female respondents than male respondents. The response ratio between women and men was generally much larger than the census statistics for gender ratio by the larger census

tracts, where the neighborhoods were located. This could be explained by the fact that women are more likely to do the shopping and various household services, like taking children to a doctor/dentist, or going to a pharmacy to get medication for family members, and therefore are more likely to respond to surveys regarding these activities.

The survey limited respondents to those who were 18 years old or above. Detroit 2 neighborhood had the most young respondents (between 18 to 30 years old), followed by Ann Arbor and the Detroit 1 neighborhood. But Ann Arbor had the largest middle-age population subgroup (between 30 to 50 years old). The remaining three neighborhoods had a higher percentage of the elder population (50 years old and above) and a lower percentage of the young. The West Bloomfield neighborhood had the least young and middle-age respondents, and the most respondents above the age of 50.

As to the racial composition, the two Detroit urban neighborhoods (Detroit 1 and Detroit 2) demonstrated disproportionately high concentrations of nonwhites (mostly blacks), compared with the four suburban neighborhoods. Also, the high concentration of blacks was coupled with lower levels of education attainment and higher unemployment and poverty rates. About half of the respondents reported annual household incomes below $20,000. This stands in great contrast to the other four suburban neighborhoods and demonstrates the extreme poverty concentration in urban Detroit.

The inclusion of the two Detroit urban neighborhoods in this study will contribute to the understanding of travel behavior and associated factors in highly segregated and disadvantaged African American neighborhoods, which are understudied in the current literature (some

exceptions include Eckert and Vojnovic 2017; LeDoux and Vojnovic 2013; Vojnovic et al. 2014; Vojnovic, Ligmann-Zielinska, and LeDoux 2020).

Table 4-2. Characteristics of all respondents from the six neighborhoods by gender, age, race, education and household income (%)

	Detroit 1	Detroit 2	Ann Arbor	Birmingham	Bloomfield Hills	West Bloomfield
Gender (%)						
Female	72.20	76.60	65.00	58.20	57.40	57.10
Male	27.80	23.40	35.00	41.80	42.60	42.90
Age (%)						
18 to 30	7.20	14.29	11.68	4.17	3.92	2.59
30 to 50	29.60	31.17	44.67	32.81	28.43	27.98
50 and above	63.20	54.55	43.64	63.02	67.65	69.43
Race(%)						
White	5.00	10.64	93.68	94.18	91.63	84.21
Non-White	95.00	89.36	6.32	5.82	8.37	15.79
Educational Attainment (%)						
No high school	15.97	20.92	0.00	0.00	1.92	3.06
High school	52.10	50.33	9.62	10.77	8.65	10.20
2-yr assoc. degree	13.45	10.46	4.81	6.15	6.25	7.14
4-yr college degree	11.76	8.50	31.27	34.36	35.10	31.63
Graduate or professional degree	6.72	9.80	53.26	48.72	48.08	47.96
Household Income by Neighborhood (%)						
Less than 20k	45.37	54.01	7.06	2.45	2.22	3.64
20k to 40k	31.48	21.90	6.69	4.91	7.22	4.85
40k to 60k	10.19	13.87	15.24	9.20	8.33	9.70
60k to 100k	8.33	7.30	30.48	19.02	25.00	20.61
100k to 150k	4.63	2.92	24.91	26.99	20.56	32.73
Greater than 150k	0.00	0.00	15.61	37.42	36.67	28.48
Occupation(%)						
Stay at home parent	9.60	18.67	5.99	11.98	8.63	7.29
Employed	32.80	30.67	68.31	55.73	53.30	63.54
Student	6.40	4.67	6.69	0.52	1.52	1.04
Retired	37.60	30.67	17.96	28.65	35.03	25.52
Unemployed	13.60	15.33	1.06	3.13	1.52	2.60
Number of responses	98	120	252	156	167	153

Source: NSF survey data; responses with missing information were removed.

4.5. Trip characteristics by neighborhoods: Descriptive statistics

4.5.1. Trip destinations and trip frequency

Among all the respondents for all the neighborhoods, the top 10 most mentioned trip destinations were religious places, friends, pharmacies, malls, banking services and ATMs, cleaners, cafés, family members, and gyms. These places were also the top 10 most visited places by frequency.

For each respondent, the number of trip destinations and the total frequency of trips capture different aspects of travel. For example, if a respondent reported going to bank A (once a week), bank B (twice a week), and a local pharmacy (once a week), the number of personal service destinations for this respondent is 3, but the total frequency of trips for personal services is 4.

The reported numbers of trip destinations and the total frequencies of trips in a typical week were averaged by neighborhood and trip purpose, as shown in Figures 4-3 to 4-8. Figure 4-3 shows the average number of trip destinations for personal services and leisure activities reported in a typical week across the six neighborhoods. Figure 4-4 shows the average total frequency of trips across the six neighborhoods. Figures 4-5 to 4-8 display the average number of destinations and the average trip frequencies for different detailed purposes (the level-2 groups). Neighborhoods of the same type are represented with the same color.

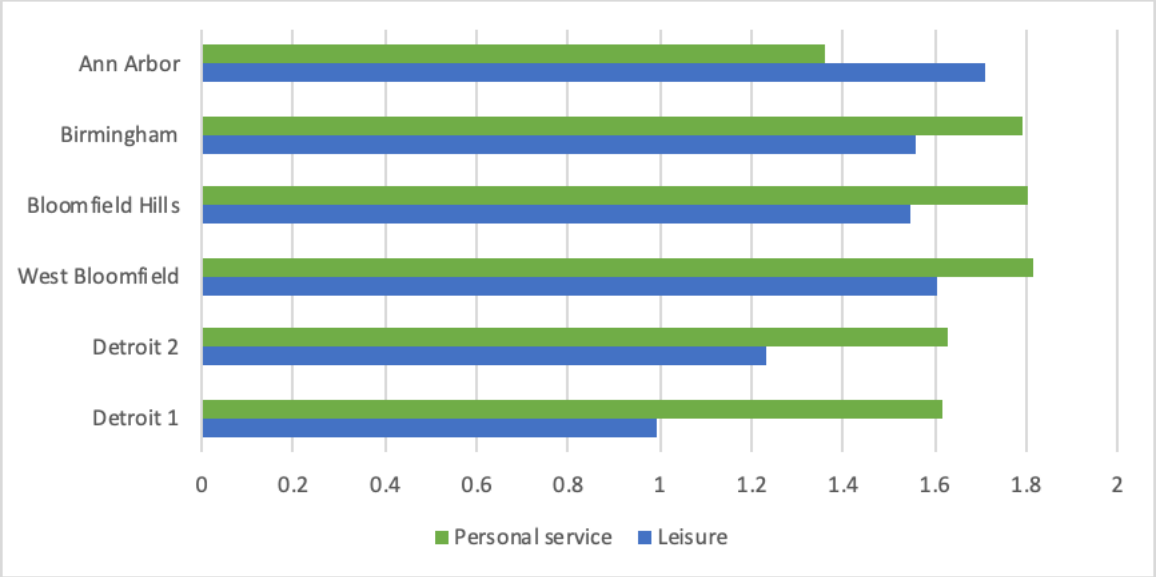


Figure 4-3. Average number of trip destinations reported for personal services and leisure activities per week per respondent, by neighborhood

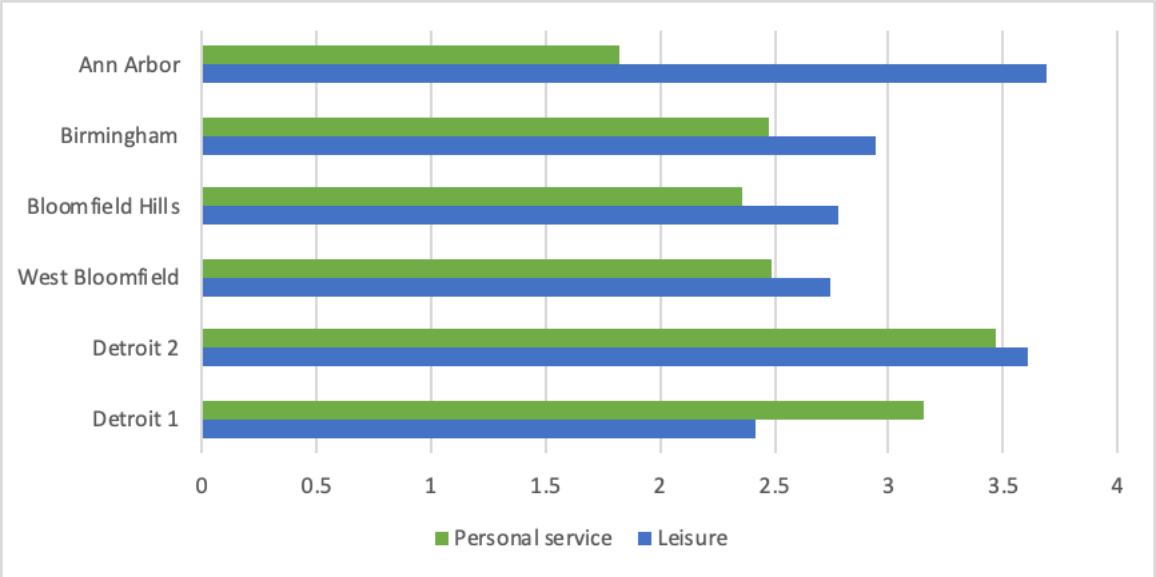


Figure 4-4. Average total frequency of trips for personal services and leisure activities per week per respondent, by neighborhood

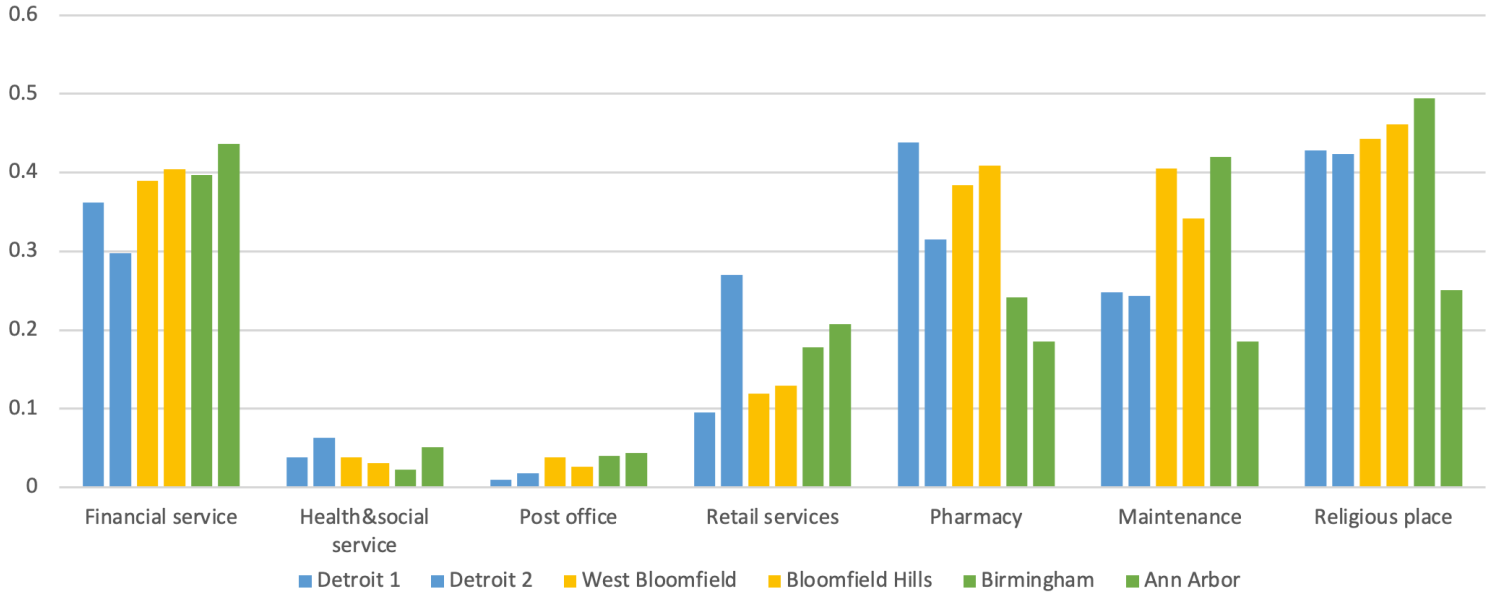


Figure 4-5. Average number of trip destinations for personal services per week per respondent, by level-2 detailed purpose and neighborhood

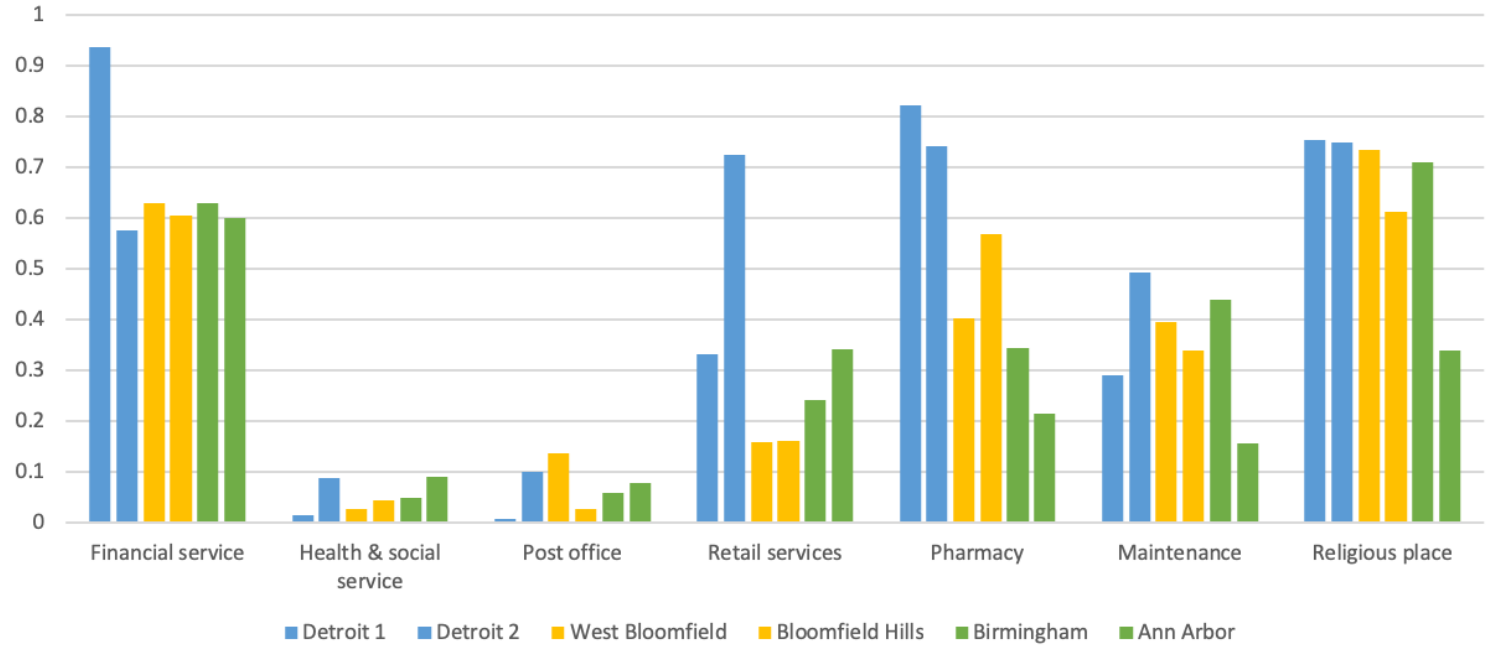


Figure 4-6. Average frequency of trips for personal services per week per respondent, by level-2 detailed purpose and neighborhood

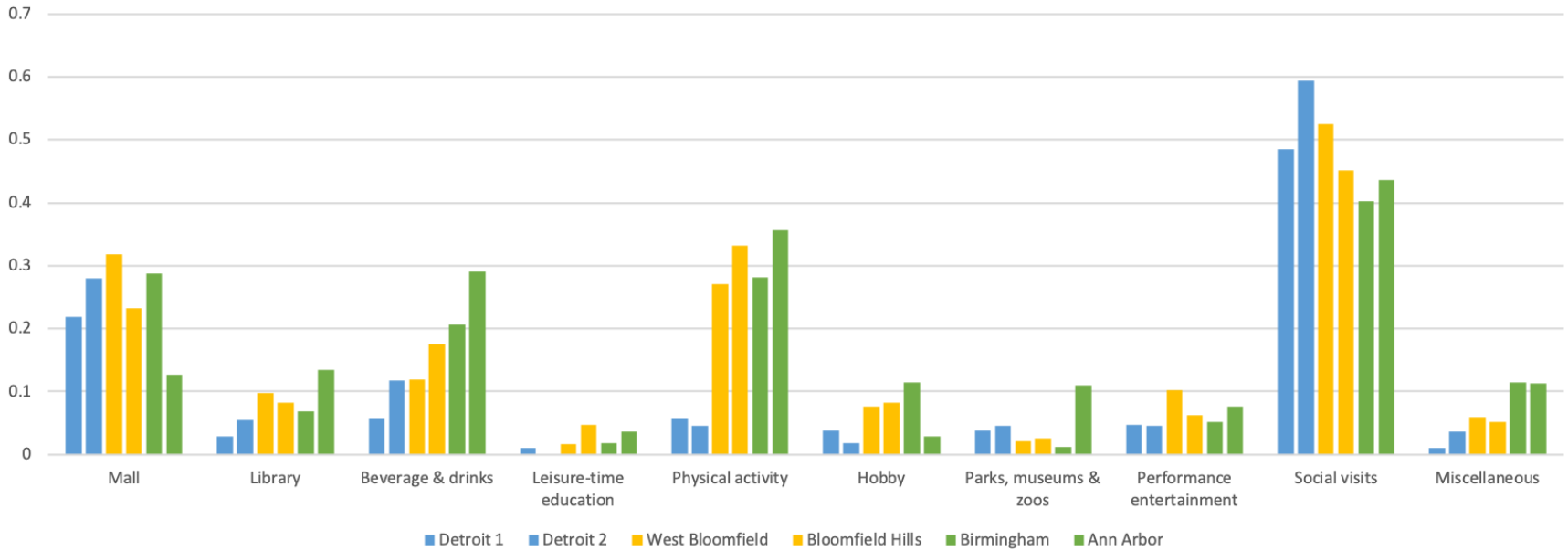


Figure 4-7. Average number of trip destinations for leisure activities per week per respondent, by level-2 detailed purpose and neighborhood

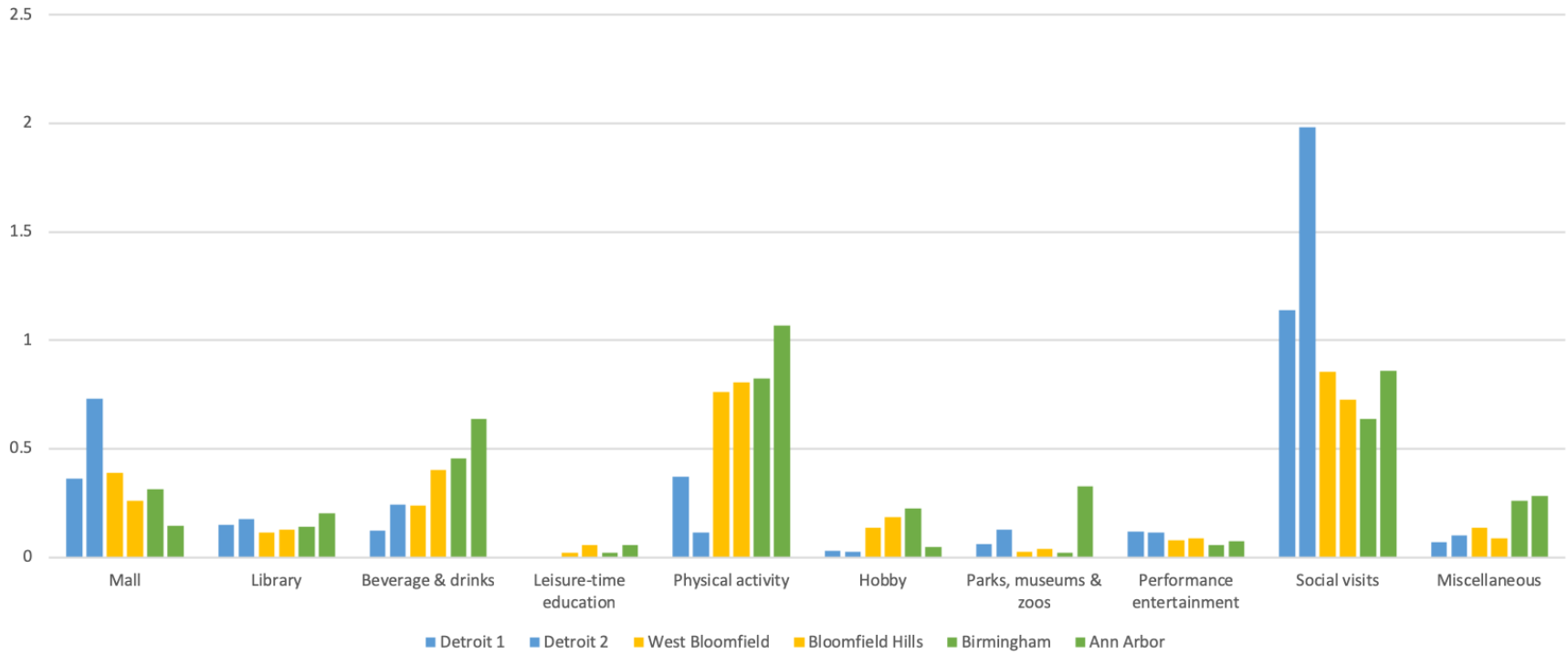


Figure 4-8. Average frequency of trips for leisure activities per week per respondent, by level-2 detailed purpose and neighborhood

High-density declining urban neighborhoods in the city of Detroit

The two neighborhoods located within Urban Detroit (Detroit 1 and Detroit 2) are adjacent to each other and represent the high-density urban neighborhood type. Overall, Urban Detroit residents visited the least leisure destinations when compared to residents in the suburban neighborhoods, and also, they went to fewer personal service destinations than most other neighborhoods (except Ann Arbor), as seen in Figure 4-3. One possibility is that Urban Detroit residents actively chose to go to less places among a diverse pool of opportunities. However, given the disinvestment and decline, caused by the exodus of businesses, a more plausible explanation is that Urban Detroit residents had limited choices regarding personal service and leisure opportunities. The trip frequencies show a different side of the story (Figure 4-4). While urban Detroit residents were likely to have limited choices, they utilized the limited pool of opportunities more often and made more visits per individual destination.

Among different types of personal service trips (Figures 4-5 and 4-6), Urban Detroit residents reported more frequent retail visits (various stores, excluding groceries) and more frequent pharmacy visits than residents in the suburbs. They went to fewer places for maintenance (e.g., personal care, cleaners and copy shops).

Among the different types of leisure trips (Figures 4-7 and 4-8), Urban Detroit residents made far more social visits, to see family and friends, yet otherwise made much fewer leisure trips of other types. They seldom went to physical activity destinations (such as gyms, tennis courts, and yoga classes), both in terms of the number of destinations and the frequency. They also went to the fewest places and had the lowest trip frequencies to destinations for beverage and drinks, leisure-time education, and hobbies (such as golfing or boating).

High-density suburbs of Ann Arbor and Birmingham

The residents in Ann Arbor and Birmingham—the High-density Suburbs—have a very different trip composition when compared to residents of the urban Detroit neighborhoods. Ann Arbor residents went to the fewest personal service destinations (Figure 4-3). The frequency of those trips was also the lowest (Figure 4-4). Specifically, they were much less likely to make trips for maintenance, pharmacies and religious places, by both frequency and the number of destinations (Figures 4-5 and 4-6). This may be related to the fact that Ann Arbor has a large population of young people, especially students, who have less demand for these services. On the other hand, Ann Arbor residents went to the most leisure destinations and visited these places most frequently, particularly libraries, recreation destinations (parks, museums and zoos), places for beverages and drinks, and facilities for physical activity (Figures 4-7 and 4-8). The one exception for frequently visited destinations by Ann Arbor residents were shopping malls, which they seldom frequented.

Compared to Ann Arbor residents, Birmingham residents engaged in fewer leisure trips and more personal service trips (Figures 4-3 and 4-4). They made more trips to religious places and for maintenance when compared to Ann Arbor residents. But they reported the least trips to friends and families and recreation places (parks, zoos and museums).

Low-density suburbs of Bloomfield Hills and West Bloomfield

The residents in Bloomfield Hills and West Bloomfield were similar to each other and to the residents in Birmingham in terms of the amount of service and leisure trips (Figures 4-3 and 4-4). Overall, they visited more places, but the trip frequency per place was relatively low compared to the other neighborhoods. As to specific types of trips, they tended to make fewer trips to retail

services (grocery and pharmacy excluded), health and social services and parks, museums and zoos in terms of the number of destinations and frequencies (Figures 4-5 to 4-8)

4.5.2. One-way trip distance and travel time

Table 4-3 summarizes mean one-way trip distance and travel time by trip purpose across the different neighborhoods. Across all six neighborhoods, trips for leisure were significantly longer and took much more time compared with trips for personal services. This demonstrates people's willingness to spend more effort to access distant leisure destinations as they seek out variety and novelty (Schlich et al. 2004).

As to neighborhood-level variations, the residents in the high-density mixed-land-use suburban neighborhoods of Ann Arbor and Birmingham had the shortest average distance and travel time of trips, compared with residents in the other four neighborhoods.

Despite the high densities and mixed land uses in the two high-density urban neighborhoods of Detroit, the mean trip distance of the Urban Detroit residents to personal services was similar to that of the residents in the Low-density Suburbs of Bloomfield Hills and West Bloomfield. The mean trip distance for Urban Detroit residents to leisure was shorter than for residents in the Low-density Suburbs but longer than for residents living in the High-density Suburbs.

Although Urban Detroit residents did not always travel the longest distances, they reported the longest travel time, even compared with residents in the Low-density Suburbs. One factor is their lower accessibility to both service and leisure opportunities and longer trip distances. Another factor is that the Urban Detroit residents had the highest percentage of trips using public transit and a low percentage of trips by driving (Tables 4-4 and 4-5).

Table 4-3. Mean distance and travel time of trips by neighborhoods.

Neighborhood	Personal service		Leisure	
	Distance	Time	Distance	Time
Detroit 1	3.7	12.8	6.8	18.5
Detroit 2	2.9	10.0	6.1	17.0
Ann Arbor	2.3	9.0	2.7	11.2
Birmingham	2.6	8.1	4.5	14.4
Bloomfield Hills	3.0	8.4	9.9	16.8
West Bloomfield	3.6	9.0	7.2	17.3

Note: The calculation of mean distance and travel time to trip destinations does not consider the frequencies of trips.

Table 4-4. Percentage of modal choices for personal service trips by neighborhood

Neighborhood	Total number of trips reported	% Driving	% Walking/Biking	% Public transit
Detroit 1	191	76%	12%	12%
Detroit 2	318	60%	27%	13%
Ann Arbor	485	71%	27%	2%
Birmingham	398	88%	12%	0%
Bloomfield Hills	370	94%	6%	0%
West Bloomfield	397	95%	5%	0%

Table 4-5. Percentage of modal choices for leisure trips by neighborhood

Neighborhood	Total number of trips reported	% Driving	% Walking/Biking	% Public transit
Detroit 1	177	72%	16%	12%
Detroit 2	264	59%	25%	16%
Ann Arbor	975	53%	46%	2%
Birmingham	473	80%	20%	0%
Bloomfield Hills	452	91%	9%	0%
West Bloomfield	536	85%	14%	0%

4.5.3. Trip mode

As shown in Tables 4-4 and 4-5, residents in the neighborhoods of Ann Arbor, Detroit 1 and Detroit 2 had high percentages of non-auto trips, followed by Birmingham. This supports the effect of high density and mixed land use on the selection of travel mode (Ewing and Cervero 2010). However, residents in these neighborhoods differed in terms of non-auto mode choices. People in Urban Detroit were the most likely to take public transit among the six neighborhoods, while people in Ann Arbor were most likely to walk or bike.

4.5.4. Summary of trip characteristics

The descriptive statistics have shown that residents in the different neighborhoods surveyed had different travel patterns. First, what trips people took and where they visited varied by the type of neighborhoods. Second, in terms of trip distance and travel time, built environments characterized by high densities and mixed land uses were associated with shorter one-way trip distances and travel time in the context of suburbs. However, this effect was not present for urban neighborhoods experiencing disinvestment and decline. Third, the neighborhoods characterized by high densities and mixed land uses – in Urban Detroit and the High-density Suburbs of Ann Arbor and Birmingham – were less dependent on automobile travel. However, within this context, while Urban Detroit residents tended to choose public transit, the residents in Ann Arbor and Birmingham were more likely to walk and bike to personal service and leisure destinations.

These travel patterns by purpose and by neighborhood, as reflected by the descriptive statistics, will be further examined and tested with statistical analyses in the following chapters. Chapter 5 will focus on one-way trip distances, Chapter 6 will examine weekly frequency and total distance

traveled, as well as mode of travel, and Chapter 7 will look at travel patterns to access pharmacies specifically.

Chapter 5. The Influence of Neighborhood, Sociodemographic Characteristics and Purpose on Trip Distance to Personal Services and Leisure Destinations

5.1. Introduction

As a central aspect of travel behavior, distance traveled can be measured in different ways. A widely used measure is the total distance traveled within a fixed time period (for example, a day, a week, or a month) by an individual, which is usually compared among residents in different built environments (Ewing and Cervero 2001, 2010; Kotval-K and Vojnovic 2015; Stevens 2017; Yang et al. 2018). Another important, yet less-focused-on measure, is one-way trip distance, which is the one-way physical distance people traveled from the origin to the destination in a trip, also termed as trip length (Ewing and Cervero 2001, 2010). Trip distance reflects how far people move in space physically to access what they need, capturing the dimensions of accessibility and mobility.

One-way trip distance (length) has been examined in the existing literature with the goal of revealing and understanding inequalities and inequities in travel. At the neighborhood level, the variation in mean trip distance was considered to reflect the variation in accessibility to amenities (Vojnovic et al. 2014). At the individual level, having low incomes, being single parents and being physically disabled were found to be associated with shorter trip distances, which is considered to indicate lack of mobility (Lucas et al. 2016; Morency et al. 2011). The variation in trip distance across age, gender, and income was also explored for trips of specific purposes, including commuting, social activities and leisure (van den Berg et al. 2011; Horner and Schleith 2012; Sang, O'Kelly, and Kwan 2011).

The city of Detroit has suffered from disinvestment, poverty, and racial segregation over the past seven decades. Compared with suburbanites in the region, Urban Detroit residents have faced losses of amenities and reduction in access to basic daily necessities due to urban disinvestment and decline, which is coupled with the burdens of poverty, particularly among the city's African American population (Vojnovic et al. 2014). Comparing trip distances across neighborhoods and sociodemographic groups in the Detroit region can help us understand inequalities in accessibility and mobility in people's daily life, particularly in the context of urban decline.

In this chapter, I examine patterns of one-way distance (length) of nonwork trips to personal services and leisure destinations[2], with a focus on residents in urban and suburban neighborhoods across the Detroit region. The term *trip distance* is used to exclusively indicate one-way distance from origin to destination for trips throughout the chapter. In this chapter, I address three research questions – 1) how trip distances vary by neighborhood type, trip purpose and sociodemographic characteristics of residents; 2) how the influence of neighborhood type on trip distances varies by

[2] In this chapter and the following chapter, the personal service trips explored include maintenance (e.g., cleaners and barbers), financial services, health services, pharmacy, postal office, religious place, and retailing (e.g., bookstores, video stores, office stores, electronics stores, music stores and clothes stores). The leisure trips explored here include social visits, bars and coffee shops, leisure education, hobby (e.g., golfing, bowling, playing cards, and choir), library, mall, physical activity, performance, recreation (e.g., parks and museums), and other miscellaneous leisure trips. Note that personal service and leisure trips studied here do not include food trips of grocery shopping and restaurant visits, which have been explored in other studies using the same dataset (Eckert and Vojnovic 2017; LeDoux and Vojnovic 2013, 2014).

the purpose of trips (personal services and leisure); and 3) how the inequalities reflected by trip distances across different population groups vary by trip purpose and neighborhood type (high-density urban, high-density suburban, and low-density suburban).

5.2. Background

5.2.1. Neighborhood environment

As reviewed in Chapter 2, characteristics in the neighborhood built environment affect how people travel within these spaces. Different dimensions of the built environment impact travel behavior in different ways. One-way trip distance (length) is strongly influenced by the spatial distribution of opportunities (potential destinations) relative to residential location and is also closely related to other dimensions of the built environment, including density, land use mix and the connectivity of the transportation network (Ewing and Cervero 2010). For example, research has shown that trip distance is shorter when people live in high-density and mixed-use neighborhoods with shorter distance to jobs or the CBD (Ewing and Cervero 2010; Moniruzzaman et al. 2013; Morency et al. 2011; Næss 2006).

What remains to be further explored is whether these findings apply to declining inner-city neighborhoods, where amenities (such as retail, services, and leisure destinations) are leaving the urban centers, and in some cases, relocating to the suburbs as a result of disinvestment within the core. These neighborhoods experiencing disinvestment are often characterized by high density, mixed land use, and high road connectivity, and are also close to the CBD (Grengs 2010), which are the typical built environment dimensions that are generally considered to be conducive to shorter trip distances. However, due to urban decline, these neighborhoods are different in terms of poverty, safety concerns, loss of amenities as businesses move out, and poor quality or higher

price of goods and/or services. Studies on travel and the built environment often do not consider the effects of these distinct characteristics caused by the neighborhood socio-economic condition, in particular, urban disinvestment and high concentrations of low-income and/or racial minority populations.

According to spatial mismatch theory, the suburbanization of jobs and the concentration of low-income racial minorities in inner-city neighborhoods due to residential segregation have resulted in a separation of low-skilled black residents from low-skilled jobs in the suburbs and led to longer commuting distances (Gobillon et al. 2007; Kain 1992). Evidence on travel to various types of destinations shows that the spatial mismatch issue is not limited to commuting (LeDoux and Vojnovic 2013; Vojnovic et al. 2014, 2020). The disinvestment led to drops in both quantity and quality of amenities and actually increases the amount of nonwork travel for local residents as well (LeDoux and Vojnovic 2013; Vojnovic et al. 2014). In this sense, declining urban neighborhoods impose added travel burdens on local residents, in terms of time and money, resulting in transportation inefficiencies and inequities at the neighborhood level.

5.2.2. Purpose

Compared with the neighborhood environment and individual sociodemographic characteristics, how travel behavior varies across different purposes is relatively under-explored in travel behavior research. There are two ways that purpose could affect travel behavior – an independent effect on travel behavior and moderating effects on the impact of other factors. An example of an independent effect would be that when controlling for all other factors, one-way trip distance (length) for leisure or work might tend to be longer than for personal services. An example of moderating effects would be that the effect of another factor, such as built environment

characteristics, on trip distance might be stronger for work trips than for leisure trips. To better understand how people might travel differently for different types of purposes, it will be helpful to separate these two possible mechanisms.

First, trip purpose could have an independent effect on travel behavior. This effect would be additive to the effects of other factors such as built environment and individual sociodemographic characteristics. In the existing literature that considers trip purpose, most studies have grouped trips by purposes, and provided descriptive statistics or analyses respectively for each category. However, how much travel behavior, and in particular, trip distance, varies among different trip purposes (and thus among different types of destinations) when all other factors are controlled is usually not directly evaluated and quantified.

There are a few studies that did try to answer this question and evaluate the variation of one-way trip distance among different trip purposes. Schmöcker et al. (2005) studied trip frequency and trip distance of the elderly and the disabled in London and used trip purpose as one of the predictors for trip distance in a multivariate regression model. The study found that people traveled the longest distance for work/educational destinations, the second longest for recreational trips, less distance for personal business and the shortest distance for shopping. Focusing specifically on trips for social activities (i.e. trips involving any non-business social contact), van den Berg and his colleagues (2011) found that trip distance varied among the types of social activities – people traveled longer distance for visiting (e.g., visiting a family member's house) or joint activities with someone else (e.g., dining in the restaurant with friends or family) than for other social activities in Eindhoven, Netherlands.

Rather than just quantifying the variation in travel behavior by trip purpose, Næss (2006) tried to provide a theoretical explanation for the effect of trip purpose on travel decision making, based on qualitative interviews. It was explained in this study that destination choice and thus trip distance is the result of two competing incentives - the shortest distance (or time) needed to travel and the best quality of the facility. Yet the balance between these two incentives differs depending on the trip purposes. On the one hand, people prefer to use nearby facilities for buying daily necessities (e.g., grocery, pharmacy, or cleaners). For such trips, minimizing trip distance is most important. On the other hand, choosing the best facility is more important for some trips (e.g., private schools for kids or visits to restaurants and cultural facilities). In addition, people are generally willing to travel long distances for work and social visits. For these trips, the destination is typically fixed without much choice involved.

Second, the impacts of other factors (the built environment and sociodemographic variables) on travel behavior may vary across trips for different purposes. Meurs and Haaijer (2001) showed that in the Netherlands, certain dimensions of the built environment impacted modal choice in trips for shopping and social or recreational purposes, but not as much for commuting trips to work. Similarly, Salon (2015) showed that the effects of multiple dimensions of the built environment on vehicle miles traveled varied between commute and nonwork trips in the context of California. As to the travel outcome of one-way trip distance focused in this chapter, Næss (2006) showed that, in Copenhagen, as the distance to CBD (a proxy for destination accessibility as a dimension of the built environment) increased, mean trip distance also increased, and this relationship was much stronger for work trips than weekend leisure trips. But these studies have yet to provide a theoretical explanation for the moderating effect of trip purpose on the effects of the built environment.

An exception is the study of Elldér (2014), based on national Swedish data, which found that the influence of residential neighborhood on *total daily distance* traveled was highly conditional on trip purposes. The residential built environment explained more variation in total distance traveled for work, service and weekday trips than in leisure and weekend trips. Utilizing a classification framework of activities by Ås (1978), Elldér explained that different trip purposes represent activities that have different levels of temporal-spatial constraint. Work trips are most constrained by space and time and therefore more subject to the influence of the local built environment, while trips taken during free time, such as to leisure destinations, are unlikely to be affected.

In addition, research has shown that the impact of individual sociodemographic characteristics on travel behavior may also vary by purpose. Using national travel data from the Netherlands, Dieleman et al. (2002) found that the total distance traveled by car increased with car ownership and higher income level, but this effect was stronger for work trips than for shopping trips.

5.2.3. Individual-level sociodemographic characteristics

One important goal of travel behavior research is to identify and understand inequities and inequalities, particularly among marginalized populations, which could assist in policymaking. Inequalities can be reflected in travel outcomes such as trip distance (length), total distance traveled, mode choices or trip frequency. Certain vulnerable population groups – such as the elderly, the disabled, women, minorities and people with lower incomes – who are the socially disadvantaged, might also face added transportation burdens compared with the rest of the population, even after controlling for any residential neighborhood environment difference (Lucas et al. 2016; Pyrialakou et al. 2016). Therefore, it is important to understand the travel behavior of

the disadvantaged, in order to have a full understanding of the mobility challenges faced by these population subgroups.

Low-income population groups have been generally considered to have greater constraints on mobility (Lucas et al. 2016; Morency et al. 2011), given the proportionately greater financial costs, whether public transit fares or gas prices. Giuliano (2005) found that people in poverty made much shorter trips, although their average trip duration was only slightly shorter compared with the non-poor. Similarly, Lucas et al (2016) found that as household income increased, the average trip distance also became longer. However, the effect of income on trip distance varies with trip purpose. While positive relationships between income level and commuting distance were often noted (Horner and Schleith 2012; Næss 2006), there were no significant impact of income found on the distance of trips for social activities, such as visiting families and hanging out with friends (van den Berg et al. 2011).

Regarding the effects of race and ethnicity on mobility, the existing findings are inconsistent. Lucas and her colleagues found no significant impact of being a minority on mean trip distance in the UK (Lucas et al. 2016). Yet, the results from Khattak et al (2000) for commuting in the US indicated that minorities actually had longer commute distances, even after controlling for neighborhood characteristics such as neighborhood median household income, neighborhood concentration of minorities and neighborhood job density. Their findings suggest that minorities not only face spatial mismatch of jobs at the neighborhood level, but also an additional layer of burden to access jobs due to their racial identity at the individual level.

Age is generally found to have a negative impact on one-way trip distance (Crane 2007; Mercado and Páez 2009; Moniruzzaman et al. 2013; Schmöcker et al. 2005). Mercado and Páez (2009)

grouped the population into age cohorts and found that the group aged from 20 to 35 traveled the longest distance per trip, and that trip distance decreased as age cohorts got older. Focusing on the specific population group of seniors who were older than 55, Moniruzzaman et al (2013) found that as people got older, they traveled shorter distances for daily trips. However, some studies have shown that the effect of age on trip distance varies when considering different types of trips. For instance, the study by van den Berg et al (2011) in the Netherlands found no negative effects of aging on how far people traveled for social trips specifically, including traveling for visiting and joint activities. Based on national data in the US, Schmöcker et al (2005) found that while aging had a negative impact on trip distance overall, the retired (60~80+) actually traveled longer distances specifically for recreational trips.

While the gender gap in commuting trips is well confirmed with a consensus that women take shorter commute trips than men (Crane 2007; Lucas et al. 2016; Næss 2006), the role of gender for other types of trips—such as leisure and personal services—is less clear. For leisure trips, Schlich et al. (2004) found that on average, women's leisure trip distances were shorter than for men. However, exploring factors impacting the distance of social trips in the Netherlands, van den Berg and his colleagues (2011) found no significant impacts of gender. When considering all types of trips together, some studies found that women traveled shorter distances (Lucas et al. 2016), but other studies found no significant effects of gender (e.g. Mercado and Páez 2009)

Household structure also influences how far people travel for their destination. Having children is often associated with shorter trip distances and being a single parent results in even shorter trip distances (Lucas et al. 2016). For commuting trips, a larger household size is associated with shorter trip distances, and being married has a negative effect on how far women commute but has a positive effect on how far men commute (Crane 2007).

In addition to the direct effects of individual-level sociodemographic variables on travel, the interaction effects that these variables have with the built environment have also been explored, though to a much lesser extent. Morency and colleagues (2011) found that while belonging to three disadvantaged population groups (the elderly, the low-income and single parents) was associated with shorter trip distances, this effect was reduced as a person lives closer to the CBD. Also, Khattak et al (2000) showed that for commuting trips, the effect of income on trip distance was smaller in the urban setting. Yet, more empirical evidence is still needed to understand how various sociodemographic characteristics affect trip distance differently across different types of neighborhood built environment.

In summary, sociodemographic characteristics are generally found to have an influence on travel behavior, including trip distance. There are, however, some variabilities in the results found for travel made for different trip purposes. Also, research has shown some coupled effects produced by sociodemographic and built environment characteristics. In general, the interaction effects of sociodemographic characteristics with trip purpose and the built environment are still underexplored, and particularly as examined in the context of neighborhoods experiencing extreme disinvestment and decline.

In this chapter, I focus on trip distance and assess the effects of trip purpose, neighborhood type, which covers the built environment and the socioeconomic conditions at the neighborhood level, and individual-level sociodemographic characteristics, including household income, race, age, gender and household structure for 6 neighborhoods across the Detroit region. I explore the separate effects of each of the factors on trip distance and evaluate the interaction effects among them to determine if the impacts of the neighborhood type on trip distance varies for different trip

purposes, and if the impacts of individual sociodemographic characteristics on trip distance vary by neighborhood and purpose.

5.3. Data and methods

5.3.1. Data

The data used were from the 2008 NSF Detroit travel survey collected in urban and suburban neighborhoods across the Detroit region (more details about the survey in Chapter 2). Data were collected from three different neighborhood types, with two neighborhoods for each urban form being studied, in order to get a stratified sample of built environment and neighborhood socio-economic conditions. The data covered two low-income urban neighborhoods in the city of Detroit experiencing severe disinvestment and decline. The two Urban Detroit neighborhoods were characterized by high-densities, mixed land uses, and high connectivity (to be referred to as Urban Detroit, HU). Also, the data included two upper-income suburban neighborhoods in Ann Arbor and Birmingham, which also maintained high densities, mixed land uses, and high connectivity (the High-density Suburbs, HS). Finally, the data included two upper-income suburban neighborhoods in West Bloomfield and Bloomfield Hills, which were characterized by low densities, predominantly single-use zoning, and low connectivity (the Low-density Suburbs, LS).

This research design employed a unique built environment-controlling data collection and analysis strategy in the study. The data was collected at the level of the neighborhood, within the three neighborhood types (high-density Urban Detroit, High-density Suburbs, and Low-density Suburb), This explicitly controlled for the built environment, instead of employing urban form and land use characteristics as control variables. This is a unique approach to controlling for the built environment not normally employed in urban form, land use and travel behavior research. This

approach makes it possible to explicitly capture the unique conditions of travel in neighborhoods experiencing rapid disinvestment and extreme decline, as in urban Detroit.

The focus of this analysis centers on travel for leisure and personal service, with trip distance patterns being examined. To remove interdependency of observations, only one response was kept for households returning multiple responses. Surveys with missing information and outliers were also removed from the analysis. A total of 436 trips from respondents with missing sociodemographic information were removed. Some additional 894 trips were removed from the dataset due to missing information on trip distance. Furthermore, almost all trips were below 50 miles in terms of distance and only four trips fell out of this range (Figure 5-1). Thus, the four trips that were above 50 miles were dropped as outliers. These steps yielded a final dataset of 1,973 trips by 739 respondents.

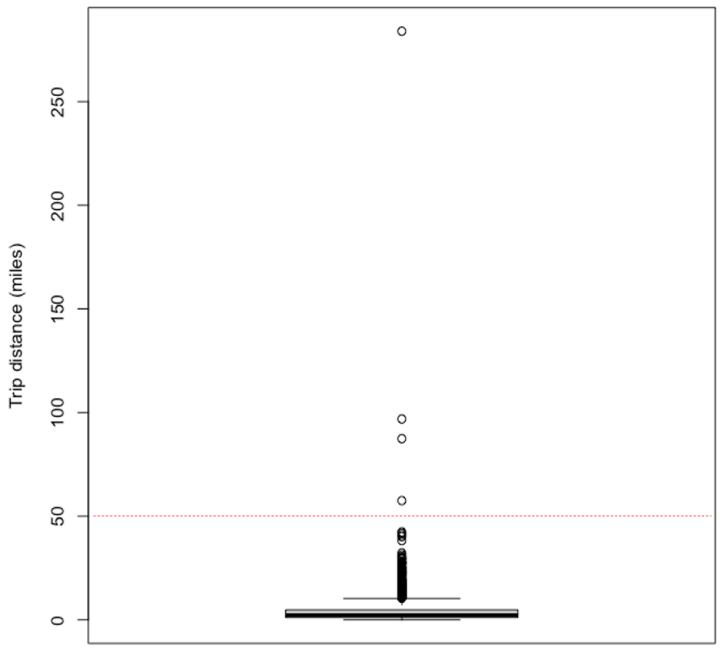


Figure 5-1. Boxplot of distances of leisure and personal service trips with sociodemographic and trip distance information before removing outliers (points beyond the red dotted line)

5.3.2. Variables

Dependent variable

For the analyses in this chapter, one-way trip distance (length) is the travel outcome of interest, which is hypothesized to be influenced by neighborhood types, sociodemographic characteristics, and trip purpose (leisure or service). I choose to examine distance at the level of individual trips instead of taking the mean trip distance traveled by respondents, since this keeps the most information in the data and enables investigation of the variation in trip distance by purpose.

The distribution of trip distance was skewed to the left (Figure 5-2 a and b). This violates the assumption of normal distribution in most statistic models such as t-test, ANOVA and OLS regression. Therefore, following the common practice in transportation research (e.g. van den Berg, Arentze, and Timmermans 2011; Elldér 2014; Ewing et al. 2015; Lucas et al. 2016; Morency et al. 2011), I took the logarithm of the trip distance and used it as the variable of interest for the analyses. The distribution of the log-transformed trip distances approximates the normal distribution much more closely compared with the original trip distances (Figure 5-2 c and d).

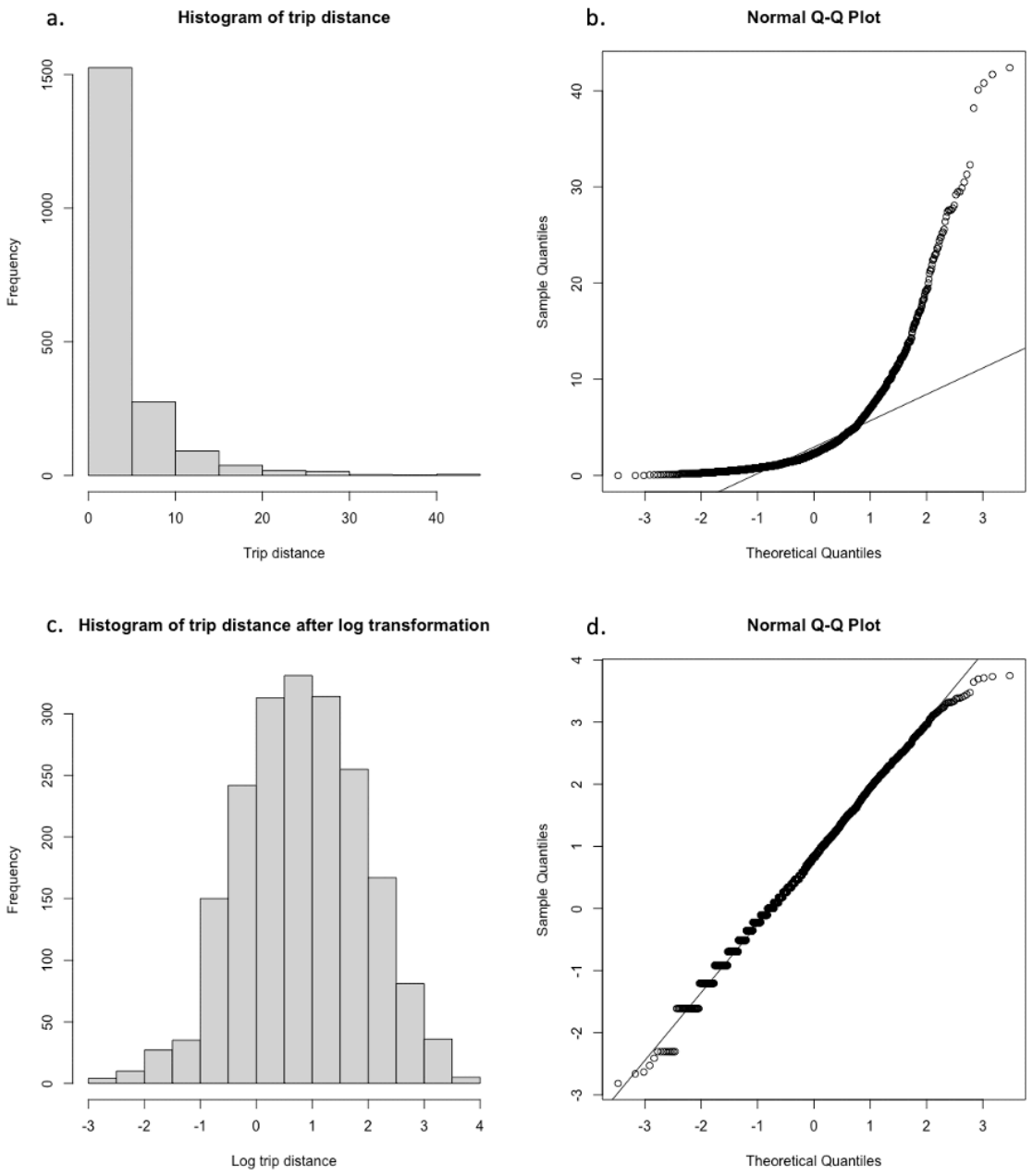


Figure 5-2. Distribution of trip distance before (panels a and b) and after (panels c and d) log transformation

Independent variables

Factors at three levels were tested as independent variables for explaining trip distance, including neighborhood type (neighborhood-level), sociodemographic characteristics (individual-level), and trip purpose (trip-level).

Neighborhood type and purpose

Three neighborhood types were used to reflect the neighborhood characteristics of the built environment and socio-economic condition – Urban Detroit (HU), High-Density Suburbs (HS) and Low-Density Suburbs (LS). Thus, in the analysis, neighborhood type was a categorical variable with three distinct values – HU, HS, and LS – corresponding to the three neighborhood types. Trip purpose was treated as a categorical variable that indicated whether the trip was for personal service or leisure purposes. It was studied as a predictor for its independent effect as well as its interaction effects with neighborhood type in the first part of the analysis.

Individual sociodemographic characteristics

Individual sociodemographic characteristics were studied to identify potential transportation disadvantage faced by vulnerable populations. The effects of these factors on trip distance were examined within each of the three neighborhood types. The results in different types of neighborhoods were compared for any heterogeneity in the effects of the same factors across neighborhood contexts. Due to severe collinearity, trip purpose and its interaction effects with sociodemographic factors were *not* linearly added as separate predictors in the exploration of the effects of sociodemographic characteristics on trip distance. Rather, the analyses were carried out for leisure and service trips separately, and the model results were compared to see if the effects of neighborhood type and sociodemographic factors on distance vary by purpose.

Race and income were included as independent variables. They are critical for understanding travel behavior across the Detroit region as both factors influence where people live and therefore what type of residential environment is experienced daily. Low-income minority populations are concentrated within the city, which has been experiencing urban disinvestment and decline for well over five decades, while the higher-income white population is dominant in the suburbs. Race was modeled as a two-value categorical variable ("white" and "nonwhite"), with different minority groups merged together into "nonwhite" due to the small sample sizes for various minority groups outside urban Detroit. To account for potential non-linear effects on trip distance by different income groups, household annual income was included as a categorical variable, representing three income levels – lowest-income/poor (less than $20,000), lower-income ($20,000 ~ $49,999), and middle and upper-income ($50,000 or more).

Age was also included as a categorical predictor. It was broken down into four groups: early young adult (<=25), young adult (26-35), middle age (35-65), young-old (65-80) and old-old (>80). This was performed to capture potential nonlinear effects of different life stages on trip distance (van den Berg et al. 2011; Mercado and Páez 2009; Moniruzzaman et al. 2013; Morency et al. 2011; Schmöcker et al. 2005).

In the analysis, I also explored the effects of gender and family responsibilities on trip distance. A binary predictor was included for gender. For household structure, a binary variable for single parents was introduced. A person is considered a single parent when she or he is not married or cohabiting with a partner and has at least one child in the household who is under 18. Data tabulation shows that, for the 720 respondents who provided information on both marital status and the presence of young children, there were 57 respondents who were single parents and almost all of them are women (N=53). Most single moms were concentrated in Urban Detroit (N=34). In

fact, about 25% of the respondents from Urban Detroit reported to be single moms, compared with only 2% and 4% of respondents from High-Density Suburbs (HS) and Low-Density Suburbs (LS) respectively.

5.3.3. Model specification

For the first part of the analysis, the effects of different factors on trip distance (length) were explored separately using t-test and OLS regression to compare and quantify the effects of neighborhood types and trip purposes on trip distance. Unequal-variance two-sample t-tests were used to account for unequal sizes of the groups compared. I then used ANOVA and OLS regressions to explore effects of sociodemographic variables on trip distance and possible interaction effects with neighborhood type for both leisure and service trips.

To evaluate the combined effects of various factors given the nested multilevel structure of the Detroit survey data (neighborhoods, individuals, and trips), the multilevel model (MLM, aka. hierarchical linear model or mixed effects model, Gelman and Hill 2006) was used in the analysis. Since transportation studies often deal with multi-level data which have zones/neighborhoods, individuals and trips, MLM has been applied in various studies to account for the grouping effects of the data structure (Elldér 2014; Hong et al. 2014; Mercado and Páez 2009; Snellen, Borgers, and Timmermans 2002).

For a multilevel dataset, the outcomes are nested within groups, which in the case of transportation are trips made by the same individual and individuals living within the same neighborhoods. This violates the OLS regression assumption of independent observations. MLM corrects for this inter-dependence by explicitly incorporating a random effect(s) for the grouping, which can capture the

similarity of trips from the same individuals or from the same neighborhoods (or both). This random effect can be introduced for the intercept or the slope of a predictor or both.

The equations below represent a two-level random intercept model with a random effect for the nestedness of trips within individuals:

$$y_{ij} = \beta_{0j} + e_i \ (level\ 1\text{:}\ trips)$$

$$\beta_{0j} = \gamma_{00} + \gamma_{01} x_{1j} + \gamma_{02} x_{2j} + \cdots + \mu_j \ (level\ 2\text{:}\ individuals)$$

$$e_i \sim N(0, \sigma_1^2)$$

$$\mu_j \sim N(0, \sigma_2^2)$$

where y_{ij} is the dependent variable, which will be log distance of trip i for individual j. β_{0j} is the mean log-trip distance by individual j, which is determined by the grand mean γ_{00}, individual-level predictors $x_{1j}, x_{2j}, \ldots$, and the error term μ_j at the individual level.

There are two sources of deviation. One is e_i, the trip-level deviation from the mean log-distance of trips for the same individual (level 1), and the second is μ_j, the individual-level deviation from the mean log-distance of all individuals (level 2) after controlling for individual characteristics as fixed-effect predictors. Fixed effect means that the effect (or coefficient) of the predictor will be the same across different groups (individuals here), just like in a typical OLS regression.

Taken together, the final equation can be written as:

$$y_{ij} = \gamma_{00} + \gamma_{01} x_{1j} + \gamma_{02} x_{2j} + \cdots + \mu_j + e_i$$

which is essentially the same as an OLS regression, with only one difference that besides the typical error term for trips, it has an additional error term for the grouping of trips by individuals at a higher level, which is the random effect for the intercept at the individual level (level 2).

Although the data structure in this study actually has three levels, I did not introduce neighborhoods as a third level in the random intercept model. The reason is that typically at least ten or more groups will be needed to model a random effect at the group level, and the Detroit survey data were sampled only from 6 neighborhoods. And more importantly, the groups in a multilevel model should be a random sample from a *population of groups*, but here, the selection of neighborhoods was stratified, and two neighborhoods were sampled for each of the three typical neighborhood types in the Detroit region. Therefore, instead of being treated as one more random effect at another level, neighborhood type was introduced as a fixed-effect categorical predictor with three distinct values, which was, simply put, just an additional predictor in the regression. This is sufficient to capture the similarity of individual behaviors within a certain neighborhood type.

In this study, random intercept models were built using the packages of *lme4* and *lmerTest* (Bates et al. 2015; Kuznetsova, et al. 2017) in R software. To begin with, I fitted a reduced model with only one fixed-effect predictor – neighborhood type and a random intercept for grouping of trips by individuals. Then, a full model was fitted by further adding individual sociodemographic variables and their interaction terms with neighborhood types as additional fixed effect predictors. The reduced and the full models were compared using the likelihood ratio to examine the overall effect of adding sociodemographic variables.

I performed the same set of analyses as explained above on three different datasets – all trips, personal service trips only, and leisure trips only. The results based on the three different datasets were compared to explore if and how the effects of neighborhood type and sociodemographic variables vary by trip purpose. An alternative approach is to add *interaction terms* for the coupled effects of trip purpose and other factors as predictors in the model, but this is not feasible in this study due to severe collinearity among the predictors.

5.4. Results

5.4.1. The separate effects of various factors on one-way trip distance

The effect of trip purpose

People generally travel longer trip distances for leisure than for personal services across all different neighborhood types (Table 5-1) and the difference in trip distance between leisure and service trips is statistically significant (Table 5-2). When used as a predictor in the OLS regression, trip purpose explained 5% of total variation in trip distance (Table 5-3), indicating that trip purpose is a significant factor for how far people travel.

Table 5-1. Mean trip distance and mean trip time by the three neighborhood types and purpose

Neighborhood type	Both types of trips		Personal service		Leisure	
	Distance	Time	Distance	Time	Distance	Time
High-density Urban (HU)	4.4	13.6	3.3	10.1	6.2	18.6
High-density Suburban (HS)	2.8	9.6	2.5	8.7	3.1	10.6
Low-density Suburban (LS)	4.9	11.3	3.3	8.4	7	15.2

Note: The mean trip distance and mean trip time are averages by trip destinations, not weighted by the frequencies of trips to each destination.

Table 5-2. Unequal-variance two-sample t-test on the difference of trip distance (log transformed) between leisure and personal service trips

Neighborhood type	t-test on difference in trip distance
All neighborhoods together	$p < 0.001$ ***
High-density Urban (HU)	$p < 0.000$ ***
High-density Suburb (HS)	$p = 0.039$ *
Low-density Suburb (LS)	$p < 0.001$ ***

Table 5-3. The OLS regression of trip distance (log transformed) on trip purpose

	Estimate	SE	P-value
Purpose			
Reference: personal service			
Leisure	0.478	0.0476	<0.001 ***
R2=0.049, N=1970			

Leisure trips not only tend to be longer in distance than personal service trips, but they also have a larger variation in trip distance (the variance is 32.12 before log transformation and 1.29 after) than personal service trips (the variance is 15.47 before log transformation and 0.92 after), meaning that there is simply more heterogeneity in how much people travel for leisure.

According to ReferenceUSA historical business data for business listings of the year 2008, the total number of personal service destinations was about ten times the total number of leisure destinations in the Detroit region, and the density of personal services is much higher than leisure destinations across the region (Figure 5-3). This indicates that leisure destinations have much larger market areas than personal services. This could at least partially explain why people travel farther to leisure destinations than personal services.

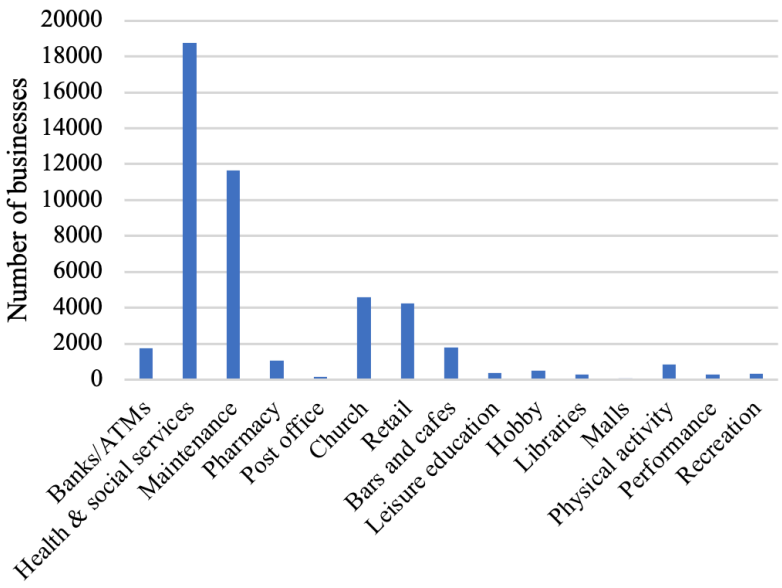


Figure 5-3. Number of businesses for detailed activity types (level-2 purpose categories) of leisure (categories from banks/ATMs to retail) and personal service (categories from bars and cafes to recreation) in the Detroit region

Source: ReferenceUSA data; this does not include destinations for the categories of social visits and miscellaneous leisure

The effect of neighborhood type

Residents in High-density Suburbs (HS) had shorter trip distances than residents in Low-density Suburbs (LS) for both personal service and leisure (Tables 5-1 and 5-4). This indicates that a neighborhood built environment with high densities, mixed land uses and high road connectivity can reduce trip distances. Also, residents in high-density mixed-use suburbs (HS) had much shorter trip distances than residents in urban Detroit (HU) (Tables 5-1 and 5-4), despite having a similar neighborhood built environment in terms of density, land use mix, and road connectivity. In fact, residents in urban Detroit (HU) traveled similar distances to reach leisure and service destinations as residents in the Low-density Suburbs (LS) (Tables 5-1 and 5-4). In addition, due to a much lower percentage of car ownership in urban Detroit (HU), the residents in the city used public

transit much more often and spent the *longest* time in traveling to both personal services and leisure destinations (Table 5-1).

Table 5-4. Unequal-variance two-sample t-test on trip distance (log transformed) comparing neighborhood types

Neighborhood type 1	Neighborhood type 2	t-test on the difference in trip distance
HU	HS	p-value < 0.001 ***
LS	HS	p-value < 0.001 ***
LS	HU	p-value = 0.256

Excluding confounding effects

It could be argued that the difference in trip distance between urban Detroit and the High-density Suburbs was a result of the effect of variation in local residents' *individual-level* sociodemographic characteristics. As seen in the descriptive characteristics of local residents in Chapter 4 on study site and data, residents in the suburbs of Detroit were mostly middle- and upper-income residents with a white majority, while residents in urban Detroit were disproportionately poor, with a black majority.

To determine if the effect of neighborhood type was partly resulted from differences in individual-level sociodemographic characteristics, three OLS regressions were done to provide a nested model comparison. The results showed that neighborhood type alone explained a significantly larger variation in trip distance (Model 1) than the effects of individual race and income levels combined (Model 2) (Table 5-5). When controlling for neighborhood type the respondent lived in, neither their race nor income level had any significant effect on trip distance (Model 3). An ANOVA analysis comparing Model 1 and Model 3 showed that Model 3 had no significant improvement over model 1 (p-value=0.33). Therefore, the significant effects of neighborhood type

on trip distance were due to neighborhood type itself, rather than variation in individual-level sociodemographic characteristics, at least when it came to personal service and leisure destination travel.

Trip distances by residents in Urban Detroit and the Low-density Suburbs were longer than in the High-density Suburbs, but these lower accessibility levels were due to different reasons. In Urban Detroit, disinvestment in the city has resulted in low access to various personal services and leisure destinations despite the high-density, mixed-land-use built environment. The urban disinvestment resulted in longer journeys by Urban Detroit residents to reach basic daily amenities. In contrast, residents in the Low-density Suburbs traveled long trip distances simply because of the nature of the low-density, single-use built environments of their isolated peripheral subdivisions that resulted in low access to amenities.

Table 5-5. OLS regressions of trip distance (log transformed) on different sets of predictors

	Model 1	Model 2	Model 3
Neighborhood type			
HS (reference)			
HU	0.454 ***		0.419 ***
LS	0.555 ***		0.545 ***
Race			
White (reference)			
Nonwhite		0.238 ***	0.108
Household income			
Lowest/poor (<20k)		-0.171	-0.139
Lower (20k~50k)		-0.061	-0.049
Middle and upper (>50k) (reference)			
R2	0.059	0.007	0.061
N = 1707			

Interaction effect of neighborhood type and trip purpose

Trip distance varied by both neighborhood type and trip purpose (Figure 5-4). The two factors explained different parts of the variation in trip distance and had comparable explanation powers (Table 5-6). Also, neighborhood type and trip purpose had a significant interaction effect on trip distance (Table 5-6). This interaction effect showed that the impact of neighborhood type on trip distance was much stronger for leisure trips than for personal service trips. Residents in High-density Suburbs generally traveled shorter distances to destinations than in other neighborhoods, but this difference was particularly large for leisure trips. For personal service trips, neighborhood type explained a very small percentage of total variation in trip distance (1.6%), while for leisure trips, it explained 14% of total variation in trip distance (Table 5-7).

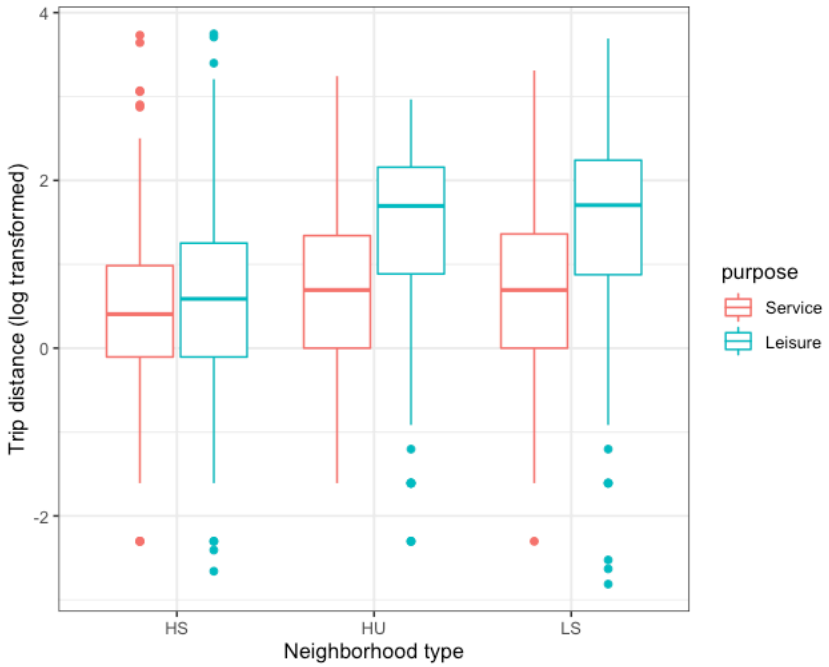


Figure 5-4. Boxplot of trip distance by neighborhood type and purpose

Table 5-6. Two-way ANOVA of trip distance (log transformed) on neighborhood types and trip purpose with interaction

Source of variation	Degree of freedom	Sum of Squares	Mean Sum of Squares	F value	P-value	
Neighborhood type	2	120.576	60.288	59.582	< 0.001	***
Purpose	1	128.094	128.094	126.594	< 0.001	***
Neighborhood type * purpose	2	46.380	23.190	22.918	< 0.001	***
Residuals	1964	1987.282	1.012			

Table 5-7. OLS regressions of trip distance (log transformed) on three neighborhood types: by trip purpose

Predictor: Neighborhood type	Regression with personal service trips only		Regression with leisure trips only	
	Estimate		Estimate	
HS (Reference)				
HU	0.246	**	0.751	***
LS	0.254	***	0.915	***
R2	0.016		0.144	
N	1090		880	

A possible reason behind this pattern is that people from different neighborhoods may have similar levels of accessibility to personal services (essential amenities) but very different levels of accessibility to leisure destinations (optional amenities). Personal services might be more evenly distributed across different neighborhood environments since they are necessary for people's daily personal needs – such as going to a pharmacy or a bank – while non-essential leisure destinations are optional for daily life and thus concentrate in neighborhoods with a large consumer base for leisure activities. However, according to ReferenceUSA historical business data of the year 2008 for the spatial distribution of business establishments in the Detroit region, while there is a much higher density of personal service destinations than leisure destinations, the density of both personal service and of leisure destinations vary greatly across neighborhoods. This rejects the conjecture described above.

The effects of individual sociodemographic characteristics with consideration of neighborhood type and purpose

Household income

The effect of income on trip distance displayed variation by purpose and by neighborhood type (Figure 5-5). Income did not have any significant effect on the distance of service trips, and while income did not have an overall consistent effect on leisure trip distance across all neighborhoods, it had a significant interaction effect with neighborhood type (Tables 5-8 and 5-9). More specifically, income affected trip distance for leisure activities in High-density Suburbs and Low-density Suburbs in opposite ways while having no statistically significant effect in Urban Detroit (Table 5-10). In addition, the effect of income on leisure trip distance was nonlinear. In the suburbs where income showed a significant effect on trip distance, only the lowest-income group traveled differently from the reference group of middle- and upper- income populations. The lower-income group (total household income between $20,000 and $49,999 annually) did not significantly differ from middle- and upper- income groups in terms of the trip distance traveled (Table 5-10).

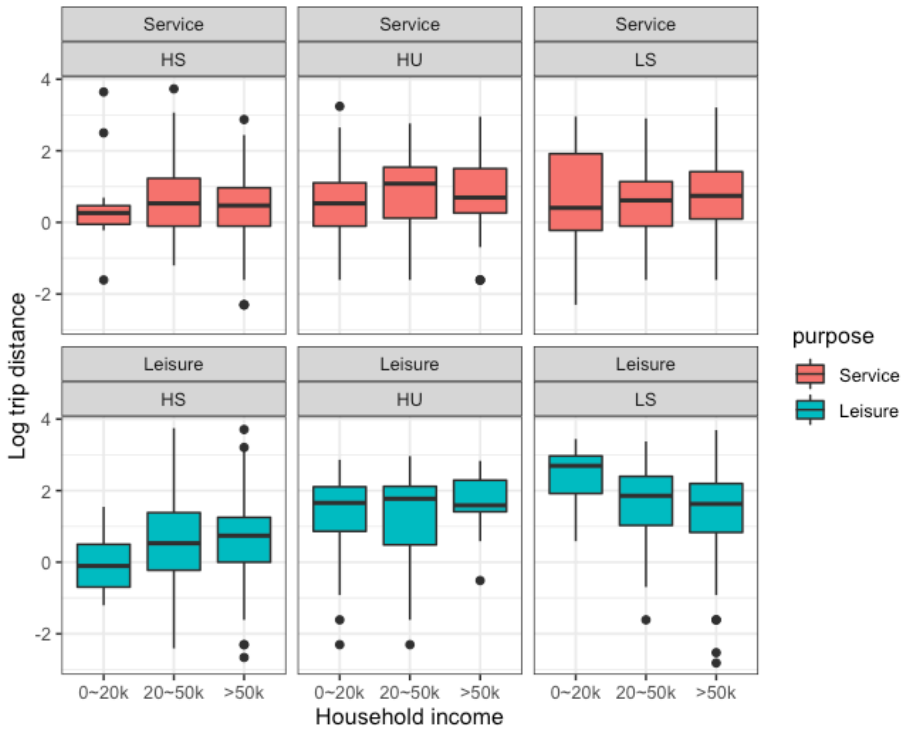


Figure 5-5. Boxplot of trip distance (log transformed) by income levels, arranged by purpose and neighborhood type

Table 5-8. Two-way ANOVA with interaction for personal service trips

Source of variation	Degree of freedom	Sum of Squares	Mean Sum of Squares	F value	P-value
Household income	2	1.4	0.70	0.77	0.463
Neighborhood type	2	17.3	8.65	9.57	<0.001 ***
Household income * Neighborhood type	4	4.8	1.21	1.34	0.253
Residuals	940	849.4	0.90		

Table 5-9 Two-way ANOVA with interaction for leisure trips

Source of variation	Degree of freedom	Sum of Squares	Mean Sum of Squares	F value	P-value
Household income	2	0.2	0.09	0.09	0.918
Neighborhood type	2	162.0	80.98	75.84	< 0.001 ***
Household income * Neighborhood type	4	21.9	5.47	5.12	< 0.001 ***
Residuals	770	822.2	1.07		

Table 5-10. OLS regressions of trip distance (log) for leisure on household income levels for each of the three neighborhood types

	HU	HS	LS
Reference: Household income: >50k			
Household income: <20k	-0.328	-0.626 **	0.941 **
Household income: 20k~50k	-0.499	-0.021	0.0589
R2	0.026	0.028	0.028
N	125	343	321

In Urban Detroit, the lowest-income/poor showed *no* statistically significant difference from the rest of the population (Table 5-10). The mean trip distance among the poor was shorter than the middle- and upper-income groups for both leisure and service trips. Given the small number of observations in Urban Detroit (N=166), one may argue that the sample size for Urban Detroit neighborhoods is too small to detect statistical significance of a very weak effect. However, while income remained significant after controlling for car ownership in the suburbs, even the numerical difference in mean trip distance among income groups in Urban Detroit disappeared after controlling for car ownership (results not shown). This indicates that when controlling for household car ownership, Urban Detroit residents traveled similarly long trip distances to reach destinations as a result of poor accessibility in their residential neighborhood, regardless of their household income levels. Due to the disinvestment in the Urban Detroit neighborhoods, there are fewer personal services or leisure amenities located in proximity to one's home. The residents in Urban Detroit simply have to travel long distances to reach many basic amenities, whether it is the low- or the more middle-income earners.

In the suburbs, the travel behavior of the lowest-income/poor was significantly different from the rest. People with the lowest income (total annual household income less than $20,000) in High-density Suburbs traveled *shorter* trip distances than other income groups while the poor in Low-

density Suburbs traveled *longer* trip distances than other income groups (Figure 5-5 and Table 5-10). It could be argued that lower income groups had lower car ownership rates, which led to shorter trip distances in the High-density Suburbs. But this was actually not the case. In both high- and Low-density Suburbs, almost all residents reported at least one car in the household (98.6% in High-density Suburbs and 99.3% in Low-density Suburbs). Therefore, being poor in the suburbs had a direct impact on trip distance, which was independent from car ownership.

The poor in the high-density and in the Low-density Suburbs consisted of different population groups in terms of occupation and age (Figure 5-6). In the High-density Suburbs, more than half of the leisure trips (52.4%, 22 out of 42 trips) reported by the lowest-income respondents were completed by young college students in Ann Arbor, where the University of Michigan is located. They frequented coffee shops and bars, visited friends, and also made trips to libraries and gyms. Most of these trips tended to be shorter than the average leisure trip (in the High-density Suburbs, the mean trip distance was 1.6 miles to coffee shops and bars, 1.9 miles to libraries, and 2.7 miles to workout places, while the mean trip distance to all types of leisure destinations was 3.1 miles). By comparison, in the Low-density Suburbs, most leisure trips (65%, 13 out 20 trips) reported by the lowest-income respondents were completed by the retired (Figure 6). Most of their trips were for the purpose of visiting families, which tended to be longer than the average leisure trip (in the Low-density Suburbs, the mean trip distance for social visits is 8.6 miles, longer than the mean trip distance of 7 miles to all types of leisure destinations).

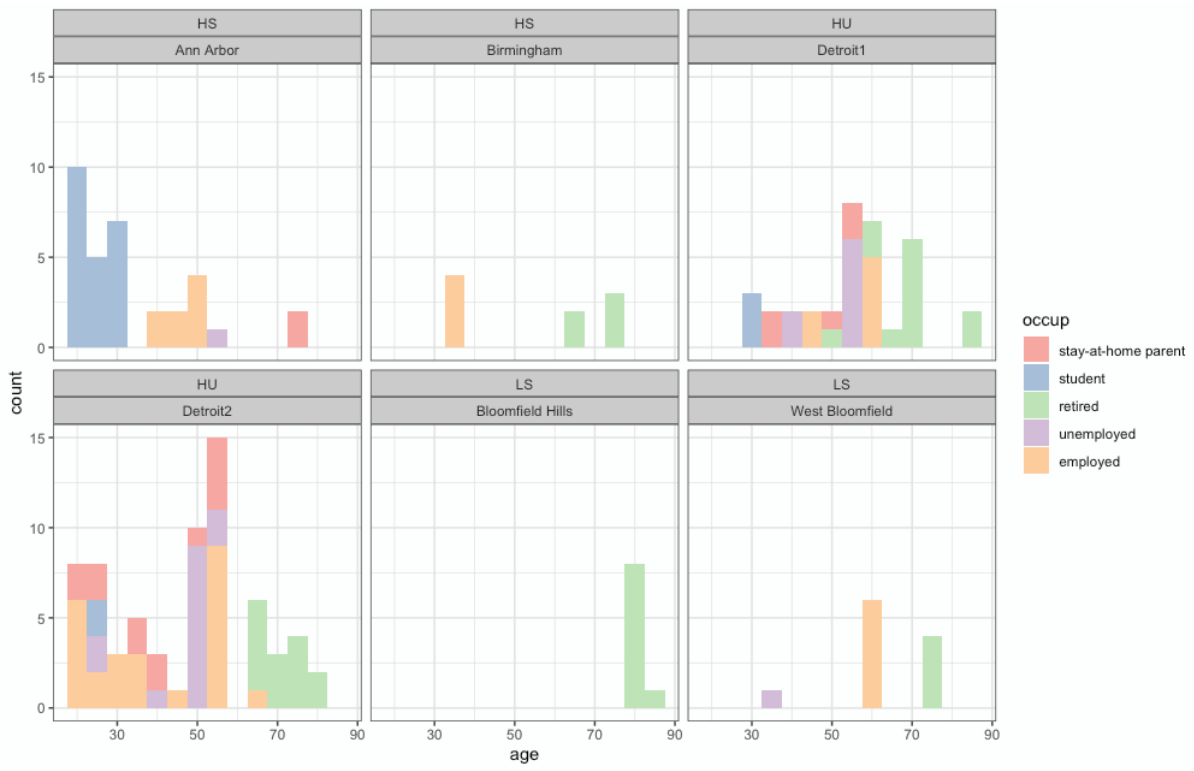


Figure 5-6. Distribution of age and occupation by neighborhood for the lowest-income/poor (with household income less than $20,000 per year)

However, additional analyses (outputs not shown) showed that the difference in the demographic nature of the poor (young students versus the retired) and their trip destinations between high-density and Low-density Suburbs was *not* linked to the diverging effects of income on trip distance. First, I performed OLS regressions of trip distance by income using data that removed the trips that the poor were more likely to make as opposed to the rest of the population. This means dropping the trips to bars/coffee shops and libraries in the High-density Suburbs, and social visit trips in the Low-density Suburbs. The results remained largely unchanged. This indicates that the effect of income and how it differs between high-density and Low-density Suburbs is not due to what types of destinations the poor frequently visit. Second, OLS regressions of trip distance by income were done using data that removed young students for High-density Suburbs and the

retired for Low-density Suburbs. Again, the results remain consistent. This indicates that the variation in the effects of income on trip distance across neighborhood types cannot be explained by differences in demographic composition or lifestyles alone across the different neighborhood types.

An alternative explanation for this is that, regardless of the types of leisure activities, while low-income residents in the High-density Suburbs generally had shorter trip distances due to financial constraints, low-income residents in wealthy Low-density Suburbs, unlike their rich neighbors, had to travel outside the neighborhood and go farther to meet their social contacts or access cheaper leisure amenities they could afford. This was supported by the data. In the High-density Suburbs, residents with the lowest incomes had shorter average trip distances for various types of leisure trips, including 1.0 mile for social visits, 0.9 mile for bars and cafes, 1.4 miles for libraries, and 1.6 miles for other leisure trips, while higher-income residents had much longer trips distances, of 4.7 miles for social visits, 1.4 miles for bars and cafes, 2 miles for libraries, and 3.2 miles for other leisure trips. In the Low-density Suburbs, lowest-income residents had longer average trip distances of 13.9 miles for social visits and 17.4 miles for other leisure trips, while residents with higher incomes had much shorter average trip distances of 8.3 miles for social visits and 6.3 miles for other leisure trips. These results showed that the effects of income on trip distance are *not* limited to trips for a particular type of leisure activities, but rather indicate a general tendency of the poor to travel shorter distances in the High-density Suburbs and longer distances in the Low-density Suburbs for all types of leisure activities.

One caveat in interpreting effect of income on trip distance is that there were very few people that fell into the category of the lowest-income/poor in the High-density Suburbs (N=18 with 42 trips) and Low-density Suburbs (N=8 with 20 trips), accounting for 2.8% and 1.2% of total respondents

and 5.6% and 2.7% of total trips in each neighborhood type respectively, which might lead to low statistical power for the effect of income in the OLS regressions.

Race

Race had no effect on trip distance for personal service trips, but a small yet marginally significant interaction effect with neighborhood type for leisure (Tables 5-11 and 5-12). When examined for each neighborhood type separately, race showed a small yet significant effect in Low-density Suburbs, where minority residents generally traveled about 1.58 times the distance of white residents for leisure trips (Table 5-13). In Low-density Suburbs, instead of visiting nearby leisure destinations that are marketed towards local wealthy white populations, minority residents might choose to travel outside of the neighborhood to reach destinations that serve their own preferences, including social and culture. A confounding effect is that visible minorities, including the African American population, tend to have lower income levels. The effect of race at the individual level will be further examined by controlling for income levels and other sociodemographic factors, as discussed in section 5.4.2.

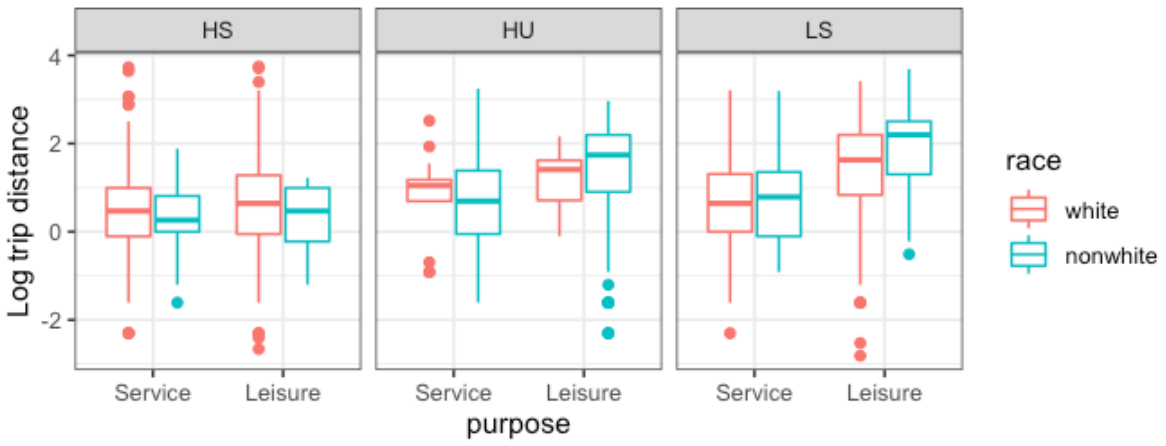


Figure 5-7. Boxplot of log trip distance by race, grouped by purpose and neighborhood type

Table 5-11. Two-way ANOVA of log trip distance by race and neighborhood type for personal service trips

Source of variation	Degree of freedom	Sum of Squares	Mean Sum of Squares	F value	P-value
Neighborhood type	2	14.1	7.039	7.853	<0.001 ***
Race	1	0	0.001	0.001	0.980
Neighborhood type * race	2	0.7	0.374	0.417	0.659
Residuals	1064	953.7	0.896		

Table 5-12.Two-way ANOVA of log trip distance by race and neighborhood type for leisure trips

Source of variation	Degree of freedom	Sum of Squares	Mean Sum of Squares	F value	P-value
Neighborhood type	2	163.3	81.67	72.526	<0.001 ***
Race	1	3.1	3.10	2.755	0.097
Neighborhood type * race	2	6.9	3.46	3.071	0.047 *
Residuals	858	966.2	1.13		

Table 5-13. OLS regressions of trip distance (log) for leisure on race by neighborhood type

	HU	HS	LS
Reference: white			
Nonwhite	0.211	-0.267	0.459 **
R2	0.002	0.004	0.02
N	117	345	371

Age

There were no clear patterns in trip distance observed by age groups (Figure 5-8). The ANOVA results of age and neighborhood type showed that for personal service trips, age did not have a statistically significant effect on trip distance (Table 5-14), and for leisure trips, age had an independent significant effect on trip distance, which remained similar across different neighborhood types (Table 5-15). For leisure trips, the young-old (from 66 to 79 years old) traveled further (approximately 1.37 times) than the reference group – the middle-aged (from 35 to 65 years old) (Table 5-16). However, this effect was weak when compared with the effect of neighborhood

type in the two-way ANOVA, and in terms of total variation explained (R2=0.01) in the OLS regression (Tables 5-15 and 5-16).

Compared with other population groups, older people reported more trips for hobbies (some examples include boating, golfing, hunting, bowling, playing cards, and choir or band practice), which tended to be longer in distance than average leisure trip, but were less likely to go to bar or coffee shops, which tended to have much shorter in distance. Trips to bar or coffee shops had the shortest distance on average among all types of leisure trips. So, it seems possible that this distinct pattern of destinations visited by older people might explain why they have shorter trip distances for leisure activities. However, this was not supported by the data. Additional OLS regression results (not shown) indicated that even if those trips for hobbies and bar/ coffee shops were excluded, the effect of age was still significant. This suggests that, regardless of the type of leisure destinations, once decided to make a leisure trip, the older people tend to visit destinations farther away than the young and the middle-aged. It is possible that the elderly have more free time and fewer job/household responsibilities, which means less spatial-temporal constraints compared to other population subgroups, particularly working parents who have to be physically present in specific locations (such as driving kids to school or going to work) at certain times of a day.

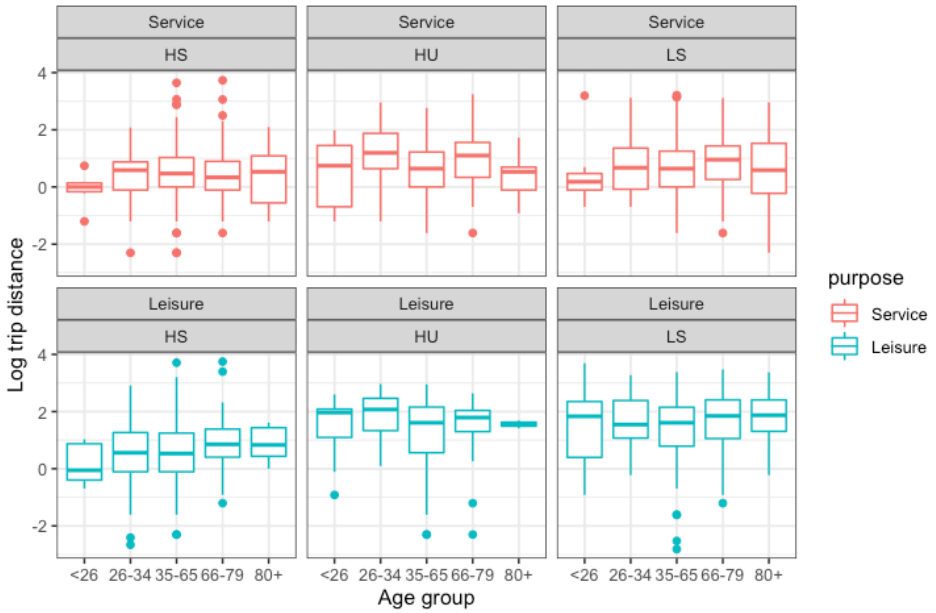


Figure 5-8. Boxplot of log trip distance by age, arranged by purpose and neighborhood type

Table 5-14. Two-way ANOVA of log trip distance by age groups and neighborhood type for personal service trips

Source of variation	Degree of freedom	Sum of Squares	Mean Sum of Squares	F value	P-value
Neighborhood type	2	14.6	7.290	8.158	<0.001 ***
Age	4	8.0	1.997	2.235	0.063
Neighborhood type * age	8	9.3	1.164	1.303	0.238
Residuals	1053	941	0.894		

Table 5-15.Two-way ANOVA of log trip distance by age groups and neighborhood type for leisure trips

Source of variation	Degree of freedom	Sum of Squares	Mean Sum of Squares	F value	P-value
Neighborhood type	2	166.9	83.43	75.552	<0.001 ***
Age	4	13.1	3.27	2.961	0.019 *
Neighborhood type * age	8	8.4	1.04	0.946	0.4778
Residuals	850	938.6	1.10		

Table 5-16. OLS regression of trip distance (log) for leisure on age for all data

	Estimate	t value	P-value
Reference: Age 35-65			
Age <26	0.051	0.280	0.779
Age 26-34	-0.035	-0.297	0.766
Age 66-79	0.317	2.874	0.004 **
Age 80+	0.351	1.860	0.063
F-statistic: 2.895 on 4 and 860 degrees of freedom, p-value: 0.021 R2=0.013			

Gender

Women had slightly longer mean trip distance for both service and leisure trips than men do (Figure 5-9 and Table 5-17). However, when further examining the trip distance distribution, no obvious difference in the distribution of trip distance by gender could be seen except for personal service trips in urban Detroit (HU, Figure 5-9). Gender had no significant effect for leisure trips, but it had a weak interaction effect with neighborhood type for service trips (Tables 5-18 and 5-19). In urban Detroit (HU), women tended to travel longer than men for personal services (Table 5-20). This is possibly related to women's gender role of household responsibilities and the potential need to go outside urban Detroit to seek better-quality services.

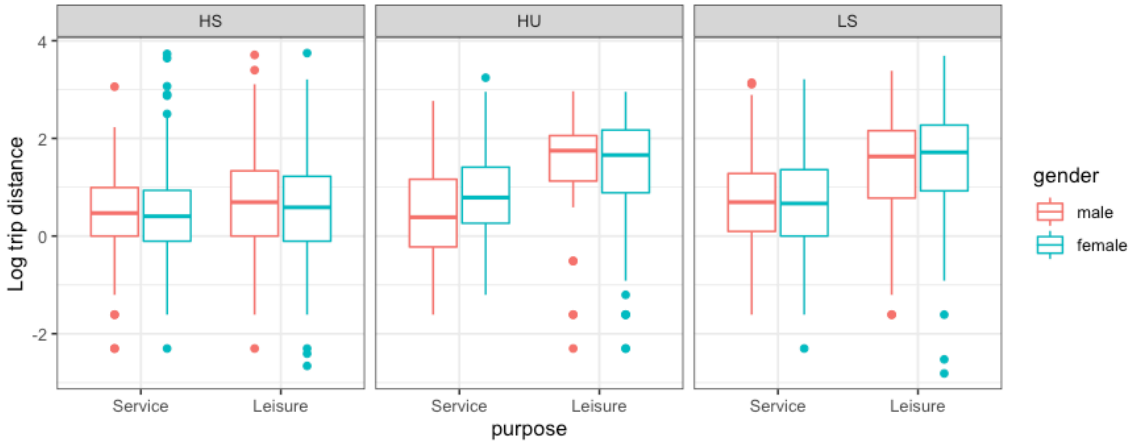


Figure 5-9. Boxplot of log trip distance by gender, arranged by neighborhood type and purpose

Table 5-17. Mean trip distance and time by gender and purpose

Gender	Service		Leisure	
	Distance	Time	Distance	Time
female	3.0	8.9	5.3	13.8
male	2.8	8.4	4.9	13.4

Table 5-18. Two-way ANOVA of log trip distance by gender and neighborhood type for personal service trips

Source of variation	Degree of freedom	Sum of Squares	Mean Sum of Squares	F value	P-value
Neighborhood type	2	14.7	7.335	8.223	<0.001 ***
Gender	1	0.4	0.385	0.432	0.511
Neighborhood type *gender	2	6.2	3.118	3.495	0.031 *
Residuals	1077	960.7	0.892		

Table 5-19. Two-way ANOVA of log trip distance by gender and neighborhood type for leisure trips

Source of variation	Degree of freedom	Sum of Squares	Mean Sum of Squares	F value	P-value
Neighborhood type	2	169.9	84.96	75.477	<0.001 ***
Gender	1	0	0	0.001	0.975
Neighborhood type *gender	2	2.7	1.37	1.215	0.297
Residuals	871	980.4	1.13		

Table 5-20. OLS regressions of trip distance (log) for personal services on gender for each of the three neighborhood types

	HU	HS	LS
Reference: male			
Female	0.443 *	0.008	-0.052
R2	0.034	0.000	0.000
N	179	397	507

Single parent

To investigate the effect of household structure on trip distance, the impact of being a single parent was tested using two-way ANOVA. No significant relationship across different types of neighborhoods and different purposes was found between single parents and the rest of the respondents (Tables 5-21 and 5-22). Therefore, the factor of being a single parent was excluded in the full model in the next section.

Table 5-21. Two-way ANOVA of log trip distance by neighborhood type and single parent for personal service trips

Source of variation	Degree of freedom	Sum of Squares	Mean Sum of Squares	F value	P-value
Neighborhood type	2	15	7.522	8.394	<0.001 ***
Single parent	1	0.1	0.137	0.153	0.695
Neighborhood type * single parent	2	0.3	0.150	0.167	0.846
Residuals	1056	946.3	0.896		

Table 5-22. Two-way ANOVA of log trip distance by neighborhood type and single parent for leisure trips

Source of variation	Degree of freedom	Sum of Squares	Mean Sum of Squares	F value	P-value
Neighborhood type	2	168.4	84.19	74.059	<0.001 ***
Single parent	1	0	0.04	0.036	0.85
Neighborhood type * single parent	2	0.4	0.18	0.159	0.853
Residuals	861	978.8	1.14		

Summary of findings

In this section, the focus is on the effects of single factors on trip distance, while considering possible interaction effects with neighborhood type and (or) purpose. The results demonstrated that purpose had significant effects on trip distance. People across different neighborhoods

generally traveled longer for leisure than for service and the variation of trip distance was larger for leisure than service trips. This might reflect a general willingness to travel longer for leisure activities.

Neighborhood type had strong effects on trip distance as well. Residents in high-density urban Detroit and Low-density Suburbs (HU and LS) traveled similar distances, and both traveled longer than residents in High-density Suburbs (HS). This shows that compact development of high-density, mixed land use and good road connectivity do not always have a consistent effect on reducing travel. The socioeconomic conditions at the neighborhood level could cancel out the effects of physical built environment on travel behavior. In poverty-concentrated, segregated minority inner-city neighborhoods, such as Urban Detroit, decades of disinvestment and decline have resulted in low access to amenities, leading to longer trip distances.

Among the individual sociodemographic characteristics investigated, all except being a single parent suggested some extent of interaction effect with either neighborhood type or trip purpose (or both). The elderly tended to travel longer trip distances than the middle-aged for leisure trips, but not for personal service trips. Income and race had significant effects on leisure trips in the suburbs, but not in Urban Detroit, and not for personal service trips in any of the neighborhoods. Also, gender had a weak effect on personal service trips in urban Detroit, but not in other neighborhood contexts, or for the purpose of leisure. These initial findings suggest that the impact of sociodemographic factors on trip distance vary by neighborhood environment and the types of travel purposes. This is important because it suggests that the same vulnerable population groups might experience transportation disadvantage in different or sometimes even opposite ways depending on the neighborhood context and what types of trips are involved. The individual effects

of these sociodemographic variables shown here will be further verified with the full multilevel model that considers all the factors simultaneously in the next section.

Table 5-23. Random intercept models (reduced) with neighborhood type as the only predictor

	All trips		Personal service trips		Leisure trips	
	Estimate	P-value	Estimate	P-value	Estimate	P-value
Intercept	0.503	<0.001***	0.432	<0.001***	0.589	<0.001***
Neighborhood type						
Reference: High-density Suburbs (HS)						
Urban Detroit (HU)	0.458	<0.001***	0.263	0.006***	0.785	<0.001***
Low-density suburbs (LS)	0.572	<0.001***	0.303	<0.001***	0.937	<0.001***
Model statistics						
Deviance	4887		2539.8		2197.9	
Variance components						
Fixed effect	0.072		0.02		0.201	
% total	6.3%		2.2%		15.6%	
Random effects						
Individuals level	0.121		0.121		0.187	
% total	10.5%		13.1%		14.5%	
Trip level	0.953		0.785		0.902	
ICC	11.2%		13.4%		17.1%	
N of individuals	634		520		453	
N of trips	1689		932		757	

Table 5-24. Random intercept models (full) with neighborhood type, sociodemographic variables and interaction terms as predictors

	All trips		Personal service trips		Leisure trips	
	Estimate	P-value	Estimate	P-value	Estimate	P-value
Intercept	0.476	<0.001***	0.368	<0.001***	0.579	0.000
Neighborhood type						
Reference: High-density Suburbs (HS)						
Urban Detroit (HU)	0.304	0.268	0.216	0.503	0.433	0.290
Low-density suburbs (LS)	0.428	<0.001***	0.373	0.005**	0.682	<0.001***
Household income						
Lowest-income/poor (0~20k)	-0.321	0.079	0.090	0.728	-0.638	0.005**
* HU	0.085	0.737	-0.320	0.331	0.325	0.356
* LS	0.569	0.083	-0.442	0.314	1.360	0.002**
Low-income (20~50k)	0.086	0.510	0.227	0.171	-0.045	0.800
* HU	-0.141	0.523	-0.045	0.864	-0.419	0.203
* LS	-0.317	0.097	-0.446	0.051	-0.065	0.813
Reference: middle- & high-income (>50k)						
Race						
Reference: white						
Non-white	-0.114	0.549	-0.050	0.838	-0.251	0.317
* HU	0.067	0.826	-0.220	0.554	0.686	0.111
* LS	0.367	0.128	0.187	0.534	0.548	0.101
Age						
Early young (< 26)	-0.116	0.441	-0.464	0.013*	0.173	0.398
Young (26-34)	0.132	0.144	0.057	0.623	0.150	0.216
Reference: middle-age (35-65)						
Young-old (66-79)	0.163	0.044*	0.066	0.484	0.329	0.007**
Old-old (80+)	0.146	0.299	0.050	0.755	0.477	0.031*

Table 5-24. (cont'd)

Gender						
Reference: male						
Female	-0.005	0.957	0.037	0.754	-0.021	0.875
* HU	0.410	0.026*	0.495	0.024*	0.265	0.329
* LS	0.181	0.180	-0.021	0.897	0.195	0.330
Model statistics						
Deviance	4858.2		2515.8		2162.9	
Variance components						
Fixed effect	0.094		0.046		0.259	
% total	8.1%		4.8%		19.7%	
Random effects						
Individuals level	0.107		0.115		0.146	
% total	9.2%		12.2%		11.1%	
Trip level	0.957		0.783		0.911	
ICC	10.0%		12.8%		13.8%	
N of individuals	634		520		453	
N of trips	1689		932		757	

5.4.2. Multilevel model of one-way trip distance (length) with multiple predictors

The reduced multilevel model with neighborhood type as the only predictor showed similar patterns as the OLS regressions on neighborhood type in the previous section (Table 5-23). Neighborhood type was influential on trip distance for both leisure and service trips. The percentage of variance explained by the predictor neighborhood type was comparable to the R^2 values in the OLS regression, with neighborhood type explaining the most variance in leisure trips but much less in personal service trips. There was large variation among individuals in terms of how far they traveled on average regardless of purpose or neighborhood type, as expressed in the random effect variance components (Table 5-23). For personal service trips, the random effect at the individual level accounted for a much larger variance (13.1% of total variance) than the fixed effect of neighborhood type. For leisure trips, the random effect at the individual level also accounted for a large percentage of total variance. Therefore, individual-level sociodemographic predictors were included in the full model to explain the variation among individuals (Table 5-24).

The full models included neighborhood type, sociodemographic variables and interaction terms as fixed-effect predictors. The sociodemographic variables included were household income, race, age and gender, which were found to influence trip distance in the prevous section. Interaction terms for income, race and gender with neighborhood type were also included as additional predictors. An interaction term for age and neighborhood type was not included for model parsimony, since it was found not significant in the previous section.

The results of the full models demonstrated varying effects of sociodemographic characteristics on trip distance between service trips and leisure trips and across different neighborhood types (Table 5-24). Except for race, the effects of sociodemographic variables pooled together generally

agreed with the findings on their individual effects in the previous section. First, the effect of being poor (household income less than $20k) had the strongest effect among all sociodemographic variables on leisure trips in terms of coefficient value and significance level in the suburbs. Being poor meant shorter trip distances in High-density Suburbs, possibly due to financial constraints, but longer trip distances in Low-density Suburbs for leisure activities, possibly due to the needs to travel outside wealthy neighborhoods to visit others with similar socioeconomic status or to reach more affordable destinations. However, being poor had no effect on trip distance in Urban Detroit, where all residents tended to travel long trip distances.

Second, age was found to have statistically significant yet modest effects on trip distance and the effects were different between service and leisure trips. The early young (below 26 years old) traveled shorter distances for service trips than the middle-aged group (35 to 65 years old). The retired groups, which include the young-old (66 to 79 years old) and the old-old (80 years old or above), traveled longer distances for leisure trips. Third, gender showed no effect on leisure trips but a positive effect for services in urban Detroit (HU), where women tended to travel longer trip distances to access personal services when compared to men. Lastly, contrary to the results from the analysis of race without controlling for other sociodemographic variables (Table 5-13), the effect of race in the Low-density Suburbs (LS) disappeared after controlling for other sociodemographic characteristics.

The variance components of the full models revealed that, overall, neighborhood type and sociodemographic characteristics had much larger effects on leisure travel than on personal service travel. The fix effects of neighborhood type and sociodemographic characteristics explained 19.7% of total variance in trip distance for leisure trips, but these factors explained only 4.8% of total variation in trip distance for personal service trips (Table 5-24).

Compared to the reduced model with neighborhood type as the only fixed-effect predictor, the full model with both neighborhood type and sociodemographic variables as fixed-effect predictors found a smaller random effect at the individual level. This held true for both the analysis on personal service and the analysis on leisure trips. It suggested that the fixed-effect predictors of sociodemographic factors had explained additional variation in trip distance. However, the overall improvement was very small, indicating that most of the variation at the individual level remained unexplained.

To test for the significance of the effect of adding sociodemographic factors on top of neighborhood type, the likelihood ratio test was performed to compare the reduced model and the full model. The result indicated that the full model was a significant improvement over the reduced model for leisure trips, but it made no significant improvement for personal service trips (Table 5-25). Overall, the total effect of sociodemographic variables on trip distance was much smaller than neighborhood type.

Table 5-25. Likelihood ratio test comparing the full model with the reduced model

	All trips	Personal service trips	Leisure trips
ch-2 statistic	28.768	23.978	35.056
Degree of freedom	16	16	16
P-value	0.026 *	0.090	0.004 **

5.5. Discussions

5.5.1. Purpose

The analysis finds that across the Detroit region, there is a much higher variation in one-way trip distances (length) for leisure than for personal services. People generally travel significantly longer distances for leisure than for personal service. There are two possible factors that affect the

variability in trip distance by purpose. First, spatial accessibility to different types of destinations may vary, due to the variation in the size of the market area for different types of amenities. Leisure amenities could have larger market areas on average than personal services. For instance, golf courses/clubs, movie theatres and malls typically have larger market areas and are more sparsely distributed than pharmacies or post offices, and people have to travel longer distances to access the former group of amenities. This was supported by the ReferenceUSA businesses data. As shown in the results, the total number of personal service destinations was much higher than the total number of leisure destinations in the Detroit region. This means that the personal service amenities are simply more densely distributed across the region, serving smaller market areas, as compared to leisure destinations. Thus, people tend to travel greater distances to reach leisure destinations when compared to personal services.

Second, people may be willing to travel farther for leisure activities than for personal services. As Næss (2006) illustrated, the decision making mechanism in destination choices, as a compromise of minimizing distance and receiving the best quality of service, varies by trip purpose. It is likely that in accessing some amenities, people mostly choose the nearest location (e.g., mailing a package at USPS or buying aspirin at a pharmacy); for others, the quality or personal preference matters more (e.g., travelling to a shopping mall, a bar, or a country club). Therefore, the difference in trip distances between reaching leisure versus personal service destinations in a typical week could also be partly explained by the fact that people tend to choose the nearest facilities for personal service, but the facilities with preferred qualities for leisure.

These two mechanisms are complementary and point to the applicability of central place theory (CPT) in explaining how trip distances vary by trip purpose (Christaller 1966 [1933]). According to CPT, different types of destinations are amenities (services) with different orders. Higher-order

amenities are those that provide services or goods that people are willing to travel longer distances for ("large range") and that require a large customer base ("large threshold"). As a result, these amenities have larger market areas. Examples include shopping malls with high-end brands and exclusive country clubs. In contrast, lower-order amenities are those that provide services or goods that people prefer to obtain with minimal distance travelled ("small range") and that require a small customer base ("small threshold"). As a result, these amenities have smaller market areas. Examples include pharmacies, ATMs, and post offices. Within this context, the longer trip distances to leisure destinations can be explained by the fact that these leisure activities are utilizing higher-order amenities on average than personal services and people travel longer to reach these goods and services.

However, there are also differences among different types of personal services. How people travel not only depends on whether the trip is for personal service or leisure, but also depends on the particular type of activity the trip is intended for. For instance, trips to pharmacies or banks are more sensitive to distance, while trips to health services or churches are more contingent on the quality or personal preferences. Due to the limitation of sample size, I am not able to test all the types of activities individually. Nonetheless, despite additional heterogeneity within each of the two broad nonwork trip purposes, the overall difference in trip distances between leisure travel and personal service travel is prominent and statistically significant.

5.5.2. Neighborhood environment

In accordance with the previous work (Ewing and Cervero 2010), this study has found that the neighborhood environment has a strong effect on people's trip distance (length) to various destinations. High-density suburban (HS) residents reported the shortest trip distances for both

services and leisure activities than low-density suburban (LS) residents (Tables 5-1 and 5-23), revealing the significant impact of the built environment, and more specifically, the synergistic effect of density, land use mix, and street connectivity in shaping travel.

However, the comparison of trip distances between residents in urban Detroit (HU) and in the High-density Suburbs (HS) shows that, given similar levels of density, land use mix, and street connectivity – commonly-measured dimensions of the built environment – people living in neighborhoods experiencing disinvestment have to travel longer trip distances to reach their destinations, compared with people in more vibrant, higher income neighborhoods. In fact, Urban Detroit residents reported similarly long trip distances as LS residents (Table 5-1). This reveals that high-density, land use mix and high street connectivity do not translate to shorter trips in urban Detroit, revealing that neighborhood socio-economic conditions can eclipse the effects of the built environment on travel behavior.

The pattern of longer trip distances in Urban Detroit can be attributed to low accessibility to amenities due to neighborhood-level socio-economic conditions – the disinvestment and decline being experienced in neighborhoods with high concentrations of low-income racial minority populations (Vojnovic et al. 2014; Vojnovic and Darden 2013). Although the physical built environment – with high densities, mixed land uses and highly connected street systems – is typically associated with better accessibility, the neighborhood socio-economic conditions in Urban Detroit resulted in much lower accessibility levels than typically expected given the urban form that characterizes these neighborhoods. These are the results of a complicated history, characterized by class and ethnic/racial intolerance and conflict that led to the suburbanization of the white population, commercial activity, and the tax base. These suburbanization processes facilitated higher city tax rates, more crime, and more expensive insurance premiums, which made

the costs of running a business in the city of Detroit higher, stimulating further rounds of disinvestment. As a result, despite similar built environment characteristics in terms of building density, land use mix, and road connectivity, the density of leisure and personal service destinations in the city of Detroit is lower than in the High-density Suburbs of Ann Arbor and Birmingham.

As explained in Chapter 3 on the study region, the adverse neighborhood socio-economic conditions in Urban Detroit are a result of suburbanization as well as historical racial and class discrimination, and particularly against the African American population. These processes left Urban Detroit with high rates if abandonment, vacant properties, and a concentration of residents, mostly African Americans, living in poverty. Although race at the *individual level* has no effect on resident's trip distance, the concentration of low-income African Americans at the *neighborhood level* impacts the neighborhood socio-economic conditions, which ultimately influences the trip distance (length) needed to access personal service and leisure amenities. Similarly, income at the individual level has no effect on trip distance in Urban Detroit. But poverty at the neighborhood level coupled with racial segregation influences how far people need to travel to access basic daily amenities. Simply put, within Urban Detroit, due to the scales of disinvestment and the resulting poor accessibility to basic amenities, a white middle-income resident living within the urban Detroit neighborhoods would likely have to travel similarly long distances to reach destinations compared with an African American low-income resident. But the concentration of low-income African Americans in Urban Detroit in highly segregated urban landscapes experiencing severe disinvestment largely explains why local residents have lower accessibility and thus longer trip distances. In fact, the travel patterns of residents in Urban Detroit

in accessing personal services and leisure destinations are similar to those of the suburban wealthy living in their exclusive and isolated residential enclaves.

In summary, the difference in travel patterns between local residents in Urban Detroit and the High-density Suburbs is due to varying neighborhood-level socio-economic conditions resulting from segregation by both race and income (class). This is an emergent outcome at the neighborhood level, as disadvantaged populations concentrate in specific areas (Kirby and Kaneda 2005). The lack of accessibility and the extra burdens of longer trips to reach personal services and leisure destinations in inner-city minority-concentrated poor neighborhoods of Urban Detroit confirms and extends the spatial mismatch theory to nonwork activities.

Despite the dire conditions of the neighborhood environment, the residents in Urban Detroit often have limited means to move. They are very much trapped in these lower southeast side Detroit neighborhoods. According to the survey used in this study, in terms of the reasons for living in the neighborhood, residents in the middle- to high-income white-majority suburbs often reported personal preferences for the neighborhoods, due to quality-of-life factors or the local school districts. In contrast, many residents in lower-income black-majority Urban Detroit neighborhoods reported their reasons as being the cheap price of property, inherited property or “no other choice”. As literature has already shown, black households living in low-income neighborhoods found it harder than whites to escape their inner-city neighborhoods and move to a socioeconomically better community (Gobillon et al. 2007). They are often trapped in low-income minority-dominant urban neighborhoods and are forced to experience lower accessibility and extra burdens for travel in such neighborhoods, even if they are actually willing to move out.

5.5.3. Interaction effect of purpose and neighborhood environment

The study found that the impact of neighborhood type on trip distance (length) was larger for leisure trips than for service trips in the Detroit region (Figure 5-4 and Tables 5-6 and 5-7). This finding of heterogeneity in the effect of the neighborhood environment on travel by trip purpose is consistent with previous studies (Elldér 2014; Salon 2015). One possible reason for the interaction effect of purpose and neighborhood type is the high density of personal services and the much lower density of leisure destinations across the Detroit region. Given the high density of personal services in all the neighborhoods, an additional increase in the density of personal services in some neighborhoods will slightly reduce trip distance but not that much. In contrast, since there are far fewer leisure destinations (about one tenth of the number of personal service destinations according to ReferenceUSA Historical Business data for the year 2008) in the Detroit region, trip distance for leisure destinations will be more sensitive to additional increases in the local density of leisure offerings. An additional increase in the amount of leisure destinations in the local neighborhood will likely significantly affect trip distances to leisure.

Regardless of the causal mechanism, the study here shows that the impact of the built environment is much stronger on leisure trips than on personal service trips. This has important practical implications. For planners and policy makers, one important goal is to reduce distance traveled to cut carbon emissions and promote efficiency and equity in transportation. This is often pursued by inducing changes in the built environment, such as increasing density or promoting diverse land uses. When evaluating the impact of the built environment on travel, it is important to distinguish different types of travel by trip purpose. Focusing on nonwork travel, including leisure and personal service trips, this chapter finds that leisure travel is more sensitive to changes in the characteristics of the built environment, as compared with personal service travel. Therefore, if the

goal is to induce changes in nonwork travel behavior, it may be more efficient to target leisure travel, such as promoting accessibility to leisure destinations by attracting more leisure activities to neighborhoods and fostering a better *leisure-housing balance*.

5.5.4. Individual-level sociodemographic characteristics

Sociodemographic characteristics at the individual level are generally considered to impact how far people travel in terms of trip distance (length). To understand the causal mechanism, one approach is to consider the constraints people face when choosing destination locations. There are three different types of constraints in the destination choice of a trip. The first is the spatial-temporal constraint that limits how far one can go in a particular journey (Elldér 2014; Hägerstrand 1970). Women and single parents are more likely to be spatial-temporally constrained due to household responsibilities. The second is the resource constraint, which limits the mobility of the poor since they have lower car ownership rates and are more sensitive to the costs of gasoline or public transit fares. The third is the physical constraint, which older people or the disabled are likely to experience due to loss of physical capabilities (Schmöcker et al. 2005). Given these constraints, one would expect that women and single parents, people in poverty, and the elderly are vulnerable groups who are disadvantaged socially as well as in mobility and will tend to travel shorter distances in their trips (Lucas et al. 2016).

However, this chapter shows that when controlling for neighborhood type, which accounts for both the physical built environment and the neighborhood-level socio-economic condition, vulnerable groups, such as racial minorities, the elderly, women and single parents, often do not show any reduction in trip distance. This means that their mobilities were not reduced by potential spatial-temporal, resources or capability constraints at the individual level, in terms of how far they are

able to travel to reach personal services and leisure destinations. The findings in the Detroit region suggest that how far an individual travels in a trip is determined primarily by trip purpose and where she lives (the neighborhood context), but not as much by her/his personal sociodemographic status, at least when it comes to accessing personal services and leisure destinations. This ultimately speaks to the importance of the neighborhood—and the amenities offered—where one lives.

Income

In the Detroit region, the impact of household income is only significant for leisure trips, but not for personal service trips. This reflects the fact that personal service trips are necessary in daily life while leisure activities are discretionary and thus more prone to changes due to resource constraints.

For leisure travel, income affects people's trip distance differently in different neighborhoods. In Urban Detroit, car ownership is a significant predictor for trip distance. When controlling for car ownership, residents with different income levels within Urban Detroit have similar trip distances. This means that, while Urban Detroiters collectively experience low accessibility and travel burdens due to neighborhood-level poverty and disinvestment (mean leisure trip distance is 6.2 miles) when compared to residents in High-density Suburbs with a similar physical built environment (mean leisure trip distance is 3.1 miles), Urban Detroiters themselves have similarly long trip distances regardless of their income levels.

In the suburbs, the effect of income in the High-density Suburbs runs contrary to the pattern in the Low-density Suburbs. In the High-density Suburbs, compared with middle- and upper-income residents (mean leisure trip distance 3.4 miles), lowest-income residents with annual household

income less than $20,000 reported shorter trip distances for leisure (mean leisure trip distance 1.3 miles). The lowest-income residents generally reported average trip distances of 1.0 mile for social visits, 0.9 mile for bars and cafes, 1.4 miles for libraries, and 1.6 miles for other leisure trips, compared to 4.7 miles, 1.4 miles, 2 miles, and 3.2 miles respectively by higher-income residents. This could be explained by the limited resources low-income residents have to reach further destinations (e.g., limited budgets to pay for gas, lack of time with multiple part-time jobs, or having to split car use with others in the house), combined with the easy access to various proximate amenities in the High-density Suburbs that enables them to meet their needs by using nearby facilities, instead of being forced to travel far like Urban Detroiters.

However, in the Low-density Suburbs, the lowest-income residents actually travel longer for leisure activities, which may seem counterintuitive at first glance. But considering that the Low-density Suburbs have the highest concentration of upper-income residents, local leisure destinations may tend to be high-end, expensive facilities which the poor cannot afford. This could be the reason that they have to travel outside the wealthy local neighborhood for leisure. And with the local physical environment characterized by low densities, single use zoning and disconnected street networks, they have little choice but to travel long distances to reach affordable leisure destinations.

In exploring the effect of household income at the individual-level, the findings on travel to personal services and leisure destinations reveal the complex nature of travel outcomes. Some studies have found that low-income populations have reduced mobility and shorter trip distances. Morency et al. (2011) showed that low-income people tended to travel shorter distances in trips across three Canadian cities. Lucas et al. (2016) also found a similar pattern in the UK. This chapter finds that the influence of income at the individual-level is complex, at least in the context of an

American metropolitan region with a declining urban core. While a negative impact of low incomes on trip distance was found to be present in the High-density Suburbs for leisure trips, this study shows that this effect may disappear, or go in the opposite direction, depending on the trip purpose or the neighborhood type. In the case of the Low-density Suburbs, the low-income residents within these neighborhoods have few alternatives but to travel greater distances than middle- and high-income groups to access appropriate leisure destinations. Therefore, the consideration of trip purpose and urban context is critical in understanding how income affects the way people travel.

Race

In the North American context, racial minorities tend to have lower socio-economic status than the whites and they are also more likely to concentrate in urban areas, a pattern particularly evident in Midwest cities. Therefore, race could be a proxy for the effects of other factors such as income and residential location. The analysis of race by neighborhood type and purpose showed that nonwhite minorities traveled longer for leisure activities in the Low-density Suburbs, although with a low statistical power. But when controlling for additional factors, such as household income in the full multilevel model, racial minorities did not show any significant disadvantage in terms of the distance traveled for leisure and personal services in the Detroit region, which is consistent with the findings by Lucas et al. (2016).

This indicates that, unlike neighborhood racial composition that has resulted in lack of accessibility and the subsequent long trip distances in Urban Detroit as discussed earlier, race at the individual-level does not affect how far people travel when controlling for neighborhood conditions. Simply put, there is a difference in trip distance between people living in a poor minority neighborhoods

and residents from affluent white neighborhoods, but there is no difference between minority and white residents living within the same neighborhood. Regardless, race is critical in understanding travel patterns in the Detroit region, as residential segregation has resulted in 90.7% of African Americans in the Detroit region concentrating in Urban Detroit. The extra burdens of travel in Urban Detroit are predominantly bore by African American populations.

Age

The current literature found that aging had an overall negative effect on trip distance when considering trips for all purposes (Crane 2007; Mercado and Páez 2009; Moniruzzaman et al. 2013; Schmöcker et al. 2005). In this study, nuances were found among trips for different purposes. The elderly reported similar trip distances as other population groups for personal services. But for leisure activities, being elderly was found to be associated with significantly longer trip distances for leisure, which is consistent with the finding of Schmöcker et al (2005). Retired and often with less household responsibilities, the elderly have more free time and less spatial-temporal constraints when compared to the middle-aged population subgroups. This allows them to travel further distances for leisure activities, and particularly if they are able to drive to these locations.

This finding indicates that the elderly in the Detroit region do not experience a significant decline in mobility in terms of trip distance, at least when it comes to accessing personal services and leisure destinations. As it will be revealed in the following chapter on frequency, total distance and travel mode, the elderly in the Detroit region stick to car as the major transport mode, as either driver or passenger. This enables them to reach far-away destinations, even with increasing physical constraints. Nonetheless, aging does influence other aspects of travel including decreased

frequency of leisure participation in Urban Detroit and a general decline in public transit use across different neighborhoods, as will be shown in the next chapter.

It is worth noting that the effect of age on leisure trip distance is consistent across the different neighborhood types in the Detroit region, unlike other individual-level characteristics such as income. This means that the retired take longer trips to leisure destinations, regardless of where they live. Also, the effect of age is present irrespective of the particular types of leisure destinations. So, the longer leisure trip distances by the old are *not* due to the types of activities they tend to engage in, but rather due to a general tendency to travel farther to access leisure destinations.

Gender and household structure

Contrary to the expectation that women and single parents tend to face more spatial-temporal constraints due to family responsibilities (Lucas et al. 2016), this study found no significant reduction of mobility in terms of one-way trip distance for women and single parents for leisure and personal services. There was no difference in how far single parents travel from the others for either leisure or personal services (Tables 5-21 and 5-22). Across neighborhoods, single parents had longer trip distances for leisure (mean trip distance 6.6 miles) than for personal services (mean trip distance 3.4 miles). This discrepancy in trip distance between leisure and personal service is similar to other population groups. It is surprising that single parents have similar trip distance patterns to the rest of the population given that single parents may tend to have strong spatial-temporal constraints due to their household responsibilities. But it might be due to the compensating effect that single parents have to do more chauffeuring for kids' activities. More studies are needed to understand the travel behavior of single parents.

A weak positive effect of being female has been detected for service trips among residents in urban Detroit. This effect can be explained by the fact that urban Detroit, due to the disinvestment, suffered from loss of amenities, while at the same time, women tend to do most of the daily family business trips, such as taking children to the doctor or dentist, and going to dry cleaners. With family needs for good-quality personal services, urban Detroit women simply have to travel longer distances. One caution to the finding about gender here is that women tend to have more complex trip chaining (Duncan 2016; Primerano et al. 2008). This might lead to a reduction of actual distance traveled than the home-to-destination distance.

5.5.5. General findings

In summary, one-way trip distance (length) has been found to be greatly impacted by the neighborhood environment and to a much lesser extent by individual sociodemographic characteristics. Furthermore, these effects are stronger for leisure trips than personal service trips.

The neighborhood type investigated in this study captures both dimensions of the physical built environment and socio-economic conditions. Both dimensions were found to be highly influential on trip distance, especially for trips to leisure destinations. The findings support previous studies that trip distance is strongly influenced by the neighborhood built environment (Ewing and Cervero 2001, 2010). Residents in High-density Suburbs travel much shorter distances than residents in Low-density Suburbs. Meanwhile, trip distance is strongly influenced by neighborhood socio-economic conditions, to an extent comparable to the neighborhood built environment. Lower-income African American residents living in Urban Detroit neighborhoods experiencing disinvestment travel longer distances, in fact greater than those traveled by high-density suburbanites, despite living in similar built environments – characterized by high-densities,

mixed land uses and high-connectivity – and this reflects the shuttering of amenities in communities experiencing decline. In fact, while residents in High-density Suburbs reported short trip distances to access both personal services and leisure destinations (the mean is 2.8 miles), residents in Urban Detroit and in Low-density Suburbs reported similarly long trip distances (the means are 4.4 miles and 4.9 miles respectively). The statistical test showed that there was no significant difference in mean trip distance between Urban Detroit and the Low-density Suburbs (Tables 5-1 and 5-4).

The majority of residents in Urban Detroit (90.4% of all respondents) are African Americans with lower income levels (annual household income less than 50,000). More than half of them live below the poverty line and reported annual household incomes of less than 20,000. This means that the adverse socio-economic conditions and the burdens of travel in Urban Detroit are disproportionately experienced by low-income African American populations sub-groups. This finding adds additional evidence to the spatial mismatch theory, which maintains that suburbanization processes, and particularly white flight, have facilitated a spatial separation of disadvantaged population groups from basic opportunities needed. Empirical results have demonstrated that low-income minorities populations concentrate in urban neighborhoods due to residential segregation, without daily proximate destinations to be found within their communities, whether jobs (Kain 1992), major supermarkets (LeDoux and Vojnovic 2013), healthy restaurant options (Eckert and Vojnovic 2017), or, as demonstrated in this research, leisure facilities and personal services destinations.

The effects of individual-level sociodemographic characteristics are overshadowed by the impact of the neighborhood-level built environment and wider socio-economic conditions of these communities. Also, the effects of individual sociodemographic characteristics are particularly

weak for personal service trips (Table 5-25). Nonetheless, knowing how sociodemographic characteristics are related to trip distance is still important for fully understanding and addressing challenges faced by disadvantaged population subgroups, particularly those living in neighborhoods experiencing urban disinvestment. Contrary to some previous findings in other urban contexts (Lucas et al. 2016; Morency et al. 2011), this study has shown that, when controlling for the type of their residential neighborhood, disadvantaged populations do not always experience reduced mobility in terms of trip distances. In fact, in some cases, disadvantaged population groups, including the poor in Low-density Suburbs, women in Urban Detroit, and the elderly throughout the Detroit region, reported longer trip distances than their neighbors within the same community This can happen when nearby services and leisure facilities within the neighborhood do not meet the needs of these population groups, due to affordability (as in the case of the poor in the wealthy Low-density Suburbs) or due to the preference for higher quality amenities (as in the case of women accessing personal services in Urban Detroit). This could result in an extra layer of burdens associated with travel, on top of those already existing for residents living in neighborhoods experiencing decline, where large numbers do not have access to a car and the fear of crime is high. Such is the case for African American women in Urban Detroit, who likely have lower incomes and no car access, but have to travel longer distances to access decent-quality personal services (mean trip distance of 3.5 miles) compared to men in the same neighborhoods (mean trip distance of 2.7 miles) and women in other neighborhoods (mean trip distance of 2.6 miles in the High-density Suburbs and 3.2 miles in the Low-density Suburbs).

Lastly, similar to previous studies (e.g. Elldér 2014; Lucas et al. 2016), the findings in this research show that the effects of various factors on trip distance are not stable across different types of travel or different neighborhood contexts. Rather, the effects of the neighborhood environment on

trip distance vary by trip purpose, and the effects of individual-level sociodemographic characteristics on trip distance vary by both trip purpose and neighborhood type. Thus, it is important to always be conscious of how various factors affect travel outcomes for different trip purposes or in different urban contexts. It cannot be assumed that the findings in one neighborhood or for a specific purpose of travel automatically apply in other cases. For instance, the effect of neighborhood type is significantly stronger for leisure trips than for personal service trips. Also, higher incomes at the individual level are associated with longer distances of leisure trips in the High-density Suburbs, but shorter distances in the Low-density Suburbs. Neglecting these nuances could risk making incorrect inferences on the travel behavior by certain populations. Despite existing research efforts, this issue has not yet received enough attention. More studies are needed to further explore this heterogeneity.

5.6. Conclusion

This chapter examines one-way trip distance (length) in the Detroit region, and it finds that trip distance varies by trip purpose, neighborhood type, and individual-level sociodemographic characteristics. First, Leisure trips tend to be longer and have more variation in trip distance than personal service trips. One-way distances for leisure trips are significantly affected by the neighborhood environment and individual-level sociodemographic characteristics, while the impact on personal service trips is not as significant.

Second, high-density, mixed use and highly-connected neighborhood environments are generally associated with shorter trip distance, but this effect disappears in neighborhoods experiencing disinvestment and decline, populated by low-income, minority residents. The concentration of low-income minorities and the disinvestment in inner-city neighborhoods has resulted in a spatial

mismatch of residents from various opportunities, with residents not only travelling extensive distances to access jobs, but also to reach a wide range of amenities necessary for their daily lives, including to access pharmacies and banks (Kain 1992; LeDoux and Vojnovic 2013; Vojnovic et al. 2014). This leads to added transportation burdens for most disadvantaged population groups in the region (Vojnovic et al. 2014).

Third, individual-level sociodemographic variables also influence trip distance albeit with a much weaker effect compared with neighborhood type, at least when it comes to travel to personal services and leisure destinations. Compared to their neighbors in the same community, socially disadvantaged groups – the poor, single parents, the elderly and women – do not necessarily have reduced mobility given the travel constraints they may face. The free time the retired elderly have counteracts the negative effect of physical constraints for leisure travel. Also, women have longer trip distances (the average 3.4 miles) than men (the average 2.7 miles) in urban Detroit to personal services. Moreover, the poor have longer trip distances (the average 14.8 miles) than the nonpoor (the average 6.7 miles) in wealthy Low-density Suburbs to leisure destinations. These population groups experience added burdens in travel, increasing costs (temporal and monetary) required to meet their daily needs.

An issue that remains is the current lack of understanding of the exact mechanism(s) behind why one-way trip distance vary by purpose and neighborhood type. Some of the probable reasons have been explained in the previous section, in the Discussions. To further pursue this question, in Chapter 7, I will focus on a particular personal service – pharmacies – and explore accessibility and actual travel patterns including destination choices and one-way trip distances across the different Detroit region neighborhood types.

Besides one-way trip distances, weekly total frequency of trips and total distance traveled by different modes are also key dimensions of travel behavior. Weekly travel and mode are important aspects of a person's daily life, reflecting one's access to amenities, activity participation, and active travel, as well as broader issues of health, carbon emissions and air pollution. Therefore, the next chapter will examine weekly total frequency of trips and total distance by different modes of travel, as well as the associated factors of neighborhood type, trip purpose and individual sociodemographic variables.

Chapter 6. The Influence of Neighborhood, Sociodemographic Characteristics and Purpose on Personal Service and Leisure Travel: Frequency, Total Distance, and Mode

6.1. Introduction

Daily travel behavior is important to understand given its role as an integral part of our daily life. Considerable effort has been devoted to understanding how the built environment impacts the amount of travel by car and alternative modes of transportation, with the goal of reducing car use and the associated carbon emissions and air pollution, as well as promoting active travel for broader health benefits (Ewing and Cervero 2001, 2010; Smith et al. 2017). Also, an increasing amount of research has examined the variation in travel behavior among different sociodemographic groups, to identify any inequity in mobility and accessibility that may be faced by vulnerable populations, such as the elderly, women and low-income groups (Lucas 2012; Luiu, Tight, and Burrow 2017; de Madariaga 2013).

While the influences of the neighborhood built environment and sociodemographic characteristics on travel behavior have been increasingly studied, less is understood about how these effects may vary by trip purpose (Dieleman et al. 2002; Elldér 2014). Furthermore, extensive studies on travel behavior have been based in dynamic urban areas, where abundant resources have been invested on surveys of residents, but far less interest has been paid to the more disadvantaged populations. Research in neighborhoods experiencing disinvestment, as in the city of Detroit, which has suffered from a declining economy, deterioration in urban infrastructures, abandonment and sharp reductions in population are less prominent in the existing literature. To fill this gap in the literature, this dissertation examines the travel behavior of residents in the Detroit region, comparing low-income urban neighborhoods to high-income suburban neighborhoods, in order to analyze how

travel for personal services and leisure activities varies by purpose, neighborhood environment and sociodemographic characteristics.

In the previous chapter, how far people traveled to reach their destinations—i.e., one-way trip distance (trip length)—was explored. In this chapter, I will focus on another dimension of travel behavior, which is how much people travel for leisure and personal services[3], with the consideration of weekly frequency and weekly total distance by each mode. Trip generation as measured by trip frequency reflects travel demand and how much people participate in various activities. Lower trip frequencies by vulnerable population groups could reflect a lack of mobility, poor access to amenities and social exclusion due to the inability to participate in economic, social, cultural and political activities that are available to the rest of the population (Lucas 2012). Total distance is the sum of distances traveled – one-way trip distance (length) times two (from home to the location and then back) and then times trip frequency within a given time period– for all destinations visited by an individual. Higher values in total distance traveled by residents in a particular neighborhood could be a result of poor accessibility in an auto-oriented, low-density, isolated suburban residential enclave or a result of disinvestment and the loss of amenities in an urban neighborhood confronting disinvestment and decline. Trip frequency and total distance by

[3] Dining-out trips and grocery trips are excluded from this study. These trips have been explored in other studies using the same dataset (Eckert and Vojnovic 2017; LeDoux and Vojnovic 2013, 2014).

different transportation modes are also important travel outcomes, as the amount of travel by car is associated with energy consumption, carbon emissions and air pollution more widely, while the amount of active travel by walking and biking is linked to physical health. Understanding travel mode patterns can help policy makers frame programs to reduce car use and promote alternative, healthier lifestyles through more active travel, such as walking and biking.

6.2. Background

6.2.1. Purpose

How travel behavior varies by trip purpose is underexplored in the current literature. As illustrated in the previous chapter, there are two ways travel behavior varies by purpose. First, purpose impacts how often people travel to specific destinations (the frequency), which impacts how much total distance they travel over a given period of time (daily/weekly/monthly) and what mode of travel they select. The total distance traveled for leisure was found to be higher than for personal services (Elldér 2014). Also, it was found that car use is prominent for work and shopping, but alternative modes are more likely to be used for school, dining-out, and social and recreational trips (Kim and Ulfarsson 2008; Lanzini and Khan 2017).

Second, the effects of various factors on travel behavior may vary by trip purpose as some studies have already shown. For example, Elldér (2014) found that the influence of the residential neighborhood on total daily distance traveled was stronger on travel for work and services than for leisure. Meurs and Haaijer (2001) showed that the effect of the built environment on modal choice was significant for shopping and social or recreational purposes, but not for commuting trips to work. Also, some studies have revealed that the effects of sociodemographic characteristics on travel outcomes differ by trip purpose. Lee, Vojnovic, and Grady (2018) found that the effect of

gender on trip generation (frequency) and total distance traveled varied by both purpose and neighborhood type in the Detroit region. Focusing solely on the disabled and the elderly in London, Schmöcker et al (2005) found that those with lower incomes made fewer leisure trips, but income had no significant effect on other types of trips, including work, personal business and shopping.

The existing evidence suggests that travel outcomes do vary by trip purpose, and so do the effects of the built environment and sociodemographic characteristics. It is also clear that a simple distinction between work travel and nonwork travel alone cannot reveal the complete picture of travel among the U.S. urban population, as nonwork travel behavior may vary by the specific purpose of the trip. More evidence is needed to better understand the heterogeneity in travel behavior among various purposes.

6.2.2. Neighborhood environment

The impacts of various dimensions of the built environment on travel outcomes has been extensively studied over the past three decades. The consensus is that compact development patterns with higher densities, mixed land uses, well-connected street networks and pedestrian-friendly designs reduce trip frequency and total distance traveled by car (VMT), while encouraging non-automobile travel (Boarnet et al. 2011; Cao, Mokhtarian, and Handy 2009a; Ewing and Cervero 2001, 2010; Ewing and Hamidi 2015; McIntosh et al. 2014; Stevens 2017). However, there are fewer studies focused on how the changes in the amount of automobile travel and non-automobile travel add up to total travel. Some found that compact developments had no significant effect on the number of trips in total, but rather led to a replacement of car trips by non-auto trips (Kitamura, Mokhtarian, and Laidet 1997). However, others found that compact developments were

associated with an increase in the number of trips in total as well as an increase in non-automobile trips (Cao 2014; Guo, Bhat, and Copperman 2007; Zhang et al. 2019).

In addition, neighborhood socioeconomic conditions could influence the effect of the built environment on travel behavior. Freeman et al. (2013) found that the impacts of neighborhood built environment on the amount of active travel (walking and biking) was stronger for residents living in high-income neighborhoods, even after controlling for individual-level sociodemographic characteristics. Moreover, Kotval-K and Vojnovic (2016) showed that compact development in the disinvested community of Urban Detroit was not translated to less total distance traveled as it was in wealthier neighborhoods with similar built environments.

6.2.3. Individual-level sociodemographic characteristics

Individual sociodemographic characteristics have been found to influence various travel outcomes. The nature of these relationships has received increasing attention over the last two decades. Efforts have been made to understand the travel behavior of particular sociodemographic subgroups, such as the elderly, the poor, and women, who could face potential transportation disadvantages (Lucas et al. 2016; Pyrialakou et al. 2016).

Age

With the aging of populations in all developed countries and many developing countries, the travel behavior and mobility distinctions between the young and elderly have been widely studied over the past two decades. In the existing literature, aging was found to be associated with a lower likelihood to make any trip as well as a reduction in the total frequency of trips (Boschmann and Brady 2013; Corran et al. 2018; Páez et al. 2007; Roorda et al. 2010). Also, some studies found that compared with younger people, older people drove less in terms of frequency and total

distance traveled by car (VMT), and used alternative modes more often (Böcker, van Amen, and Helbich 2017; Cao, Mokhtarian, and Handy 2010; Schwanen and Páez 2010). In addition, heterogeneity in travel behavior was found within the older population. Travel behavior among the elderly was found to vary by sociodemographic characteristics, such as income and gender, as well as disability and also the residential built environment (Boschmann and Brady 2013; Cao et al. 2010; Chudyk et al. 2015; Habib 2015; Schmöcker et al. 2005, 2008; Schwanen et al. 2001; Winters et al. 2015).

As to travel patterns for specific purposes, the effects of aging are not conclusive and different results were found in different studies. Based on national travel data in the Netherlands, Schwanen and colleagues found that both the total frequency of leisure trips (social visits, recreation and participation in sports, leisure walking and shopping) as well as the total frequency of non-leisure trips declined with age (Schwanen et al. 2001). In Northern California, Cao et al found that while the elderly made fewer trips for physical activity purposes and going to restaurants, they made more trips for personal services, such as church, shopping destinations and banks (Cao et al. 2010). However, there have been other studies which found that unlike work trips, the number of trips for going to church, social activities, eating, sports, and entertainment did not actually decrease much as people got older (van den Berg et al. 2011; Pettersson and Schmöcker 2010). In fact, Rosenbloom (2001) found that, in wealthy western countries, the young elderly (who are in their late 60s and early 70s) had more nonwork trips than the young and the middle-aged groups. However, as they reached their 80s, the number of non-work trips decreased. Additional evidence from various urban contexts is needed before conclusions can be drawn.

Moreover, the effect of aging on travel outcomes depends on the built environment. Aging was found to reduce the number of driving trips, and this effect was greater in traditional urban

neighborhoods than in the suburbs, where the former type of environment was more conducive to pedestrian travel (Cao et al. 2010). Also, a neighborhood environment characterized by high density, mixed land uses, high connectivity and good accessibility to transit and shopping destinations was found to promote walking, and this effect is stronger for the elderly than younger populations (Cao et al. 2010; Cheng et al. 2019).

Lastly, it is worth noting that social institutions and cultural norms are also important in understanding how aging affects travel outcomes (Schwanen and Páez 2010). This necessitates the study of aging in different urban contexts, beyond wealthy urban regions with dynamic and robust neighborhoods in high-income countries. For instance, Feng (2017) shows that urban Chinese elderly, mainly traveled by walking and public transit, and rarely used cars, compared with their counterparts in western countries. Even within high-income countries, there is huge discrepancy in socioeconomic status among different neighborhoods within cities and potentially considerable differences in daily travel patterns among elderly residents in neighborhoods of different class standings.

Income

Low-income population subgroups are generally considered to be not only socially disadvantaged, but also transport-disadvantaged, and less mobile due to their lack of financial resources (Lucas et al. 2016; Pyrialakou et al. 2016). Lower income levels have been found to be associated with fewer trips and less total distance traveled in a number of different urban contexts (Blumenberg and Pierce 2012; Lucas et al. 2016; Roorda et al. 2010). Also, people in poverty are more likely to make no trips at all on a given day (Corran et al. 2018). Moreover, income impacts mode choice, with both direct effects and indirect effects through car ownership. People with lower incomes

tend to travel less by car and more by non-automobile modes, such as public transit, biking and walking (Dieleman et al. 2002; Ewing et al. 2015; Kotval-K and Vojnovic 2015; Paulley et al. 2006; Pucher and Renne 2003).

There is less research on how the effect of income varies by purpose of travel or neighborhood built environments. Income was found to affect the frequency of recreation trips, including trips for entertainment, sports and social activities among the elderly, but it had no effect on other types of trips (Schmöcker et al. 2005). Also, the effect of income on mode of travel was found to be only present in neighborhoods characterized by high densities, mixed land uses and high connectivity, but not in auto-oriented Low-density Suburbs, where the built environment forced all trips to be taken by car (Kotval-K and Vojnovic 2015). Additional evidence is needed to explore the heterogeneity in the effect of income on trips of different purposes and in different neighborhood environments.

Gender

Although the travel behavior of women and men has been converging, with women increasingly driving more, a gender gap in travel is still present and significant (Crane 2007; Frändberg and Vilhelmson 2011). Women tend to travel less total distance, drive less and make more walking trips (Goddard et al. 2006; Lu and Pas 1999). However, the gender differences in travel outcomes also depend on the trip purpose. Women were found to make fewer trips for work and leisure, but more trips for shopping, which reflected the expected gender roles (Crane 2007; Lucas et al. 2016; Mcguckin and Fucci 2018). Women's travel is influenced by household structure as women take more responsibilities in household duties. Women with young children are more reliant on the car, travel longer total distances and make more chauffeuring trips (Goddard et al. 2006; Lee et al.

2018). Regarding neighborhood characteristics, women's travel patterns were found to be more sensitive to neighborhood safety but less sensitive to neighborhood accessibility to leisure destinations (Goddard et al. 2006).

6.3. Data and methods

6.3.1. Data

To explore and compare the travel patterns, focusing on trip frequency and total distance, data from the 2008 NSF Detroit travel survey were used in this analysis. The survey sampled residents across three types of neighborhoods – Urban Detroit, High-density Suburbs, and Low-density Suburbs – all located in the Detroit region. The data are described in detail in Chapter 4 Study Site and Data, but some of the major points will be repeated here, as a reminder. If a household sent back more than one survey response, only one was kept to avoid interdependency of the responses, since intra-household dynamics are not considered in this study. Outliers were also removed, including trip destinations with a frequency of more than 14 times a week and one-way trip distance larger than 50 miles. It was considered unrealistic for someone to visit the same leisure or personal service destination more than twice a day throughout a typical week. A few trips with one-way trip distance of 50 miles or more were treated as outliers and removed. Respondents who gave incomplete information or no information on trip frequency or the one-way trip distance on any of their reported destinations were also dropped. After these steps, I got a final dataset with complete information for 576 respondents with 1856 trips.

6.3.2. Variables

Dependent variables: travel outcomes

In this chapter, multiple travel outcomes were investigated. Each of the dependent variables was explored for leisure travel and personal service travel separately. First, to study how often people travel, weekly total frequency by all transport modes was examined. To understand the mode use in terms of frequency, weekly total frequencies by automobile and by non-auto modes of travel (public transit, walking and biking) were modelled separately as well.

Second, to study how much distance people travel, weekly total distance traveled by all transport modes was modeled. To understand the mode use in terms of distance traveled, total distance by automobile and total distance by non-auto modes were also modelled separately. Instead of using the original value, the logarithm of total distance plus 1 was used as the dependent variables in the analyses to correct for the skewed distribution and to approximate a normal distribution for unbiased estimates in the OLS regression. The value of 1 was added to avoid any null value generated after taking the log transformation. This can happen when a respondent reported no trip at all for a specific trip purpose and thus has 0 for total distance traveled, or reported no trip traveled by a specific mode and thus has 0 for total distance traveled by this mode. The log-transformation was applied to the three total distance variables for travel by auto, non-auto, and all modes.

Independent variables

Neighborhood type

Neighborhood type was tested for the influence of the neighborhood environment on frequency and total distance for leisure and personal service travel. As explained in previous chapters, three types of neighborhoods were sampled, which represent two dimensions – the built environment

and sociodemographic conditions. The neighborhoods include: 1) two Urban Detroit neighborhoods (HU) with high-density mixed-use built environments and a concentration of African Americans, with many living in poverty; 2) two High-density Suburbs (HS), neighborhoods in Ann Arbor and Birmingham, with similar high-density mixed-use built environments as in urban Detroit, but with a relatively wealthy white-majority population; and 3) two Low-density Suburbs (LS), neighborhoods in Bloomfield Hills and West Bloomfield, with a low-density and largely single-use built form, and a relatively wealthy white-majority population.

Sociodemographic characteristics

This study included three sociodemographic characteristics as independent variables. First, annual household income was included as a categorical variable, with three income levels – lowest-income/poor (less than $20,000), lower-income ($20,000 - $49,999), and middle and upper-income ($50,000 or more). Second, age was included to test the effect of aging on travel. In the previous chapter, age was included as a categorical predictor to capture the non-linear effects of age on one-way trip distances. In this chapter, preliminary results showed that aging has a linear effect on both total frequency and total distance across all neighborhoods. Therefore, age was treated here as a continuous variable. This also helped reduce sample size requirements given the limited number of observations for each type of neighborhood at the respondent-level. Third, gender was included to test if the amount of travel was affected by gender roles.

6.3.3. Model specifications

Since weekly trip frequency was a count variable, which was discrete and did not follow a normal distribution, instead of using OLS regression, I used negative binomial regression to deal with dispersed count data that had a much larger variance than the mean and thus did not follow a

Poisson distribution. Efron's R^2, a type of pseudo R^2, was used to measure how much variance was explained by the model predictions. Also, I used OLS regression to model the weekly total distance traveled with a log transformation. Besides presenting descriptive statistics, separate groups of analyses were performed on each of the three types of neighborhoods, to explore the effects of sociodemographic characteristics on travel patterns and how the effects may vary by neighborhood environment, For each neighborhood type, negative binomial regressions and OLS regressions were applied to simultaneously model the effects of income, age and gender on the amount of travel residents reported, including weekly trip frequency by modes and in total as well as weekly total distance traveled by modes and in total.

6.4. Results

Overall, the results showed that, the amount of travel – the weekly total distance and frequency of trips – in total as well as by mode varied by the purpose of travel, neighborhood type, and sociodemographic characteristics. Also, the effects of neighborhood type varied by trip purpose, and the effects of sociodemographic characteristics – which includes income, age, and gender – varied by both trip purpose and the type of neighborhood.

6.4.1. Travel patterns by purpose

Travel patterns were different between the two purposes examined – leisure and personal services. For weekly trip frequencies, residents in the suburbs reported making more trips for leisure activities than for personal services, while residents in Urban Detroit reported making more trips for personal services (Figure 6-1). This could be attributed to differences in lifestyle, accessibility and resources between residents living in declining inner-city neighborhoods and those living in much wealthier suburbs.

For weekly total distance traveled by each purpose, across all neighborhoods, residents traveled significantly more distance for leisure than for personal services (Figure 6-2). This is expected given that residents reported much longer one-way trip distances for leisure across all neighborhoods, as found in the previous chapter.

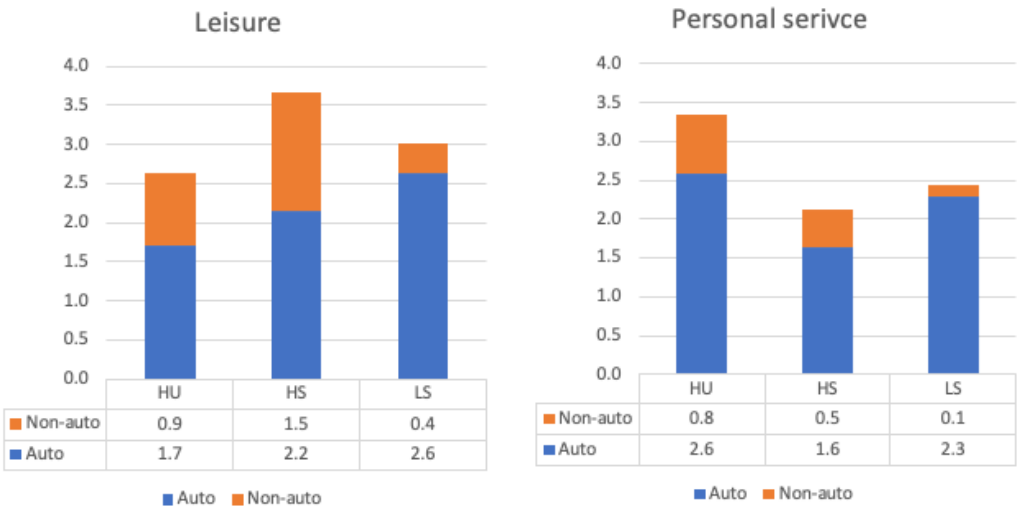


Figure 6-1. Average weekly frequency of trips per respondent, by purpose and neighborhood type

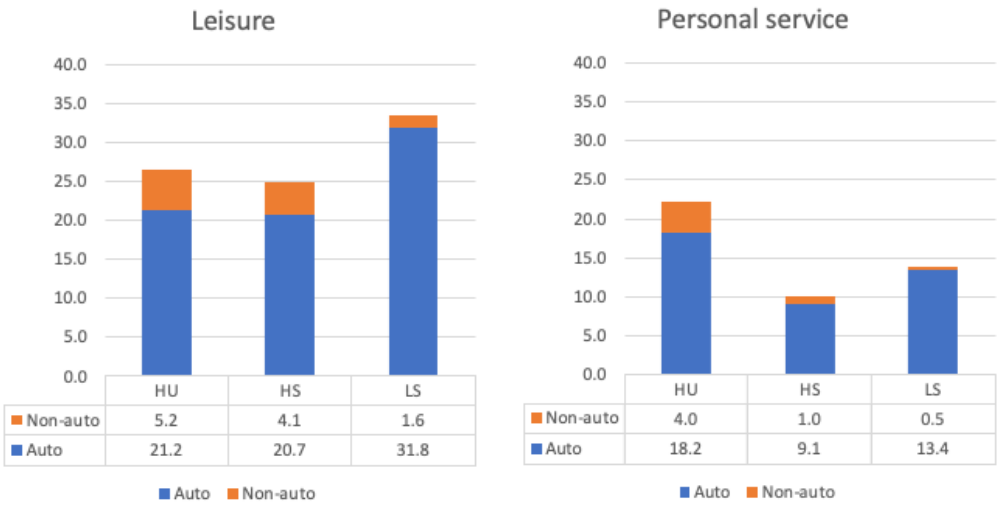


Figure 6-2. Average weekly total distance traveled per respondent, by purpose and neighborhood type

Across all neighborhoods, people reported more travel using non-auto modes for leisure activities than for personal services. As shown in Figures 6-1 and 6-2, the share of travel by non-auto modes – in terms of both weekly trip frequency and total distance – was generally higher for leisure activities than for personal services. In addition, a breakdown of leisure and personal service trips by the detailed types of activities showed that people utilized non-auto modes of walking, biking or transit more often for trips that involved going to bars and cafes, fitness facilities, recreation (i.e., parks), libraries, and visiting friends and family, compared to other leisure activities (Figure 6-3). Given the nature of these activities and the proximity of associated amenities, people may find it easier, and/or more enjoyable, to walk or bike to these places.

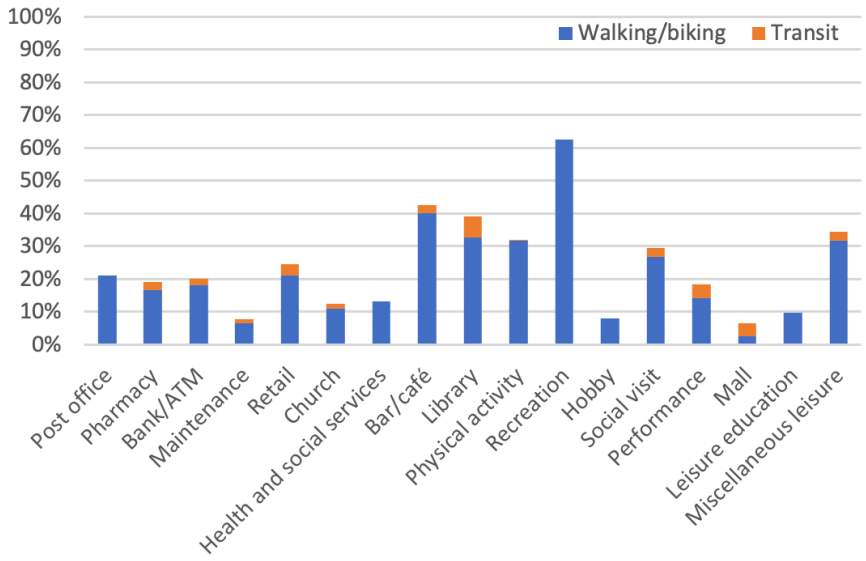


Figure 6-3. Percentage of non-auto trips, by mode and by detailed activity type (level 2 purpose)

6.4.2. Travel patterns by neighborhood type

Compared to residents in other neighborhood types, residents in the High-density Suburbs made the most trips to leisure destinations, but the least trips for personal services, despite good access and short one-way distance to personal service providers (Figure 6-1). A further breakdown of

trips by the types of activities (Figure 6-4) illustrated that residents in the High-density Suburbs reported the most trips to fitness facilities, bars, cafes, parks and museums, and reported the least trips to two major personal service destinations – pharmacies and churches. In contrast, and as already noted, residents in Urban Detroit traveled the most trips for personal services, but the fewest trips for leisure (Figure 6-1). More specifically, Urban Detroit respondents reported the most trips to churches, pharmacies, retail stores, and financial services, yet made few leisure trips, with visits to malls and friends and families dominating their leisure destinations (Figure 6-4). The variation in trip frequency by neighborhood and purpose is likely a result of lifestyle differences and disparities in accessibility and resources among residents in the different types of neighborhoods.

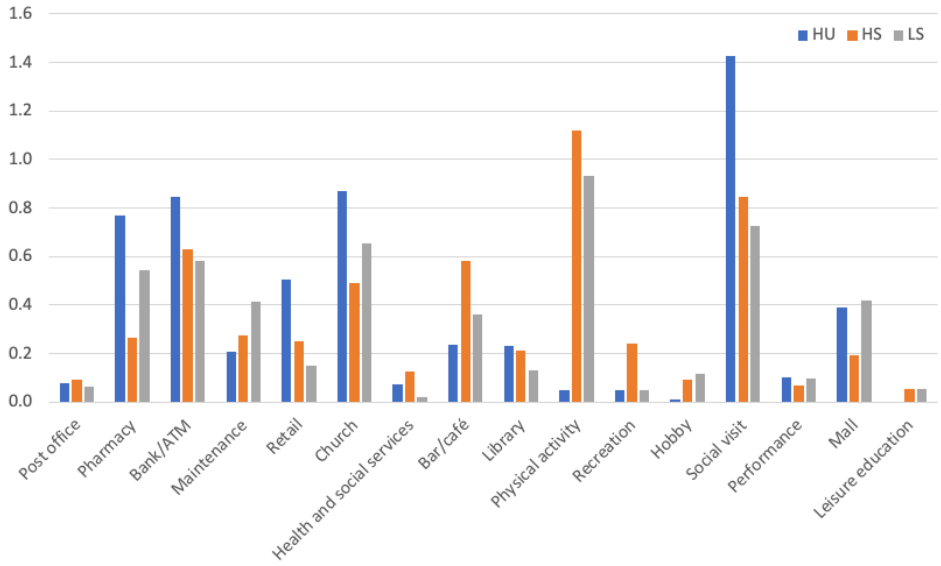


Figure 6-4. Average weekly trip frequency by detailed activity type (level-2 purpose) and neighborhood type

As to the weekly total distance traveled, this value depends on two variables, the total number of trips (frequency) and the two-way distance to the destinations and back home, which is twice the

one-way trip distance (length) as studied in the previous chapter. Both variables are influenced by neighborhood type. Residents in Low-density Suburbs reported the longest total distances traveled in a typical week for leisure (Figure 6-2). This is expected as they have the longest one-way trip distances on average, as shown in the previous chapter. Residents in Urban Detroit reported the longest total distance traveled for personal services, which can be attributed to both their long one-way trip distances and high trip frequencies (Figure 6-2). Their average weekly total distance traveled for leisure was similar to that traveled by residents living in the High-density Suburbs, but much lower than for the low-density suburban residents (Figure 6-2). However, more respondents in Urban Detroit (27%) reported no leisure travel at all compared with respondents in the High-density Suburbs (10%) (Figure 6-5). For the rest of the respondents who did travel at least once for leisure in a typical week, the average total distance traveled was actually much higher in Urban Detroit (37.4 miles) than in the High-density Suburbs (27.6 miles) (Figure 6-6). In part, this reflects the poor access to amenities that results in longer one-way trip distances (length), despite the high-density physical built environment in Urban Detroit, as recognized in the previous chapter. Residents in the High-density Suburbs reported low total distances traveled in a typical week for both leisure and personal services (Figure 6-2). This is expected, given the high residential densities, the rich land use mix and highly connected street networks within these neighborhoods. It matches the findings in the previous chapter, showing that trips are generally much shorter in length, i.e., one-way trip distances, in the High-density Suburbs.

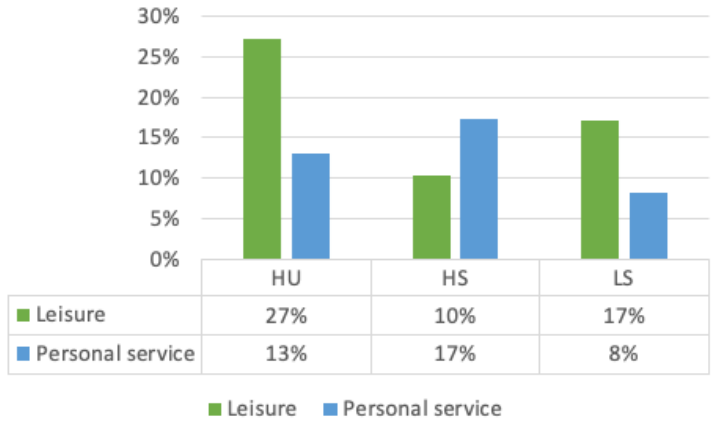


Figure 6-5. Percentage of respondents who reported no travel, by purpose

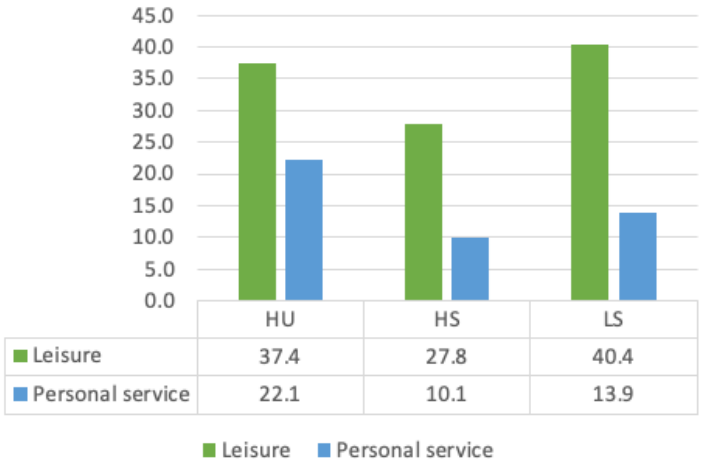


Figure 6-6. Average weekly total distance for respondents who reported any travel, by purpose and neighborhood type

As to the mode of travel, residents in the high-density neighborhoods, both urban and suburban, had significantly more non-auto travel – they were far less reliant on the car – than residents in low-density neighborhoods (Figures 6-1 and 6-2). This, in large part, reflects the impact of the built environment on mode choice. A more detailed examination of the data shows that although residents in Urban Detroit and in the High-density Suburbs had comparable levels of non-auto

travel, Detroit residents had a higher percentage of trips by transit, while the Ann Arbor and Birmingham respondents had a higher percentage of trips by walking and biking (Figure 6-7).

OLS regressions on mode share percentage of trips by neighborhood type and sociodemographic characteristics (results not shown) indicated that, the differences in the modal shares of transit and of walking/biking between Urban Detroit and high-density neighborhoods remained significant even after controlling for individual-level variables of income and age. This, in part, could be attributed to safety concerns of walking/biking reported by residents in Urban Detroit, which were data also collected in the survey.

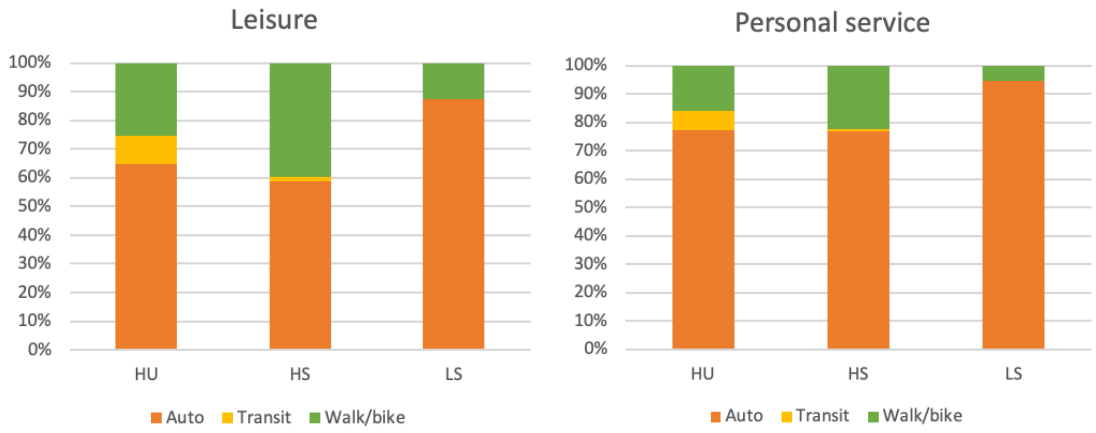


Figure 6-7. Percentage of trips by mode, neighborhood type and trip purpose.

Table 6-1. Negative binomial regressions of weekly trip frequency by sociodemographic characteristics for Urban Detroit (N=92 respondents)

	Leisure						Personal service					
	Total		auto		non-auto		Total		auto		non-auto	
	b	p-value	b	p-value	b	p-value	b	p-value	b	p-value	b	p-value
Intercept	1.437	0.007 **	1.336	0.061 .	-0.78	0.467	1.565	0.000 ***	1.126	0.020 *	0.879	0.337
Income												
Reference: >50k												
0~20k	0.436	0.178	0.183	0.665	1.506	0.037 *	0.033	0.898	-0.004	0.988	0.081	0.881
20k~50k	0.481	0.152	0.192	0.664	1.7	0.021 *	0.086	0.743	0.062	0.838	-0.059	0.918
Age	-0.022	0.004 **	-0.028	0.007 **	-0.008	0.569	-0.007	0.234	-0.002	0.742	-0.027	0.044 *
Gender												
female	0.194	0.515	0.389	0.338	-0.45	0.428	-0.056	0.812	-0.072	0.79	0.042	0.934
theta	1.142		0.599		0.271		1.784		1.307		0.415	
Pseudo R2 (Efron's)	0.069		0.042		0.038		0.013		0.002		0.039	

† b indicates the coefficients of the estimated regression. This applies to all the regression tables in this chapter.

Table 6-2. Negative binomial regressions of weekly trip frequency by sociodemographic characteristics for High-density Suburbs (N=241 respondents)

	Leisure						Personal service					
	Total		auto		non-auto		Total		auto		non-auto	
	b	p-value	b	p-value	b	p-value	b	p-value	b	p-value	b	p-value
Intercept	1.172	0.000 ***	0.361	0.197	0.787	0.079 .	-0.028	0.904	-0.661	0.018 *	-0.633	0.233
Income												
Reference: >50k												
0~20k	0.09	0.668	-0.508	0.096 .	0.569	0.194	-0.173	0.48	-0.531	0.097 .	0.396	0.432
20k~50k	0.283	0.082 .	-0.064	0.771	0.754	0.029 *	-0.097	0.592	-0.562	0.017 *	0.735	0.058 .
Age	-0.001	0.707	0.005	0.334	-0.012	0.135	0.016	0.000 ***	0.024	0.000 ***	-0.008	0.368
Gender												
female	0.201	0.092 .	0.281	0.071 .	0.004	0.988	0.042	0.736	-0.005	0.973	0.259	0.391
theta	2.209		1.337		0.382		2.824		2.006		0.397	
Pseudo R2 (Efron's)	0.025		0.028		0.048		0.064		0.113		0.047	

Table 6-3. Negative binomial regressions of weekly trip frequency by sociodemographic characteristics for Low-density Suburbs (N=168 respondents)

	Leisure						Personal service					
	Total		auto		non-auto		Total		auto		non-auto	
	b	p-value	b	p-value	b	p-value	b	p-value	b	p-value	b	p-value
Intercept	1.065	0.002 **	0.921	0.013 *	-0.659	0.572	0.497	0.056 .	0.325	0.236	-0.349	0.762
Income												
Reference: >50k												
0~20k	-1.06	0.065 .	-0.947	0.11	-27.164	1	-0.543	0.176	-0.666	0.121	1.582	0.262
20k~50k	-0.145	0.604	-0.196	0.513	0.294	0.743	-0.092	0.654	-0.121	0.571	0.316	0.762
Age	-0.005	0.422	-0.004	0.508	-0.015	0.434	0.007	0.078 .	0.009	0.039 *	-0.027	0.179
Gender												
female	0.533	0.002 **	0.524	0.004 **	0.645	0.262	0.008	0.947	0.067	0.602	-0.872	0.151
theta	1.471		1.293		0.121		7.605		6.423		0.199	
Pseudo R2 (Efron's)	0.05		0.042		-0.001		0.027		0.037		0.018	

Table 6-4. OLS regressions of weekly total distance traveled by sociodemographic characteristics for Urban Detroit (N=92 respondents)

	Leisure						Personal service					
	Total		auto		non-auto		Total		auto		non-auto	
	b	p-value	b	p-value	b	p-value	b	p-value	b	p-value	b	p-value
Intercept	3.664	0.000 ***	3.076	0.000 ***	1.049	0.059 .	2.271	0.000 ***	1.755	0.009 **	1.064	0.036 *
Income												
Reference: >50k												
0~20k	-0.254	0.586	-0.287	0.556	0.172	0.604	-0.511	0.17	-0.686	0.088 .	0.312	0.303
20k~50k	-0.014	0.977	0.154	0.761	0.138	0.688	-0.107	0.78	-0.199	0.631	0.307	0.329
Age	-0.026	0.019 *	-0.026	0.026 *	-0.007	0.402	0.001	0.913	0.006	0.559	-0.01	0.154
Gender												
female	-0.217	0.617	-0.112	0.805	-0.295	0.341	0.427	0.218	0.553	0.139	-0.207	0.461
R2	0.064		0.065		0.019		0.041		0.06		0.042	

Table 6-5. OLS regressions of weekly total distance traveled (log transformed) by sociodemographic characteristics for High-density Suburbs (N=241 respondents)

	Leisure						Personal service					
	Total		auto		non-auto		Total		auto		non-auto	
	b	p-value	b	p-value	b	p-value	b	p-value	b	p-value	b	p-value
Intercept	2.508	0.000 ***	1.877	0.000 ***	1.263	0.000 ***	0.804	0.004 **	0.496	0.101	0.351	0.033 *
Income												
Reference: >50k												
0~20k	-0.382	0.245	-0.858	0.024 *	0.597	0.024 *	-0.041	0.885	-0.316	0.3	0.215	0.194
20k~50k	-0.024	0.927	-0.343	0.253	0.563	0.007 **	0.017	0.939	-0.164	0.498	0.307	0.020 *
Age	-0.003	0.625	-0.001	0.931	-0.011	0.017 *	0.016	0.001 **	0.019	0.000 ***	-0.002	0.463
Gender												
female	0.176	0.33	0.373	0.074 .	-0.094	0.515	0.273	0.080 .	0.233	0.166	0.101	0.27
R2	0.01		0.036		0.07		0.051		0.064		0.038	

Table 6-6. OLS regressions of weekly total distance traveled (log transformed) by sociodemographic characteristics for Low-density Suburbs (N=168 respondents)

	Leisure						Personal service					
	Total		auto		non-auto		Total		auto		non-auto	
	b	p-value	b	p-value	b	p-value	b	p-value	b	p-value	b	p-value
Intercept	2.82	0.000 ***	2.504	0.000 ***	0.414	0.128	2.04	0.000 ***	1.873	0.000 ***	0.395	0.019 *
Income												
Reference: >50k												
0~20k	-1.938	0.004 **	-1.882	0.007 **	-0.215	0.561	-1.119	0.026 *	-1.116	0.029 *	-0.014	0.95
20k~50k	-0.236	0.547	-0.256	0.53	0.089	0.685	-0.045	0.878	-0.101	0.735	-0.009	0.948
Age	-0.009	0.244	-0.006	0.475	-0.004	0.397	0.004	0.535	0.005	0.394	-0.004	0.158
Gender												
female	0.819	0.001 ***	0.859	0.001 ***	0.071	0.591	0.08	0.652	0.149	0.409	-0.1	0.22
R2	0.135		0.119		0.012		0.03		0.031		0.019	

6.4.3. Travel patterns by sociodemographic characteristics

To investigate the effects of individual-level sociodemographic characteristics on the amount of travel by respondents, negative binomial regressions on weekly trip frequency and OLS regressions on weekly total distance traveled for auto mode, non-auto mode and the total were performed with three predictors – income, age, and gender. The analysis was done for each of the three types of neighborhoods and for the purposes of leisure and personal service separately. In total, 6 sets of analyses (18 negative binomial regressions and 18 OLS regressions) were performed. The results of the negative binomial regressions on trip frequency are shown in Tables 6-1 to 6-3, and the results of the OLS regressions on total distance are shown in Tables 6-4 to 6-6. Overall, the results revealed that all three sociodemographic characteristics impacted some dimension(s) of travel outcomes, and the effects varied by neighborhood type and purpose of travel.

Age

As to weekly total trip frequency, the results of the negative binomial regressions (Tables 6-1 to 6-3) showed that aging did affect the total number of trips made and the effect varied by neighborhood type and trip purpose. For leisure travel, older residents in Urban Detroit tended to have fewer trips, but older residents in the suburbs were not significantly different from other age groups in terms of the total number of trips. A breakdown of trip frequency by types of destinations revealed differences in the types of activities that residents participated in between Urban Detroit and the suburbs (Figures 6-8 to 6-10). In Urban Detroit, social visits to friends and families constituted the majority of leisure trips (55%) reported. Aging significantly reduced the frequency of trips for social visits, resulting in a decrease in the total frequency of leisure trips in Urban Detroit. However, the picture was more complex in the suburbs. There was still a negative effect of aging on trips for social activities in the suburbs. But besides visiting friends and families,

suburban residents made numerous trips for a variety of other leisure activities. While younger people in the suburbs had more trips to bars and cafes, older people made more trips to hobby destinations (e.g., golf, boating or choir). Also, suburban residents made more trips to perform physical activities as they got into middle age, such as going to the gym, taking a walk, going to yoga classes, and playing tennis. When adding these subtle differences together, the effect of aging on total leisure trips was not strong enough to be statistically significant from 0 for suburban residents. Therefore, the variation of aging effect by neighborhood type is due to differences in activity participation among the older residents in different neighborhoods.

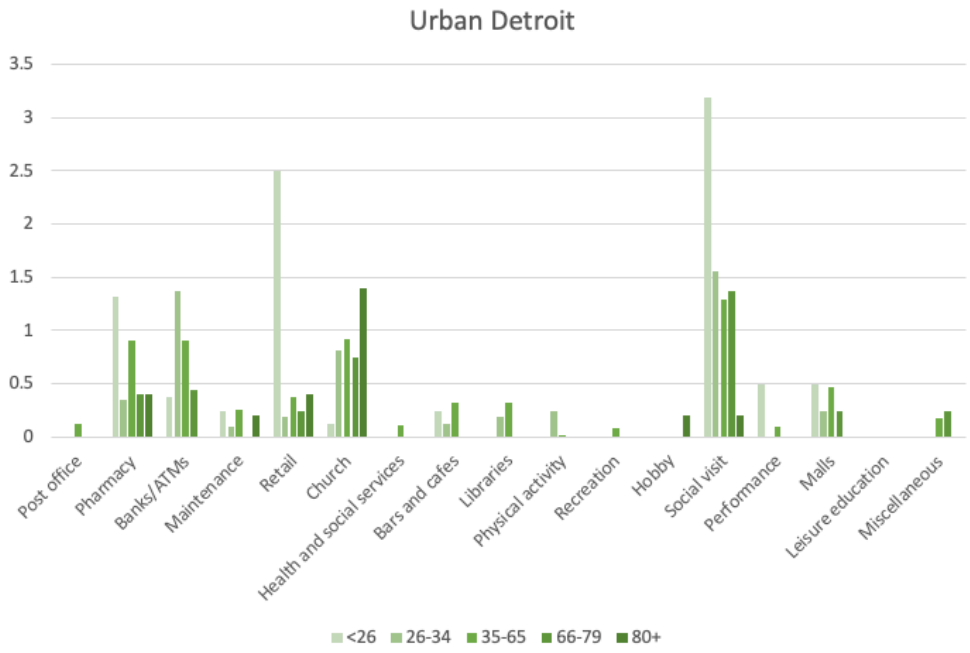


Figure 6-8. Average weekly trip frequency to various types of personal services and leisure destinations by age groups in Urban Detroit

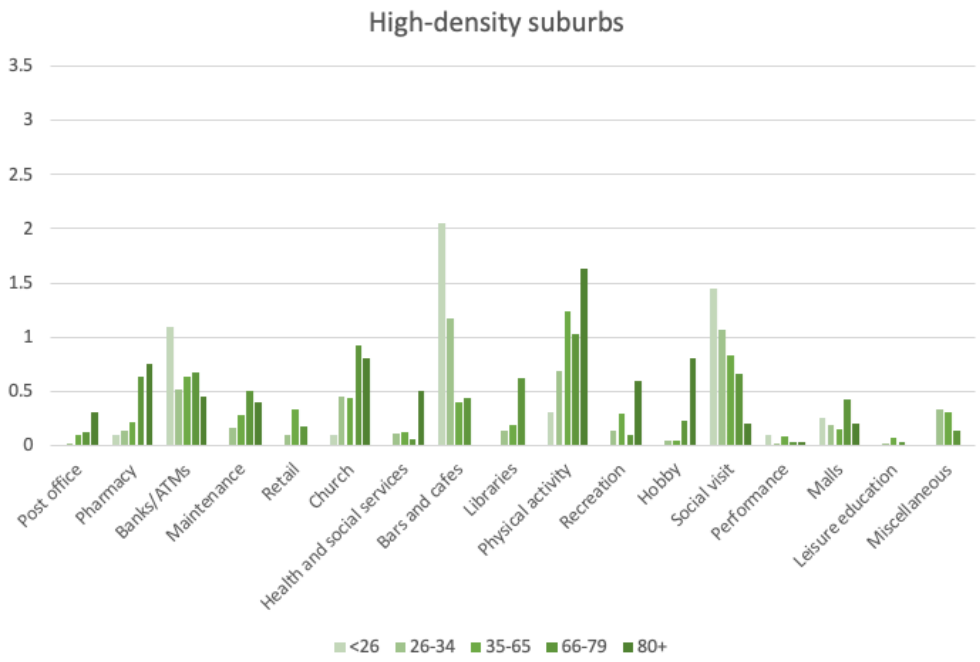


Figure 6-9. Average weekly trip frequency to various types of personal services and leisure destinations activities by age groups in High-density Suburbs

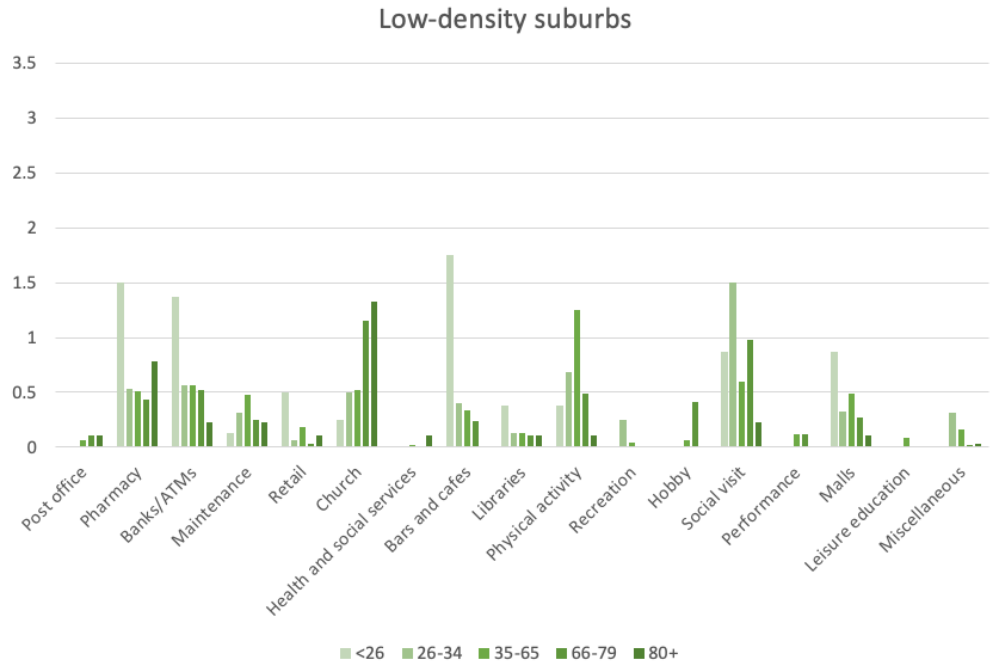


Figure 6-10. Average weekly trip frequency to various types of personal services and leisure destinations by age groups in Low-density Suburbs

For personal services, the effect of aging also varied across the different neighborhood types (Tables 6-1 to 6-3). In the suburbs, older people reported more personal service trips in a typical week. This effect was strong and statistically significant in the High-density Suburbs, but not for residents in Urban Detroit or the Low-density Suburbs. The variations evident from the effect of aging on personal service trips across neighborhoods can be attributed to the differences in travel behavior among younger residents in the different neighborhood types. In the High-density Suburbs, younger residents, especially those who are in their 20s, made much fewer trips than their counterparts in other neighborhoods for various personal services, with the only exception being financial services (Figure 6-9). As a result, their trip frequencies for various personal services were much lower than for the older residents. In contrast, in Urban Detroit and in the Low-density Suburbs, younger residents made the most trips to pharmacies, banking and retailing, while older residents made more trips to church (Figures 6-8 and 6-10). This explains why aging did not show any significant effect on total frequency of personal service trips in Urban Detroit or the Low-density Suburbs.

As to the weekly total distances traveled, similar to patterns seen in total frequency for leisure destinations, older people traveled less total distance for leisure in Urban Detroit (Table 6-1). Although the retired old had longer one-way trip distances for leisure trips, they still traveled less total distance for leisure throughout the week because of the much lower trip frequencies. For personal services, older people in the High-density Suburbs reported travelling more total distance, and at statistically significant levels, which is expected given their higher trip frequencies (Table 6-2).

As to the mode of travel, the results suggested a positive effect of aging on auto use but a negative effect on the use of non-auto modes across neighborhoods and for trip purposes. Compared with

the coefficients for the overall effects of aging on the total frequency by all modes, the coefficients for frequency by car tended to be larger and the coefficients for travel by non-auto modes tended to be smaller, which applied to travel for both leisure and personal services in the suburbs and travel for personal services in Urban Detroit (Tables 6-1 to 6-3). The only exception was leisure travel in Urban Detroit, for which aging showed no effect on mode use in terms of trip frequency. This is likely related to the small sample size in Urban Detroit, due to a low survey response rate typically seen in poor communities, as well as the fact that residents in Urban Detroit reported much fewer leisure trips than residents in other neighborhoods.

Two logistic regressions of trip-level mode choice (auto vs non-auto) – one for leisure trips and another for personal service trips – were performed to evaluate the propensity to choose non-auto modes instead of driving only in a trip by the predictors of age and neighborhood type (data not shown). The results showed that the effects of age and neighborhood type on mode choice were statistically significant for both leisure and personal travel. But likelihood ratio tests (data not shown) showed that adding an interaction term of age and neighborhood in the logistic regressions was not statistically significant for either leisure travel or personal service travel. This means that aging significantly reduces the likelihood for an individual to travel without a car in a trip, and this effect remains similar across neighborhoods and for both leisure and personal service travel.

Moreover, the percentage of respondents who reported any non-auto travel in a typical week decreased with age (Figure 6-11). There was a linear negative relationship between age and transit use (Figure 6-12). Seniors who were 80 or older had the lowest rate of transit use, which reflected the physical and cognitive difficulties for them to take a bus. Also, there was a constant decrease in walking/biking with age for people who were less than 80 years old (Figure 6-13). The results indicated that despite potential challenges in continuing to drive, senior residents sticked with their

cars or arranged to get rides. In addition, for people aged 80 or above, while the percentage of travel by walking and biking was lower compared with the middle-aged residents aged 35-65, it was slightly higher than for those young retired aged 66 - 79. This reflects the loss of the ability to drive as people reach their 80s and 90s.

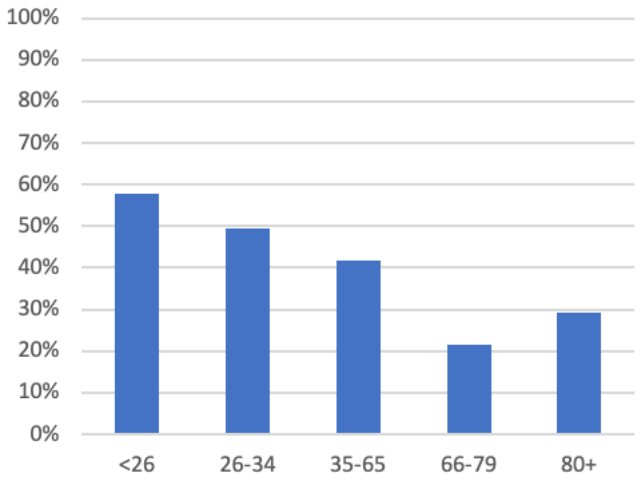


Figure 6-11. Percentage of respondents who reported any non-auto travel, by age groups

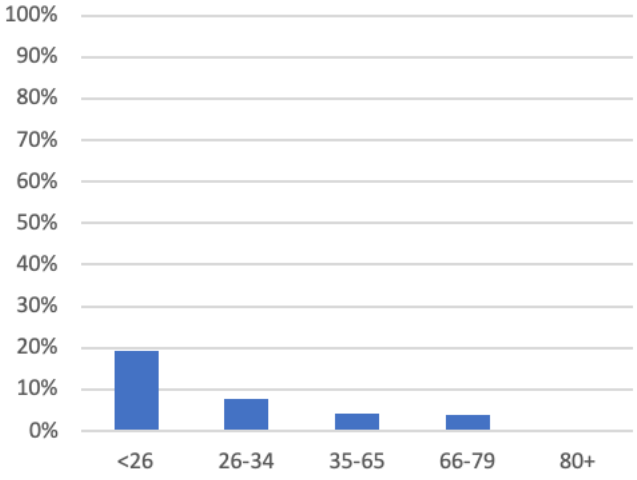


Figure 6-12. Percentage of respondents who reported any travel by transit, by age groups

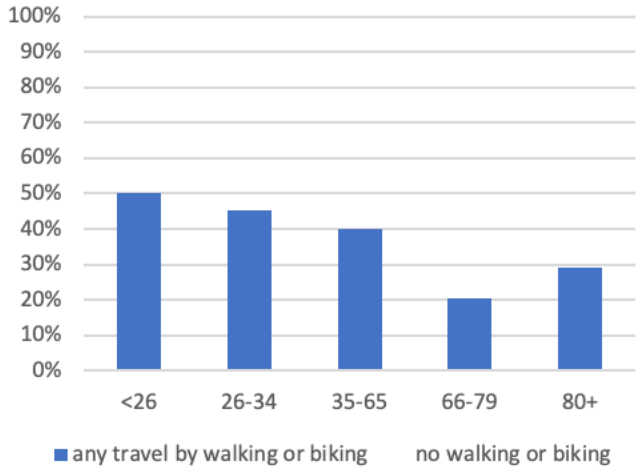


Figure 6-13. Percentage of respondents who reported any travel by walking and biking, by age groups

Income

Income had no statistically significant effects on weekly total frequency, as revealed by the negative binomial regressions (Tables 6-1 to 6-3). However, for leisure travel, numeric differences in trip frequency among income groups, as shown by the model coefficients, suggested that the lowest-income/poor residents (annual household income of $0~20k) and the lower-income residents (annual household income of $20~50k) made more trips for leisure activities in a week than middle- and high-income residents (annual household income of more than 50k) in Urban Detroit and the High-density Suburbs. The opposite was the case in the Low-density Suburbs, meaning that the lowest- and lower-income residents made fewer trips. However, none of these differences were statistically significant and therefore these patterns observed are not reliable.

A breakdown of weekly trip frequencies by the type of activities showed that the effect of income on trip frequency varied among different leisure activities as well as among different personal services across the different neighborhood types (Figures 6-14 to 616). This explained the

insignificance of the effect of income on total frequencies for leisure and for personal services. In Urban Detroit, residents with lower income levels reported more trips to visiting friends and family (the predominant leisure destinations in Urban Detroit) and to bars and cafes, but fewer trips to malls or for physical activity (Figure 6-14). These opposite effects of income on various leisure activities canceled each other out, which explained why no effect of income was found on total frequency for leisure, especially with the small sample size (N=92) in Urban Detroit.

In the High-density Suburbs, residents with lower income levels reported more trips to bars and cafes, libraries, and performances (such as sports events or movie theaters), but fewer trips that involved doing physical activities and going to malls (Figure 6-15). This explained why no significant effect was found on total frequency for leisure.

In the Low-density Suburbs, residents with the lowest income reported much fewer trips to destinations that involved physical activity, slightly fewer trip frequencies to visit friends and family, and no trips to other leisure activities, when compared to residents with middle- and upper-incomes (Figure 6-16). But with very few lowest-income residents (annual household income less than $20,000) in the Low-density Suburbs (N=5, 3% of total respondents), it was hard to detect statistical significance in the total frequency of leisure trips for the lowest-income group. Lastly, it was worth noting that weekly trip frequency to locations for physical activities increased with income for residents in all three neighborhood types. This reflects the fact that people with higher incomes have the resources to afford time and monetary costs to access fitness facilities and to undertake physical activities, when compared with the poor.

For personal service travel, the coefficients of negative binomial regressions showed that in terms of numeric values, the lowest- and lower-income residents made more trips in a week than middle-

and high-income residents in Urban Detroit, while the lowest- and lower-income residents made fewer trips in a week than middle- and high-income residents in the suburbs (Tables 6-1 to 6-3). But none of these were statistically significant with large p-values, meaning that the patterns could be an artifact of randomness in the sampling. This was due to variation in the effect of income on different types of personal services. In Urban Detroit, residents with lower incomes reported less trips to banks and ATMs, but residents with the lowest income (annual household income less than 20,000) reported slightly more trips to pharmacies, churches and retail services, such as convenience stores and dollar stores, when compared to other residents (Figure 6-14). In the High-density Suburbs, residents with lower incomes reported fewer trips for retail services, churches and maintenance (such as cleaners and barbers), but more trips to post offices (Figure 6-15). In the Low-density Suburbs, residents with the lowest income and the lower incomes together (annual household income less than 50,000) reported more trips to pharmacies but fewer trips to banks and ATMs than the middle- and upper-income groups (annual household income more than 50,000) (Figure 6-16).

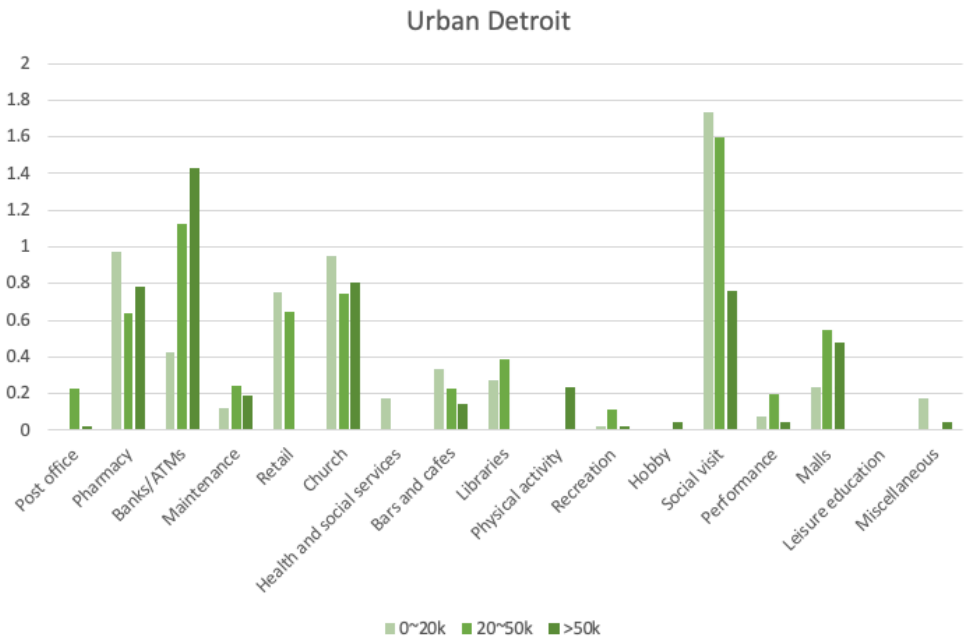


Figure 6-14. Average weekly trip frequency to various types of personal services and leisure destinations by age groups in Urban Detroit

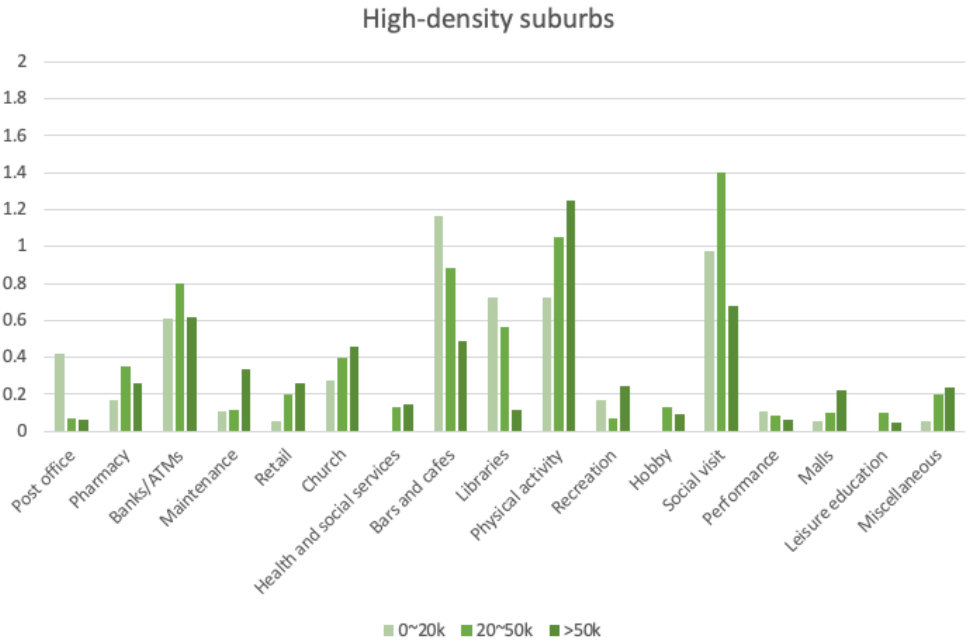


Figure 6-15. Average weekly trip frequency to various types of personal services and leisure destinations activities by age groups in High-density Suburbs

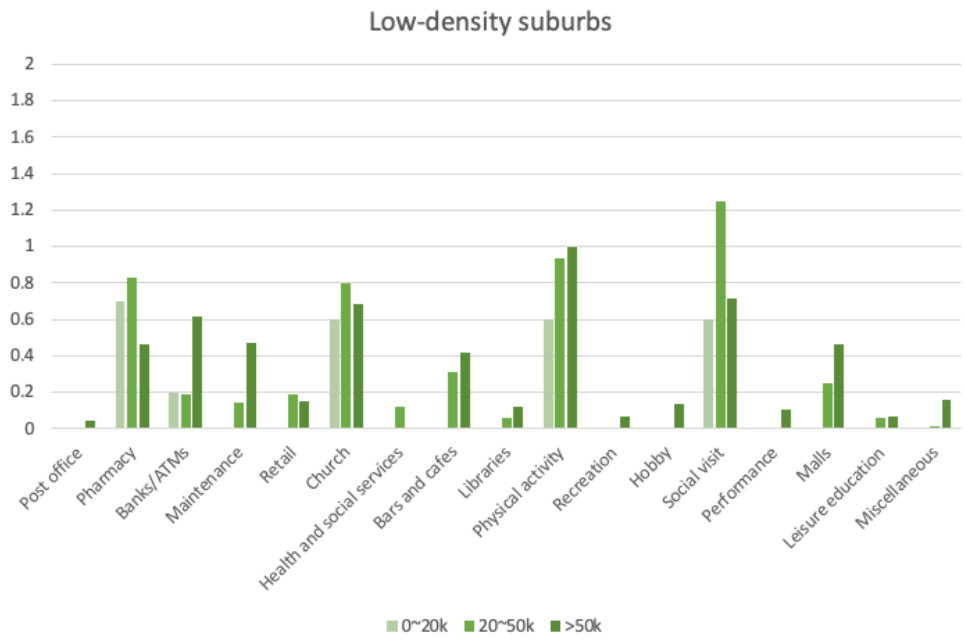


Figure 6-16. Average weekly trip frequency to various types of personal services and leisure destinations by age groups in Low-density Suburbs

As to weekly total distance traveled, the effect of income was only significant in the Low-density Suburbs (Tables 6-4 to 6-5). The lowest-income residents reported less total distance traveled for both leisure and personal services, which could be attributed to the fact that they reported making fewer trips in total for both purposes.

As to the mode of travel, lower incomes were associated with less car use and more non-auto travel in the High-density Suburbs and Urban Detroit, but not in the Low-density Suburbs (Tables 6-1 to 6-6). First, income had the strongest influence on trip frequency and total distance of travel in the High-density Suburbs. As the coefficients of income levels in the regression results on frequency and total distance of travel by mode indicated (Tables 6-2 and 6-5), low-income residents in these neighborhoods had a larger share of trips and total distance traveled by non-auto modes and correspondingly less trips and less total distance traveled by car, compared to middle- and high-

income residents. This held for both leisure and personal service trips. Second, income affected the mode use for leisure travel in Urban Detroit, where low-income residents had significantly more leisure trips by non-auto modes than middle- and high-income residents. Third, income did not show any significant effect on the use of non-auto modes among residents living in the Low-density Suburbs. The low-income residents here did not use non-auto modes more than other residents. This could be explained by the low-density auto-oriented built environment in these neighborhoods. Residents with lower incomes do not have a choice to use alternative modes for travel in these exclusive and isolated low-density suburbs. There is little choice within these neighborhoods other than to travel by car to reach destinations, which tend to be located at considerable distances from these peripheral enclaves.

Moreover, the percentage of respondents who reported any non-auto travel in a typical week also decreased with higher incomes in both the High-density Suburbs and Urban Detroit, with the strongest effect being in the High-density Suburbs (Figures 6-17 and 6-18). But the percentage of respondents who reported any non-auto travel was constant across income groups in the Low-density Suburbs (Figure 6-19). These results are consistent with the findings above based on regressions and confirms the absence of any effect of income on mode of travel in the Low-density Suburbs.

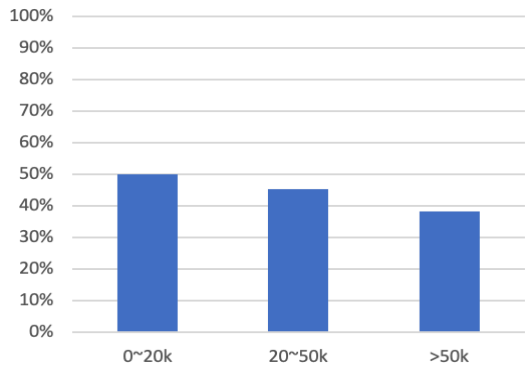


Figure 6-17. Percentage of respondents who reported any non-auto travel, by income groups, Urban Detroit

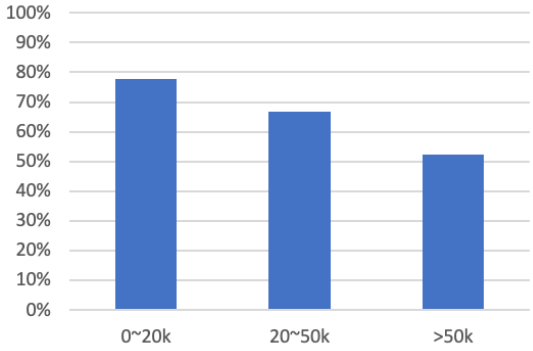


Figure 6-18. Percentage of respondents who reported any non-auto travel, by income groups, High-density Suburbs

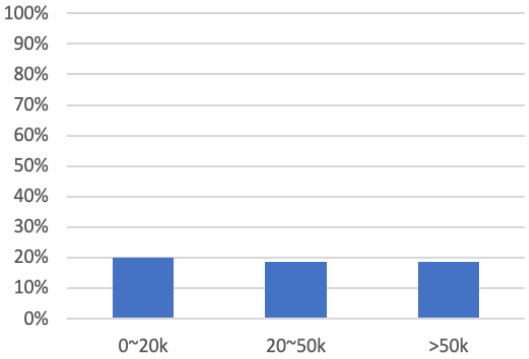


Figure 6-19. Percentage of respondents who reported any non-auto travel, by income groups, Low-density Suburbs

Additional analyses (results not shown) that included car ownership as a control variable showed that the effects of income remained even after controlling for whether respondents had access to a functioning vehicle. This excludes the possibility of the effect of income as only an indirect effect of car ownership. It means that even with access to a car, the poor still use the car less and are more likely to travel by non-automobile modes, such as transit, walking and biking. This could be due to their more limited resources. For instance, the individual may have to negotiate with other family members to use the car or drive less to reduce gas costs.

Gender

The effects of gender on leisure and personal service travel were dependent on neighborhood type and the purpose of travel (Tables 6-1 to 6-6). As to total frequency, in the Low-density Suburbs, women reported making more leisure trips than men, and this is statistically significant (Table 6-3). However, gender did not show any significant effect on leisure travel in Urban Detroit or the High-density Suburbs. A breakdown of trips by types of leisure activities (data not shown) reveals that women across all neighborhoods made more trips to cafes, libraries, and malls than men, but women in the suburbs made more trips to visit family and friends. Also, women made many more trips than men for physical activities, such as aerobic exercise or yoga classes, weight training, tennis, and taking a walk, in the Low-density Suburbs, but women made fewer trips for physical activities in Urban Detroit and the High-density suburbs. This resulted in a particularly strong effect of gender on leisure travel with high statistical power in the Low-density Suburbs, but not in other neighborhoods, i.e., Urban Detroit and High-density Suburbs.

Further analysis with additional control variables in the negative binomial regression for trip frequency (results not shown) suggests that the positive effect of being female on leisure trip

frequency is independent from family structure factors, including marital status, household size, and the presence of children in the household.

For personal service travel, women reported more trips than men in the suburbs, but women reported fewer trips than men in Urban Detroit. However, the numerical differences by gender were not statistically significant and therefore a real effect cannot be confirmed.

As to total distance traveled, women in the Low-density Suburbs traveled significantly longer total distances for both leisure and personal services. Women also drove significantly more total distance than men. These findings are expected given higher trip frequencies and longer one-way trip distances traveled by women in the Low-density Suburbs.

6.5. Discussion

6.5.1. Purpose

Existing studies found that leisure trips are more likely to be traveled by non-auto modes when compared to work and shopping trips (Kim and Ulfarsson 2008; Lanzini and Khan 2017). Based on data from the Detroit region, this study complements these findings. Respondents were found to be much more likely to utilize non-auto modes for part of a trip, or the entire trip, to leisure destinations than to personal services (Figures 6-1 and 6-2).

A breakdown of various personal services and leisure destinations show that the use of alternatives to the car for travel is more common for certain leisure activities, such as going to bars and cafes, visiting friends, going to parks, trips that engage in physical activities and going to libraries (Figure 6-3). Several mechanisms may be at play. First, people walk, bike or take buses more often for certain leisure destinations that are more convenient to reach by these non-auto alternatives. For

instance, cafes are densely distributed and typically located within short distances from concentrations of jobs, commercial activities and entertainment venues. Walking to cafes with friends or colleagues is part of social life for many people. If going out with friends for an evening in town, some people also prefer to walk or take a bus due to concerns about driving after drinking. Additionally, some people regularly visit their friends at home, some of whom live close enough for them to walk or bike to their homes.

Second, people who have an active lifestyle and do regular physical activities are more willing to walk or bike to fitness facilities, or simply have a leisurely walk. Third, people who utilize libraries tend to have lower incomes, which are associated with less car use and more travel by alternative modes. Lastly, due to the nature of parks and the deliberate even distribution across urban areas, trips to parks are both convenient and enjoyable, which encourages walking and biking. In sum, the decision-making mechanisms for mode of travel likely vary by different types of activities. A further exploration of modal preferences among different trip purposes, especially the more detailed activity types, is needed for future study.

6.5.2. The neighborhood environment

In this study, the neighborhood type is found to be associated with the amount of travel people make, in terms of weekly frequency and weekly total distance. The neighborhood type is also found to be associated with mode of travel. Weekly trip frequency is shown to vary by neighborhood type and purpose (Figure 6-1). Urban Detroit residents reported the most personal service trips with an average of 3.4 trips per week, compared to 2.1 trips in the High-density Suburbs and 2.4 trips in the Low-density Suburbs. In contrast, Urban Detroit residents reported the least number of trips to leisure destinations, with an average of 2.6 trips per week, compared

to 3.7 trips in the High-density Suburbs and 3 trips in the Low-density Suburbs. On one hand, their high frequencies of personal service trips are likely due to a number of reasons. First, churches play an important role in the Urban Detroit neighborhoods and local residents participate in a lot of religious activities. Second, Urban Detroit has poor access to big, one-stop-for-all stores and residents have to take more trips to smaller stores to get what they need for non-food shopping. Third, residents in low-income communities might rely more on cash and have to frequent banks/ATMs more often.

On the other hand, the low total frequencies of trips to leisure destinations among Urban Detroit residents are due to fewer trips to places like bars, cafes, or fitness centers, which are frequented more often by the residents in the suburbs (Figure 6-4). Several reasons could explain these travel patterns to leisure destinations. Lower spatial access to facilities such as fitness centers in the Urban Detroit neighborhoods impose extra burdens to reach leisure destinations. Also, low-income residents in Urban Detroit have limited financial resources and they have little money left to spend on discretionary leisure activities, such as going to bars or buying a gym membership. In addition, poor minority residents in Urban Detroit may not have enough free time for leisure activities. The poor in Urban Detroit, including many single mothers, may hold multiple part-time jobs to support their families, with no time and no money to go out for a workout or attend a concert. Having fewer leisure options than residents in the suburbs, residents in Urban Detroit visit friends and families more often, which dominates their leisure activities.

High-density suburban residents reported the least personal service trips but the most leisure trips throughout the week. The low average weekly total frequency to personal services is due to few trips to two major personal service destinations – pharmacies and churches (Figure 6-4). This could be associated with high concentrations of young/middle-age populations, who are either going to

college or hold college degrees, in these neighborhoods. These population subgroups are less likely to go to church, because religiosity decreases with a younger age and higher education levels (Pew Research Center 2015). The younger population also tend to be healthier and less likely to frequent pharmacies for medications.

The high average weekly total frequency to leisure destinations in the High-density Suburbs is due to a large number of trips to fitness facilities, bars, cafes, and parks and museums (Figure 6-3). One important factor within the High-density Suburbs is the proximity to a dense concentration of leisure amenities, making it easy to access various destinations. A second factor is the better health awareness among the population within the High-density Suburbs, who tend to have higher education levels when compared to populations in the other neighborhoods. The result of a logistic regression indicates that, in general, residents with higher education levels in the Detroit region are far more likely to make trips for physical activities (results not shown). A third factor shaping travel within the High-density Suburbs is the concentration of the young, a population subgroup who tend to frequent bars and cafes.

In summary, the variation of trip frequency by neighborhood type is, in part, a result of lifestyle differences among residents in neighborhoods with different sociodemographic compositions, combined with the lack of spatial access to amenities and the lack of resources among some population subgroups.

As to weekly total distance traveled, despite the high-density and mixed-use built environment characteristics, Urban Detroit residents have to travel similar amounts of total distance in a week as the residents of the Low-density Suburbs to reach various leisure and personal service destinations. This confirms the burden of travel in a low-income, highly segregated, minority-

concentrated community confronting disinvestment, with the loss of urban amenities overshadowing the effects of the built environment – the high densities, mixed land uses, and connected street systems.

As to the mode of travel, it is found to be significantly impacted by both the built environment and the socioeconomic conditions of the neighborhood. Residents in both high-density Urban Detroit and the High-density Suburbs utilize non-auto modes much more, compared with residents living in the Low-density Suburbs, reflecting the impacts of compact development on encouraging alternative modes of travel to the car. However, Urban Detroiters mainly rely on transit and are more reluctant to walk or bike due to safety concerns in their neighborhoods, while the High-density Suburban residents walk and bike more often to their weekly destinations (Figure 6-7).

The reason for the mode of travel differences between Urban Detroit and the High-density Suburbs can be largely attributed to differences in neighborhood socioeconomic conditions, which are also closely linked to issues of safety. The city of Detroit has been suffering from poverty, disinvestment and decline, and it is a U.S. city with some of the highest crime rates in the country. In the 2008 NSF Detroit survey, among residents in the different neighborhood types, Urban Detroit residents reported having the most concerns with crime and traffic within their communities that prevented them from walking.

On the other hand, suburban Detroit residents live in relatively wealthy and safe enclaves, and feel little threat in walking within their neighborhoods. Residents living in the High-density Suburbs reported having few concerns over walking outside. As a result, despite similar physical built environments, residents in the minority-dominated lower-income urban neighborhoods tend to engage in less active travel due to safety concerns when compared to residents in the suburbs. This

is consistent with findings by Jensen et al. (2017), who show that people who are more likely to travel by active modes – walking and biking – have less fear of traffic and crime within their neighborhoods.

6.5.3. Sociodemographic characteristics

Beside the role of neighborhood type and trip purpose in defining travel, one key finding from this study is that across the Detroit region, the effects of the sociodemographic characteristics of aging, income and gender vary by the type of travel (whether personal service or leisure) and they too are also contingent on the neighborhood environment. The importance of these sociodemographic variables is discussed in more detail below. It is worth noting that weekly total distance is mostly determined by the total frequency of weekly trips, so the discussion will mainly focus on the effects on weekly total frequency and travel mode.

Age

This study finds that the effect of aging on trip frequency varies by the purpose of travel. While aging reduces weekly frequencies of leisure trips, aging actually increases weekly frequencies of personal service trips. But the effect of aging is only significant in certain neighborhoods, depending on the purpose of travel. With respect to travel for leisure, aging has a negative effect on the total frequency of leisure trips, but the effect is only significant in Urban Detroit. In Urban Detroit, there is an overall decrease in leisure trips with aging (Table 6-1). Senior residents make fewer trips for visiting family and friends, and they do not participate in many other leisure activities even though they may have more free time once retired (Figure 6-5). This lack in the quantity and the diversity of leisure activities among the elderly Urban Detroit residents can be explained by poverty and poor access to amenities in neighborhoods experiencing disinvestment.

Senior residents in Urban Detroit have limited budgets to pay for various leisure activities, whether fitness centers or golf club memberships. They also live farther from quality leisure facilities due to the disinvestment and decline within their neighborhoods, despite their high-density, mixed-use, and highly-connected built environments.

However, aging does not have any significant effect on weekly frequencies of leisure trips in the suburbs. In the suburbs, while older residents still make fewer trips to visit friends and family when compared to the younger population subgroups, they make more trips for other leisure activities, such as engaging in physical activity, golfing, boating, and visiting parks and museums (Figures 6-6 and 6-7). In the wealthy suburban neighborhoods, any negative effect of aging on leisure travel is mitigated by more free time and the more abundant resources (e.g., access to money and transportation options) enjoyed by the elderly in these neighborhoods.

The amount of leisure trips is an indicator of the participation in leisure activities, which has been linked to better mental and physical health for the elderly (Everard et al. 2000; Hutchinson and Nimrod 2012; Pondé and Santana 2000). In this study, while the elderly in the suburbs are involved in various leisure activities, the elderly in poor minority-dominated neighborhoods of Urban Detroit face barriers to active leisure participation, which likely has negative impacts on their wellbeing. Combined with the various adverse conditions in their community – from lack of urban amenities to heightened safety concerns – the elderly in Urban Detroit experience multiple layers of inequity and burdens.

With respect to travel for personal services, the effect of aging varies by neighborhood type. Aging is associated with significantly more personal service trips in the High-density Suburbs, but there is little effect found in other neighborhoods (Tables 6-1 to 6-3). This is, in part, due to behavioral

difference among the younger population subgroups in the different neighborhoods. In the High-density Suburbs, younger residents make few trips to personal service destinations compared to the older residents. This is true for all types of personal services, except banking. However, in other neighborhood types, younger populations make more trips to some types of the personal service destinations (e.g., pharmacies, banking and retailing) but fewer trips to others (e.g., churches) (Figures 6-14 to 6-16). A possible reason for this difference is that the High-density Suburbs have a large population of young, educated residents, mainly professionals and students, who may have a smaller household size and less demand for personal services than young people in the other neighborhoods.

As to the mode of travel, while some of the existing studies (Böcker, van Amen, and Helbich 2017; Cao, Mokhtarian, and Handy 2010) found that the elderly (older than 65) use alternative modes to the automobile more than the non-elderly for their trips, this study shows the opposite travel pattern for the specific purposes of leisure and personal services among residents in the Detroit region. The findings here show that across all neighborhoods, aging reduces non-automobile modes of travel and increases the likelihood to drive or being driven for a trip. The results show that automobile dependence for nonwork trips increases with age. This effect is independent of the built environment, whether it is a high-density or low-density neighborhood.

Despite the existing programs to reduce bus fares for the elderly, the results in this study indicate that they are the least likely to use transit for leisure and personal service trips (Figure 6-12). The findings in this research suggest that improving public transit may not be as effective in promoting mobility among the elderly at its current form. Taking a bus might be particularly challenging for the older population subgroups, as they have to follow up-to-date bus schedules, walk to and from bus stops, and get on and off the bus, all with their physical mobility likely in decline.

It is worth noting that for residents aged 80 and above, there is a slight increase in walking when compared to the young old age group aged 65 to 79. This indicates that when facing challenges in continuing to drive, some senior residents may find it hard to find a ride by car, and choose to walk to meet their travel needs. To facilitate the transition from automobile dependent lifestyle, it is critical to alleviate barriers for the elderly to use public transit, provide a safe and walkable neighborhood environment with good access to amenities, and offer programs that provide easy and affordable door-to-door rides.

Income

In Urban Detroit and the High-density Suburbs, low-income residents use the car less frequently and make more use of non-auto modes of travel. This is not the case, however, in the Low-density Suburbs, due to the necessity of travel with a car within these isolated, low-density suburban enclaves. This shows that the built environment itself can suppress the impact of income in defining travel patterns, and particularly automobile reliance. A distant and isolated low-density, single-use suburban neighborhood simply does not provide the option to travel other than by car, and this remains true for even low-income residents. This confirms the findings by Kotval-K and Vojnovic (2015) that income has a positive effect on car use in Urban Detroit and High-density Suburbs, neighborhoods with compact developments, but has no effect in the Low-density Suburbs, where residents have no option other than to travel by car. The study here shows that these findings apply even specifically to travel for personal services and leisure activities.

Gender

In the Low-density Suburbs, women reported significantly more leisure trips and more total distance traveled for leisure activities (Tables 6-3 and 6-6). It is worth noting that this pattern in

travel by gender was not affected by household structure and thus could not be attributed to household gender roles, such as chauffeuring children. But when it came to travel for leisure or personal services, the gender effect was not significant in Urban Detroit or the High-density Suburbs (Tables 6-1, 6-2, 6-4, and 6-5). This suggests that women in the Low-density Suburbs live a different lifestyle than women in the other neighborhoods. With higher household incomes on average than women in the other neighborhood types, women in the Low-density suburbs have more free time and financial resources for leisure activities, such as engaging in regular physical activity. They may also confront stronger social pressures to stay fit within their social networks.

6.6. Conclusion

This part of the dissertation examines the effects of trip purpose, neighborhood environment and individual sociodemographic characteristics on the trip frequency, total distance traveled and mode of travel across different types of neighborhoods in the Detroit region. The key findings in this chapter are summarized as follows. First, mode of travel is affected by trip purpose. People are more likely to engage in active travel for leisure activities than for personal services. Second, while the effects of the neighborhood built environment on reducing car use is confirmed, the socioeconomic conditions of the neighborhood also affect the mode of travel. While walking and biking are the most common non-auto modes used in neighborhoods considered safe with compact development patterns, these modes are seldom used in urban neighborhoods experiencing disinvestment, like Urban Detroit. Instead, public transit is the main non-auto mode of travel in these low-income, segregated urban neighborhoods in decline.

Third, the impact of sociodemographic characteristics is contingent on the neighborhood type and the purpose of the trip. With regard to age, the negative effect of aging on leisure travel is most

felt in Urban Detroit, which has limited access to urban amenities and where the population mostly lives in poverty and maintains serious safety concerns. This may lead to adverse health consequences for the elderly who live in such neighborhoods. However, aging does not have much of an impact on leisure travel in the suburbs, where residents have access to amenities and/or abundant financial resources to engage in leisure activities. Also, aging is found to increase car dependence for nonwork travel, and specifically in accessing leisure and personal service destinations.

The likelihood of using public transit decreases linearly with age. Senior residents who are in their 80s and 90s are actually the least likely to take buses. To improve the mobility of the seniors who lose the ability to drive, it would be important to offer programs that provide door-to-door rides, improve the accessibility of transit, and ensure a safe and walkable neighborhood environment with good access to amenities. As to the effect of income, higher income levels are associated with increased automobile dependence, even when controlling for working vehicle ownership rates. However, this effect is only present in the high-density neighborhoods, both urban and suburban. The impact of income on mode of travel is suppressed in the low-density neighborhoods, where there is no choice of alternative modes of travel other than by car.

With respect to gender, women in the Low-density Suburbs are found to travel more for leisure activities but this is not found among women in the other neighborhood types. This is mainly due to more trips for engaging in physical activity specifically by women living in the Low-density Suburbs, which is likely shaped by peer pressure to maintain fit, combined with the free time and abundant resources to join fitness clubs of various types.

The findings of this study have implications for policy, and specifically development practices aimed at reducing automobile reliance and promoting more active travel. It is important to consider the types of businesses that will shape fine grained land uses in local development. Compact development with various leisure amenities, such as city parks, bars, cafes and fitness facilities, will likely induce more non-auto travel than a similar built environment with only personal service destinations, like banks, cleaners, salons, and miscellaneous stores. In addition, when the goal is to promote active travel, it is not only important to promote compact development patterns, but it is also critical to address deeper issues, the socioeconomic conditions of the neighborhood and safety in the community, which will have an influence on the extent to which walking and biking will be pursued by residents.

This analysis underlines the importance of neighborhood context both as a separate factor and as a moderating factor in how various sociodemographic groups travel. The condition of Urban Detroit, which has experienced extreme disinvestment and decline, emerges as unique within this context. Compared with residents in the suburbs, Urban Detroit residents, and especially the elderly, engage in fewer leisure activities. This is reflected in both the diversity and the frequency of leisure trips among Urban Detroit residents, which in turn, likely have negative consequences on their mental and physical health. Also, the effect of the built environment – the high densities, high connectivity and mixed land uses – is much weaker in promoting active travel in the context of communities experiencing decline. This becomes particularly evident when comparing the High-density Suburbs and Urban Detroit neighborhoods, which have similar built environments, but very different sociodemographic compositions. These findings show the importance of urban context, and the role of class and ethnicity/race, in understanding leisure and personal service travel.

Urban neighborhoods in decline have been largely ignored in the research on travel behavior, and this is especially true when considering trips for leisure and personal services. This chapter makes a distinct contribution to the existing literature by showing how residents in declining urban neighborhoods travel differently from residents in wealthier suburbs, even when the built environments of their communities are similar.

Chapter 7. Accessibility and Travel to Pharmacies in the Detroit Region

7.1. Introduction

In the previous chapters, travel patterns examined as one-way trip distance, weekly total frequency and total distance, and mode use for personal service and leisure trips have been found to vary significantly across the three types of neighborhoods in the Detroit region. Accessibility to services and leisure destinations is a major factor that shapes travel behavior. In this chapter, I select one of the most essential types of personal services – pharmacies – to examine access to pharmaceutical services and travel patterns – the outcome of accessibility and personal choices – of residents across the three types of Detroit region neighborhoods.

Pharmaceutical services are important components of community health care because community pharmacies provide medications and consultations, health screening of common medical conditions (e.g., hypertension, diabetes, and high cholesterol), and also vaccinations. During the Covid-19 pandemic, pharmacies such as CVS and Walgreens have been critical neighborhood destinations in offering Covid-19 testing and vaccinations.

While pharmacies are easy to spot in cities, not all neighborhoods have good access to pharmaceutical services. Pharmacy deserts were identified in low-income, minority-concentrated neighborhoods and also rural communities (Chisholm-Burns et al. 2017; Erickson and Hirshorn 1996; Erickson and Workman 2014; Ikram et al. 2015; Pednekar and Peterson 2018; Qato et al. 2014). Lack of easy access to pharmaceutical services was linked with less utilization (Hiscock et al. 2008). However, compared to health care providers and hospitals, research on accessibility to pharmacies has received less academic attention. In particular, an evaluation of accessibility by pharmacy type is still lacking. Given the important roles of pharmacies in community health, it is

vital to evaluate and compare accessibility to pharmaceutical services across various neighborhoods with different sociodemographic compositions and to identify potential areas of pharmacy deserts. In addition, travel patterns for pharmacies reflect how people choose and utilize available pharmaceutical services, which might be more complex than simply visiting the closest location. Yet, travel to pharmacies has been underexplored in the existing travel behavior literature. This study aims to fill in these gaps and add more insights into the accessibility to pharmacies and actual travel patterns by residents to pharmaceutical services in neighborhoods of different sociodemographic composition.

As described in previous chapters, the Detroit region is characterized by a city that has experienced rapid disinvestment over the last six decades and have a high concentration of low-income visible minorities, and suburbs that tend to be wealthier and white-dominant. This is one of the most highly segregated metropolitan regions, by class and race, providing an opportunity to explore accessibility and travel to pharmacies among physically and socially distinct neighborhood types. Focusing on the Detroit region, this chapter will explore the spatial distribution of pharmacies, along with the accessibility and the actual travel by different sociodemographic groups across the three neighborhood types (Urban Detroit, the High-density Suburbs, and the Low-density Suburbs).

The following research will pursue two set of questions. First, what was the spatial distribution of pharmacies across the Detroit region, what was the spatial accessibility to pharmacies for residents in the three neighborhood types and do these patterns vary by pharmacy type? Second, what were the travel patterns to pharmacies by different sociodemographic groups in the different neighborhoods sampled in the Detroit region? More specifically, who visited pharmacies, what types of pharmacies did the respondents visit, how did respondents make destination choices

among available options and what were the one-way trip distance and mode of travel used to reach their destination pharmacies?

It is worth noting that the concept of accessibility in this study is limited to spatial accessibility – the ease to overcome spatial separation to reach destinations – which is determined by the spatial distribution of the demands and the opportunities as well as the transportation system. In this sense, spatial accessibility is a location-based characteristic that does not vary by individual. Broader conceptions of accessibility that include dimensions of individual characteristics, such as physical disabilities and time budgets (Geurs and van Wee 2004) are not considered here.

7.2. Background

7.2.1. Spatial distribution and accessibility to pharmacies

As a vital part in the health care provision system, access to pharmaceutical services is important to communities. Lower spatial accessibility to pharmacies could potentially contribute to less utilization of pharmaceutical services and less adherence to medical treatment (Hiscock et al. 2008; Syed, Gerber, and Sharp 2013). Thus, it is important to study the spatial access to pharmacies and identify pharmacy deserts, i.e., geographic areas where more residents have poor access to pharmaceutical services and the associated risk factors (Qato et al. 2014).

Compared to other types of health services, such as primary care (Todd et al. 2015; Luo and Wang 2003; Guagliardo 2004), spatial accessibility to pharmacies has received less academic attention. During the last decade, results from a number of studies that have explored the spatial distribution and accessibility to pharmacies have shown that accessibility to pharmacies was associated with the racial composition and socioeconomic conditions of neighborhoods (Chisholm-Burns et al. 2017; Erickson and Workman 2014; Ikram et al. 2015; Qato et al. 2014). For example, in Wayne

County, where the city of Detroit sits, lower socioeconomic and minority ZIP codes were found to face greater barriers to obtaining prescription drugs and other pharmaceutical services (Erickson and Workman 2014). Similarly in Chicago, pharmacy deserts were found to be primarily in segregated minority neighborhoods, and the discrepancy of access between white neighborhoods and minority neighborhoods actually increased from 2000 to 2012 (Qato et al. 2014).

Different measures of spatial accessibility have been used in previous studies to evaluate accessibility to pharmacies, such as distance to the nearest pharmacy (Pednekar and Peterson 2018), presence of pharmacies within a certain radius (Qato et al. 2014), and the two-step floating catchment area (2SFCA) method (Ikram et al. 2015). Different types of measures capture different dimensions of how easy it is to obtain pharmaceutical services. A simple accessibility indicator is the minimal distance or travel time to the nearest (or the m^{th} nearest) potential service providers. This is most useful when proximity of services is the primary concern. It is also straightforward and does not require additional data to calibrate the parameters. Another type of accessibility indicator measures the cumulative opportunities reachable from a location, including the presence of the quantity of opportunities reachable within a certain threshold by radius d or travel time t, and gravity indicators that capture the attractiveness of opportunities weighted by distance impedance (Miller 2018). Such indicators require additional information from the study area (typically travel patterns) to determine parameters such as the threshold radius d or distance decay function (Páez, Scott, and Morency 2012). Since people living in different places have different travel patterns, the parameters determined are specific to the study area. Furthermore, since some services are competitive in nature, such as physicians or hospital beds, accessibility indicators such as the two-step floating catchment area (2SFCA) method were developed to account for the ratio

of the supply of services and the demand by the population within a typical threshold of travel time (Wang 2012).

Empirical results have shown that different measures may reveal different patterns of accessibility to pharmacies from different perspectives. In Baton Rouge, Louisiana, it was found that African Americans disproportionally lived in areas with shorter travel time to the nearest pharmacy than whites, because pharmacies tended to concentrate in the city with high densities of population and businesses (Ikram et al. 2015). But a different measure of accessibility considering the ratio between the amounts of supply (number of pharmacies) and demand (population) revealed that they faced more competition for a limited amount of pharmacy services due to high population densities in their urban neighborhoods (Ikram et al. 2015).

7.2.2. Variation of services by pharmacy type

Pharmacies can be classified into different types – community pharmacies that include chain pharmacies such as CVS or Walgreens, local independent pharmacies, and supermarket pharmacies, as well as others, such as institutional pharmacies. Community pharmacies are the ones that are commonly used, providing easy access to medications and consulting and basic health screening services for local communities. These are also the ones that existing studies on pharmacies have focused on.

Studies have found that the services and the pricing of drugs vary among different types of pharmacies. In terms of services, Qato et al. (2017) found large differences in pharmacy characteristics by pharmacy type at the national level. Chain pharmacies were more likely to open 24 hours and offer a drive-up window, when compared to other pharmacy types. However, they were less likely to offer home-delivery or multilingual staff compared to independent pharmacies.

Also, Doucette and colleagues (2017) found that chain and supermarket pharmacies provided significantly more types of services than independent pharmacies. However, Kalsekar, Sheehan, and Peak (2007) reported that, independent pharmacies offered better-quality consultations and had higher patient satisfaction scores. In terms of cash prices of medications, Gellad et al. (2009) found that chain pharmacies had less variation and lower means in the prices for 4 types of drugs in Florida. Similarly, Luo et al. (2019) found that chain pharmacies offered lower prices for generic drugs than independent pharmacies at the national level.

Despite significant variations in services and pricing among different types of pharmacies, very few studies have examined the spatial distribution and accessibility of pharmacies by type. The percentage of chain pharmacies was found to be significantly lower in segregated black neighborhoods (Qato et al. 2014) and in neighborhoods with lower income (Gellad et al. 2009). As services and prices in pharmacies vary by pharmacy type, accessibility to chains and to independent pharmacies may impact residents in different ways. A distinction of accessibility by pharmacy type will add valuable information to our current understanding of pharmacy accessibility.

7.2.3. Choice of pharmacy services by residents

Besides an evaluation of the spatial accessibility to pharmacies, it is important to examine the actual selection of pharmacies by residents, and how it might vary by individuals and neighborhoods. Various factors affect how people choose among pharmacies for generic over-the-counter medicines or filling prescriptions. Proximity, as captured by spatial accessibility, is an important factor for people to choose where to go, but not the sole factor. Some important nonspatial factors include pharmacist traits (e.g., knowledgeable, professional and caring), costs

(e.g. prices of drugs, discount programs and insurances that are accepted for prescriptions), the types of drugs carried, as well as convenience factors like hours of operation, delivery, drive-through window, and wait time (Franic et al. 2008; Patel et al. 2020). In particular, with prices for drugs increasing rapidly in the U.S. over the past decade, more patients were reported to have difficulties with paying for medications (Deb and Curfman 2020; Kesselheim, Avorn, and Sarpatwari 2016). As a consequence, cost has been an increasingly important factor in choosing a pharmacy. Facing large variations in drug prices among pharmacies, customers have been pushed to shop around for savings (Luo et al. 2019; Kullgren et al. 2017; Moshtaghi et al. 2017; Hauptman et al. 2017).

Travel patterns for pharmacies are a useful source of information that reflect people's choices and utilization of pharmaceutical services and how they physically move across space to obtain healthcare provision. For instance, whether an individual makes any pharmacy trip reflects the pharmacy utilization rate. Destination choices reflect the negotiated result between the supply of opportunities and the demand of individuals, which reflects what one needs and personally prefers. One-way trip distances reflect the costs, monetary and temporal, of travel to obtain pharmaceutical services.

Some studies have examined subjective perceptions of transportation barriers by people who need medication for certain health conditions (Syed et al. 2013). However, little research on actual pharmacy travel can be found in the existing literature. To my best knowledge, there has been no study that focused on actual travel to pharmacies within the past three decades. A combined examination of accessibility and actual travel for pharmacies is needed for a better understanding of pharmacy availability and uses by population subgroups.

7.3. Data and methods

7.3.1. Data

Locations of pharmacies in Detroit region

A complete list of pharmacies for the Detroit region was compiled based on the ReferenceUSA historic data for the year 2008 (Data Axle 2008). This dataset was used to measure the accessibility to pharmacies from home addresses by respondents in the 2008 NSF Detroit survey. As indicated by the survey data, the longest one-way trip distance reported for a trip to a pharmacy was less than 17 miles, and the average trip distance was 1.79 miles. It is important to recognize that the shortest distance from any of the six neighborhoods sampled in the 2008 Detroit survey to St Clair County, which is at the northeast corner of the Detroit region, is more than 20 miles. This means that, the pharmacies in St Clair do not actually serve the six neighborhoods sampled in the Detroit survey. So, businesses in St Clair County were excluded. Then, all the remaining businesses listed as a pharmacy were selected, resulting a total of 1,183 business listings. All the pharmacy outlets were checked by company name. Duplicate listings and businesses that were not actually pharmacies, or cannot be verified, or infusion services were removed, reducing the data to a total of 1087 pharmacy stores.

In addition, I classified these pharmacies in the Detroit region into five types (Figure 7-1) – 1) national chains that had operations beyond Michigan (e.g., CVS and Walgreens), 2) local chains defined as locally-owned pharmacies that had three or more franchises in the Detroit region (e.g., Knight Drugs in Detroit), 3) supermarket pharmacies (e.g., Walmart, Kroger or Costco pharmacies), 4) independent local pharmacies, and 5) institutional pharmacies (e.g., St John Hospital pharmacy). The most common pharmacy type were the national chains, followed by

independent local pharmacies. There was a much less but significant number of supermarket pharmacies. There were also very few pharmacies that were local chains or institutional pharmacies (4% of total pharmacies). Thus, local chains and institutional pharmacies will not be discussed in this study due to the small numbers of these pharmacies and low utilization rate.

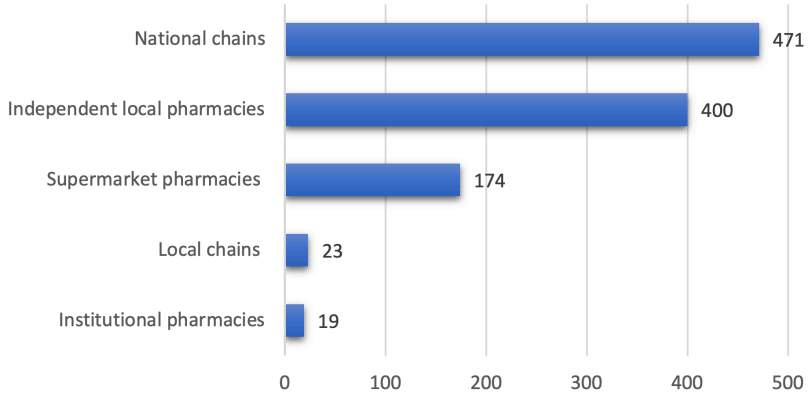


Figure 7-1. Total number of pharmacies by type in the Detroit region

2008 NSF Detroit survey on travel behavior

The home addresses of 997 respondents[4] from the six sampled neighborhoods in the 2008 NSF Detroit survey were geocoded into geographic coordinates using ArcGIS geocoding tool and

[4] A total of 1191 responses were returned for the survey. In some cases, multiple surveys were returned from the same household and only one of them was kept in the data. This yielded a final dataset by 997 respondents who gave complete or partial responses for the survey.

Google Maps. The accessibility to pharmacies in the six neighborhoods in the Detroit region was then measured from these home locations.

Information on pharmacy trips by respondents from the 2008 NSF Detroit survey was used to indicate where people actually went for pharmaceutical services. There was a total of 290 pharmacy trips reported by respondents from the six sampled neighborhoods for a typical week, with 75 trips from Urban Detroit (HU), 82 trips from the High-density Suburbs (HS) and 133 trips from the Low-density Suburbs (LS). Note that this was a count of trip destinations reported without weighting by trip frequency. One pharmacy may be reported as a trip destination multiple times by different respondents. These pharmacy trips reported by respondents were further geocoded and matched with pharmacy stores in business in the year 2008, which gave a total of 184 verified pharmacy trips covering 49 different pharmacies, as reported by 175 respondents for a typical week.

7.3.2. Method

The spatial distribution of pharmacies of different types was mapped in QGIS with an added layer of density. The density layers of pharmacies were generated using the *Heatmap tool* in the software. Density for each location on the map was calculated by counting the pharmacies that fell within a circular neighborhood of a specified size from that location.

The spatial accessibility to pharmacies was calculated for all 977 survey respondents from the six sampled neighborhoods. It was measured as the shortest road network distance to the nearest pharmacy. Data for the complete road network in Michigan by the State of Michigan were downloaded from *Michigan GIS Open Data* website. The shortest road network distances from 997 respondents to all 1087 pharmacies were calculated in ArcGIS using the Network Analyst tool,

giving a 997-by-1087 origin-destination distance matrix. Then the nearest pharmacy *k* was identified for each respondent *i*. The spatial accessibility to pharmacies for respondent *i* would be the shortest road network distance from pharmacy *k* to the home address of respondent *i*. Four accessibility measures were calculated, one for all types of pharmacies considered together, and three other measures for national chains (the predominant pharmacy type used by respondents), for local independent pharmacies, and for supermarket pharmacies.

To explore spatial patterns of pharmacy trips, destination pharmacies and trips with origin and destination were mapped first. Then, multiple statistical analyses were performed on pharmacy trips. First, a logistic regression was performed to evaluate factors that impact the likelihood to actually make any trip to a pharmacy. Three types of predictors were included – accessibility to pharmacies (all types of pharmacies considered), neighborhood type, and individual-level sociodemographic variables of age, gender, income and car ownership. Second, the rankings of destination pharmacies, in terms of proximity to respondents, were explored with Mann-Whitney U tests to test differences by neighborhood type, and then modeled with ordered logistic regression, to see what factors made people more willing to go beyond nearby pharmacy options. A destination pharmacy with a proximity rank of *K* would be the *Kth* nearest pharmacy store to the home address of the respondent. Meanwhile, there would be *K-1* pharmacies that were closer in distance than the destination pharmacy. A lower proximity rank (i.e., a larger *K* value) of the destination would indicate that the respondent bypassed more pharmacies closer and picked a pharmacy located farther away. Third, the relationship of one-way trip distances and accessibility to pharmacies were modeled with OLS regression for each of the three types of neighborhoods. Lastly, a logistic regression was used to examine whether any non-auto mode was used in order to understand factors that affected mode choice for pharmacy trips.

7.4. Results

7.4.1. The spatial distribution of pharmacies in the Detroit region

To evaluate the quantity and the types of pharmacies accessible in the case-study neighborhoods, I mapped all the pharmacies within and outside the six selected neighborhoods across the Detroit region and plotted the density of pharmacies by type, for the year 2008 when the survey data were collected (Figures 7-2 to 7-5).

Pharmacies were mostly distributed across the urban and suburban areas of the Detroit region, but not much in the rural areas, corresponding to differences in the population densities (Figure 7-2). Different types of pharmacies showed distinct spatial distribution patterns. National chains were more concentrated in the immediate surrounding areas outside the Detroit city boundary, and the density of national chain pharmacies was lower within the city, especially in the east side (Figure 7-3). The distribution of supermarket pharmacies was peripheral by nature. All the supermarket pharmacies were scattered in the suburbs and there was not one single supermarket pharmacy within the boundary of Detroit city (Figure 7-4). This was expected given the lack of major national/regional supermarket chains within the city at the time of the survey (LeDoux and Vojnovic 2013). On the contrary, local independent pharmacies tended to concentrate in the city of Detroit, likely to fill the gap within the urban market (Figure 7-5).

At the neighborhood level, the two eastside Urban Detroit neighborhoods, in comparison to the four suburban neighborhoods, had the most local independent pharmacies, which were located both within the neighborhood boundaries and close to the neighborhoods (Figure 7-5). However, the Urban Detroit neighborhoods were not well served by national chains such as CVS (Figure 7-3). While the city had national chain pharmacies, the two eastside neighborhoods were part of a

desert in the east side of the city and did not have any national chain pharmacies within the neighborhood boundaries. Also, there were no supermarket pharmacies at all, not only within the neighborhoods, but also within the city boundary (Figure 7-4). These patterns suggested that while the eastside Urban Detroit neighborhoods had good access to pharmaceutical services from local independent stores, they did not have good access to services from national chains and supermarket pharmacies, which typically had longer operation hours, offered more services and had more stable prices for medications than local independent pharmacy outlets (Qato et al. 2017; Luo et al. 2019; Doucette et al. 2017).

The high-income Detroit suburbs showed a very different pattern in the distribution of pharmacies. The two high-density suburban neighborhoods had higher densities of pharmacy services within the neighborhoods and in proximity, with various types of pharmacies, including local independent pharmacies, national chains and supermarket pharmacies, located within the neighborhoods or adjacent to the neighborhood boundaries (Figures 7-2 to 7-5). In comparison, the Low-density Suburbs had lower densities of pharmaceutical services when compared to the High-density Suburbs. But this was due to the low number of local independent pharmacies. The residents of the Low-density Suburbs were still closer to national chains and supermarket pharmacies when compared to the residents of the Urban Detroit neighborhoods, which was noteworthy given that Low-density Suburbs had much lower population densities (Figures 7-3 and 7-4).

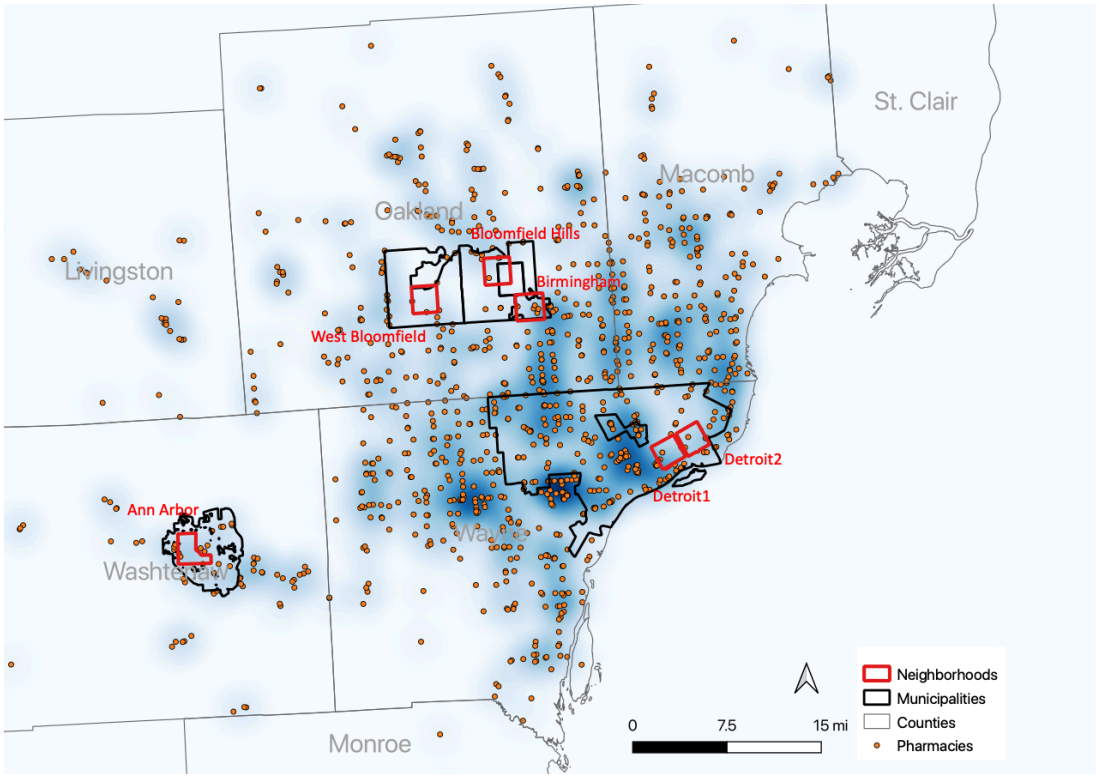


Figure 7-2. Distribution of pharmacies of all types (darker **blue** indicate higher density)

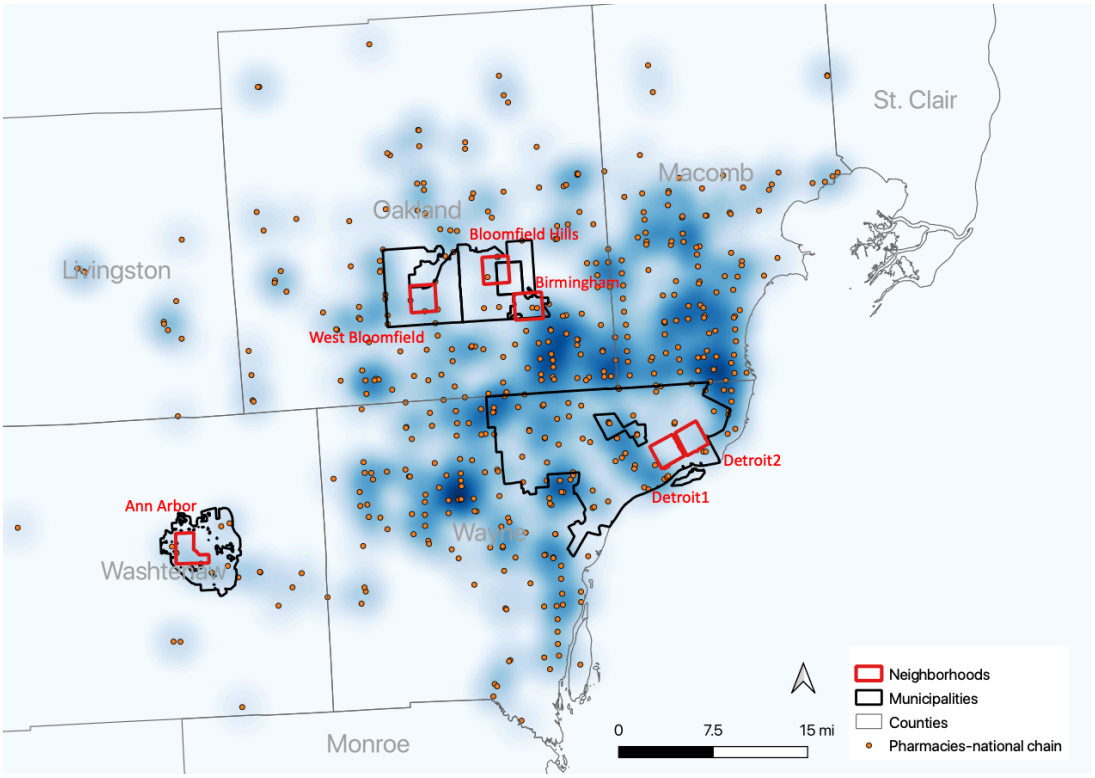


Figure 7-3. Distribution of national chain pharmacies (darker **blue** indicate higher density)

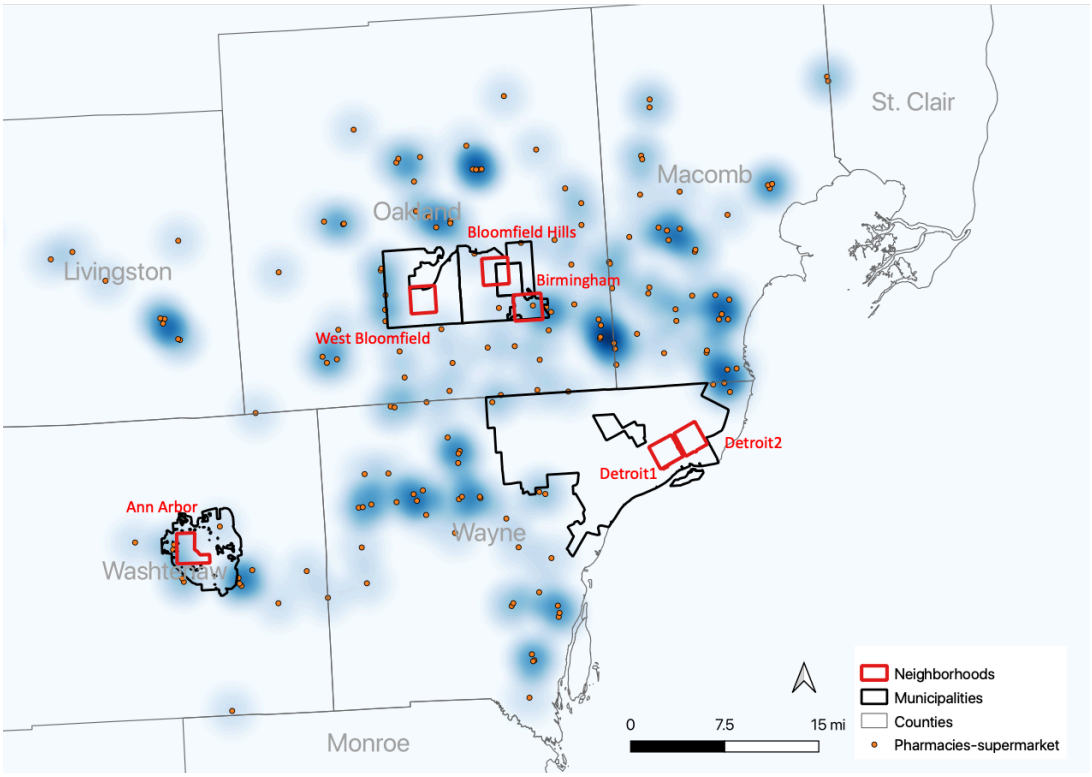


Figure 7-4. Distribution of supermarket pharmacies (darker **blue** indicate higher density)

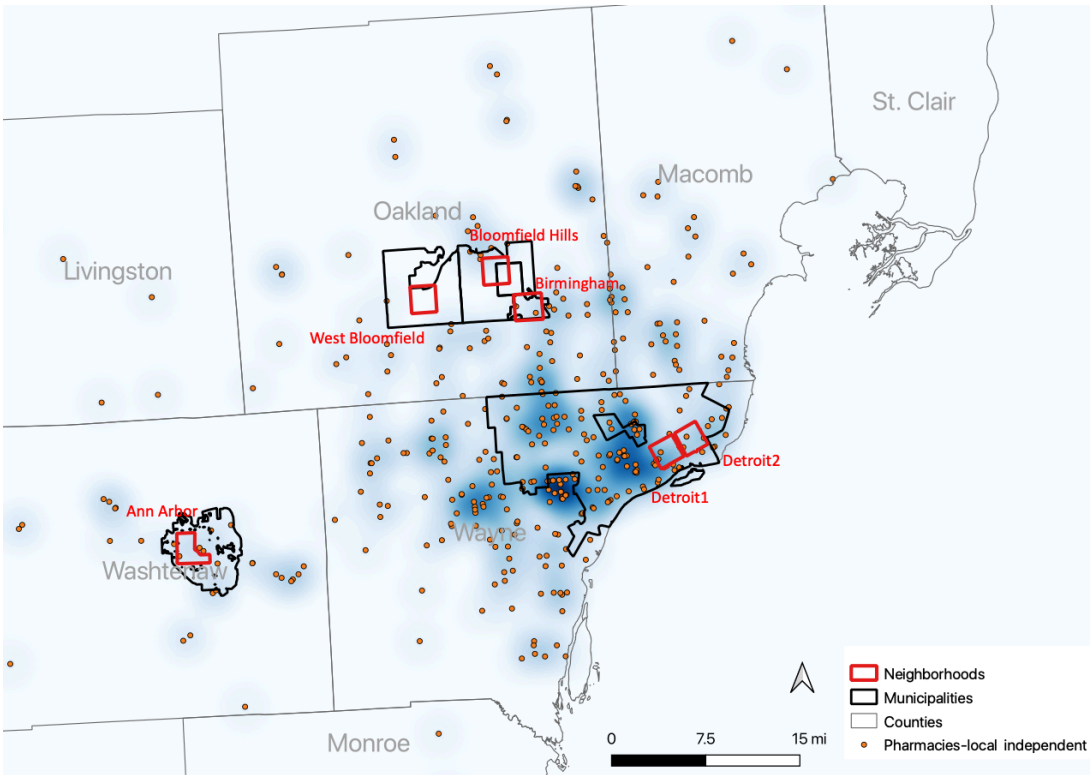


Figure 7-5. Distribution of local independent pharmacies (darker **blue** indicate higher density)

7.4.2. Accessibility to pharmacy

The results show that accessibility to pharmacies differed significantly across different types of neighborhoods, regardless of the measure used (Table 7-1 and Figure 7-6). Urban Detroit residents, mostly lower-income African Americans, actually had the best accessibility if considering all types of pharmacies, measured by distance to the nearest pharmacy. This was a result of the access to local independent pharmacies. However, Urban Detroiters had to overcome the longest distances to reach any national chain or supermarket pharmacy. This warrants attention since national chains like CVS or Walgreens were found to offer more services and lower prices (Qato et al. 2017; Luo et al. 2019; Doucette et al. 2017) and were the main pharmacy destinations Urban Detroit residents actually visited.

Residents in the suburbs, mostly middle- and upper-income white Americans, generally had good access to pharmacies compared to Urban Detroit residents. First, residents in High-density Suburbs had the best accessibility to supermarket pharmacies and good access to national chains and local independent stores as well. Second, despite the low-density built environment, residents of Low-density Suburbs actually had better access to pharmaceutical services from national chains (the main pharmacy type visited) and supermarkets compared to Urban Detroit residents. These findings indicate that to fully understand accessibility to pharmaceutical services, it is critical to evaluate access to different pharmacy types. Aggregating all pharmacies together will sometimes erase important discrepancies in access that might be evident among neighborhoods of different class and/or race compositions.

Table 7-1. One-way ANOVA of accessibility to pharmacy by respondents on neighborhood type

	Urban Detroit (HU)		High-density suburbs (HS)		Low-density suburbs (LS)		One-way ANOVA	
	Mean	SD	Mean	SD	Mean	SD	F-value	P-value
Distance to nearest pharmacy (all types)	0.73	0.28	0.81	0.36	0.88	0.38	12.05	0.000
Distance to nearest national chain	1.35	0.47	1.07	0.47	0.91	0.39	72.09	0.000
Distance to nearest local independent pharmacy	0.74	0.28	0.93	0.34	2.44	0.93	790.8	0.000
Distance to nearest supermarket pharmacy	6.21	1.37	1.46	0.69	2.64	0.66	2206	0.000

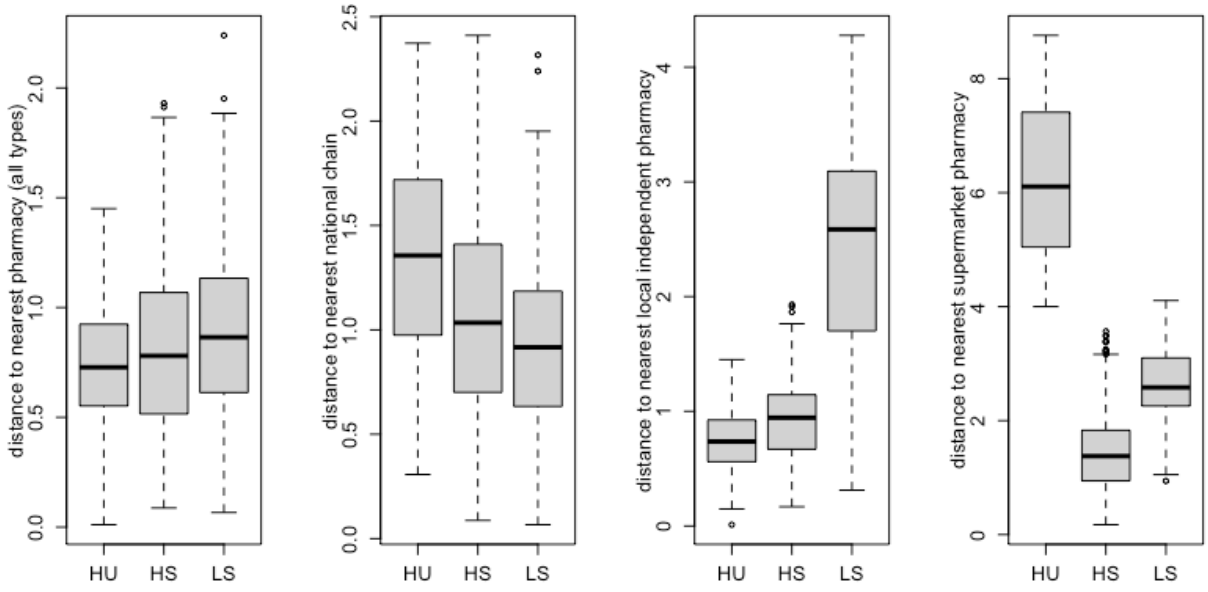


Figure 7-6. Accessibility by pharmacy type and neighborhood type (measured as the shortest road network distance to the nearest pharmacy)

7.4.3. Travel patterns to pharmacies

Who visited pharmacies

Out of 997 respondents, 278 (28%) reported making at least one pharmacy trip in a typical week. Low-density suburbs had the highest percentage of respondents who used pharmacy services (38%), while High-density Suburbs had the lowest percentage (20%) (Figure 7-7).

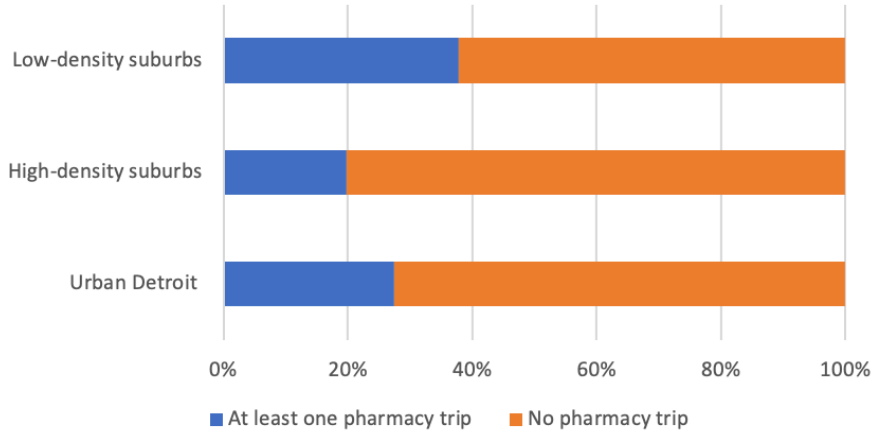


Figure 7-7. The percentage of respondents who reported pharmacy trips, by neighborhood type

The results of the logistic regression on the likelihood to actually make any trip to a pharmacy (Table 7-2) showed that, first, the likelihood to use pharmacies was influenced by accessibility to pharmacies, as measured by the distance to the nearest store. This means that people were less likely to utilize pharmaceutical services when they did not have a pharmacy near their homes. For a one-mile increase in the distance to the nearest pharmacy, the likelihood of a resident using pharmaceutical service decreased by 2.4 times ($1/e^{-0.871}$).

Second, the likelihood to use pharmacies varied significantly across neighborhoods. Residents in the High-density Suburbs were the least likely to use a pharmacy, even after controlling for accessibility and sociodemographic factors. The odds of visiting one or more pharmacies as

opposed to visiting no pharmacy at all in a typical week was 2.5 times ($e^{0.913}$) lower for residents in the High-density Suburbs, as compared to residents in the Low-density Suburbs. A possible explanation of this difference is that residents in the High-density Suburbs were in better health than the residents of the other neighborhood types. This was suggested by their healthier lifestyle, given that they maintained the lowest BMI (average BMI 24.5), the most trips for the purpose of doing physical activities – such as playing tennis or going to a fitness class – (the average trip frequency was 1.1 trips per week) and the fewest fast food trips (the average trip frequency was 1.2 trips per week), compared to residents in Urban Detroit (average BMI 29.9, with 0.3 trip for physical activities and 5.7 fast food trips per week), and residents of the Low-density Suburbs (average BMI 25.3, with 0.8 trip for physical activities and 2.3 fast food trips per week).

In addition, while Urban Detroit residents likely had the least favorable health conditions with the highest BMI, the most fast-food restaurant trips and the least trips for physical activities on average, they were less likely to visit pharmacies compared to residents of the Low-density Suburbs, even after controlling for individual-level factors of age, gender, income and car ownership. This indicates that the needs for pharmaceutical services might be suppressed in Urban Detroit. One potential factor is the socioeconomic composition of Urban Detroit – high concentrations of lower-income African Americans. There might be lower density of health care providers, less health insurance coverage, lack of easy access to medical information through social networks, or cultural norms and values in such segregated disadvantaged communities that discourage people from utilizing health care services, including pharmacies (Gaskin et al. 2012).

Third, age and gender affected whether a respondent visited a pharmacy. The odds of visiting a pharmacy rather than visiting no pharmacy at all in a typical week was 1.15 times ($e^{0.014*10}$) higher for every ten-year increase in age, and 1.91 ($e^{0.645}$) times higher for women than men. This reflects

a greater need for medications by seniors and women. It could be argued that the tendency for women to visit pharmacies is due to household responsibilities and shopping for others. Additional analysis that controlled for household size, presence of children under 18 and marital status indicated that the effect of gender was actually independent from household structure (results not shown). Even among residents who lived alone, women were more likely to visit pharmacies than men. This was expected given that women tended to utilize significantly more services and spend more on health care than men (Owens 2008). However, having lower income levels or no access to a car did not affect whether someone used pharmacy services.

Table 7-2. Logistic regression of the likelihood to visit a pharmacy in a typical week

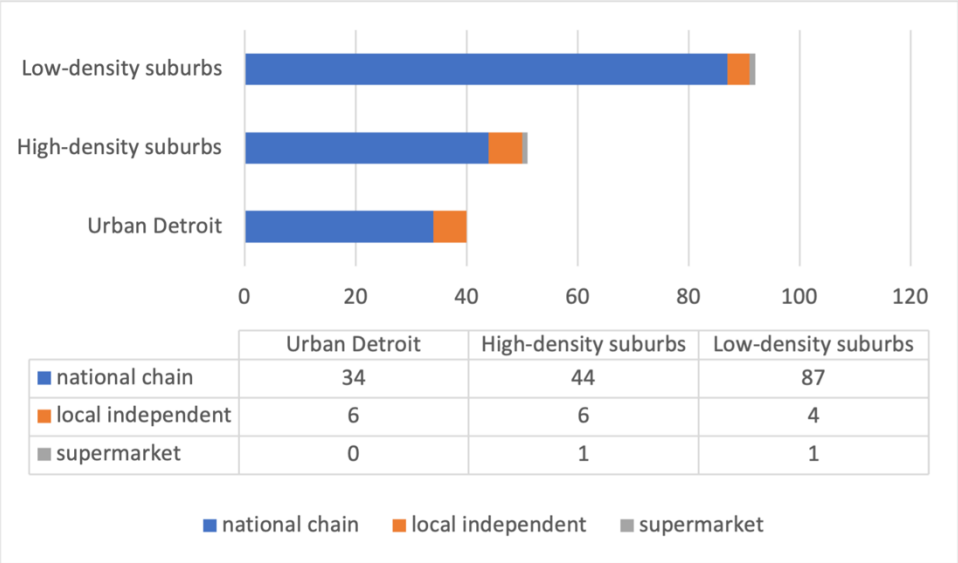
	Coefficient	SE	p-value	
Intercept	-1.253	0.350	0.000	***
Accessibility	-0.871	0.240	0.000	***
Neighborhood type				
HS (reference)				
HU	0.321	0.262	0.219	
LS	0.913	0.193	0.000	***
Age	0.014	0.005	0.011	*
Female	0.645	0.183	0.000	***
Household income				
>50k (reference)				
0~20k	0.361	0.291	0.216	
20~50k	0.164	0.240	0.496	
Car ownership				
no car	-0.253	0.345	0.463	
Efron's R2 = 0.066				
N = 816 respondents				

Note: Accessibility was measured as distance to the nearest pharmacy of any type

Destination choices for pharmaceutical service

Type of pharmacy visited

The number of trip destinations reported for different types of pharmacies, by the three types of neighborhoods, are shown in Figure 7-8. The results indicated that national chains were the main type of pharmaceutical services used by residents across the different neighborhoods in the Detroit region. While national chain pharmacies constituted 43% of all pharmacies in the Detroit region (Figure 7-1), they made up 90% of all pharmacy trip destinations by respondents in the six sampled neighborhoods. In contrast, local independent pharmacies constituted 37% of all pharmacies in the Detroit region, but they made up only 9% of all pharmacy trip destinations by respondents in the six sampled neighborhoods.



	Urban Detroit	High-density suburbs	Low-density suburbs
national chain	34	44	87
local independent	6	6	4
supermarket	0	1	1

Figure 7-8. Total number of pharmacy trip destinations reported by neighborhood type

Figure 7-9. Distribution of pharmacies in the city of Ann Arbor; varying sizes of red circles – how many respondents reported visiting the pharmacy; black circles – pharmacies not visited by respondents

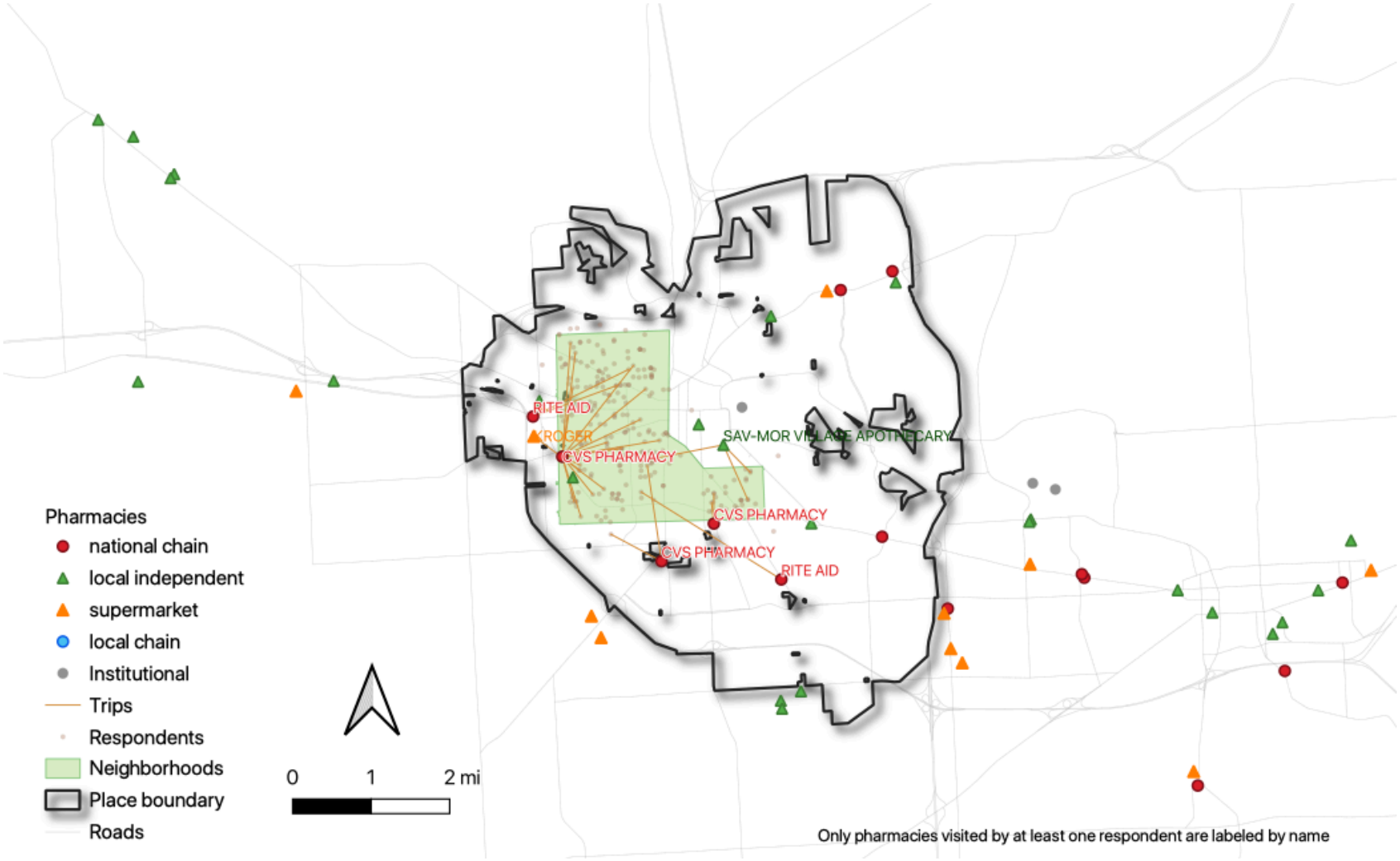


Figure 7-10. Pharmacy trips with origins and destinations in the city of Ann Arbor

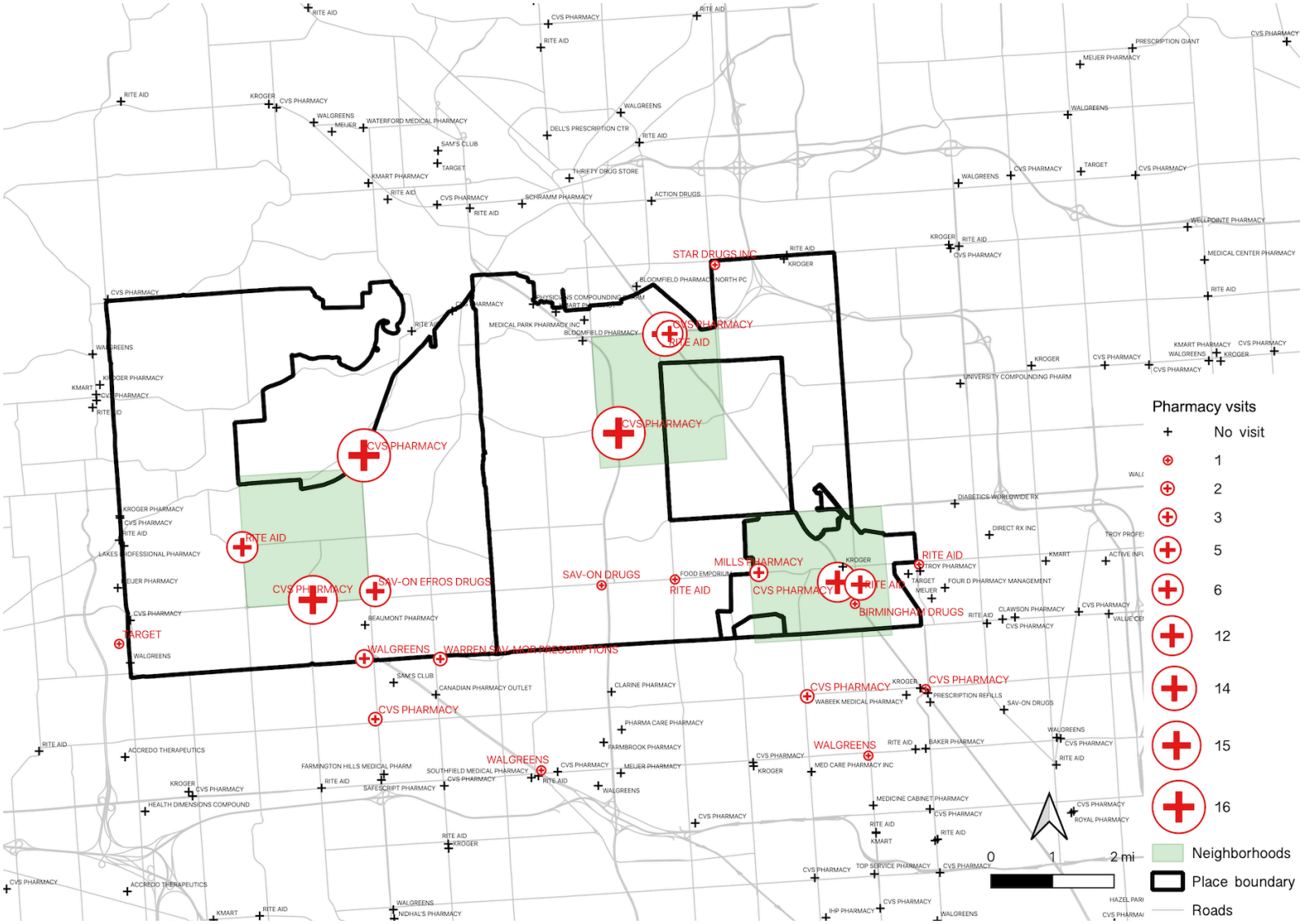


Figure 7-11. Distribution of pharmacies in two Low-density Suburbs (neighborhoods on the left and upper middle) and one high-density suburb (Birmingham, neighborhood on the right); varying sizes of red circles – how many respondents reported visiting the pharmacy; black circles – pharmacies not visited by respondents

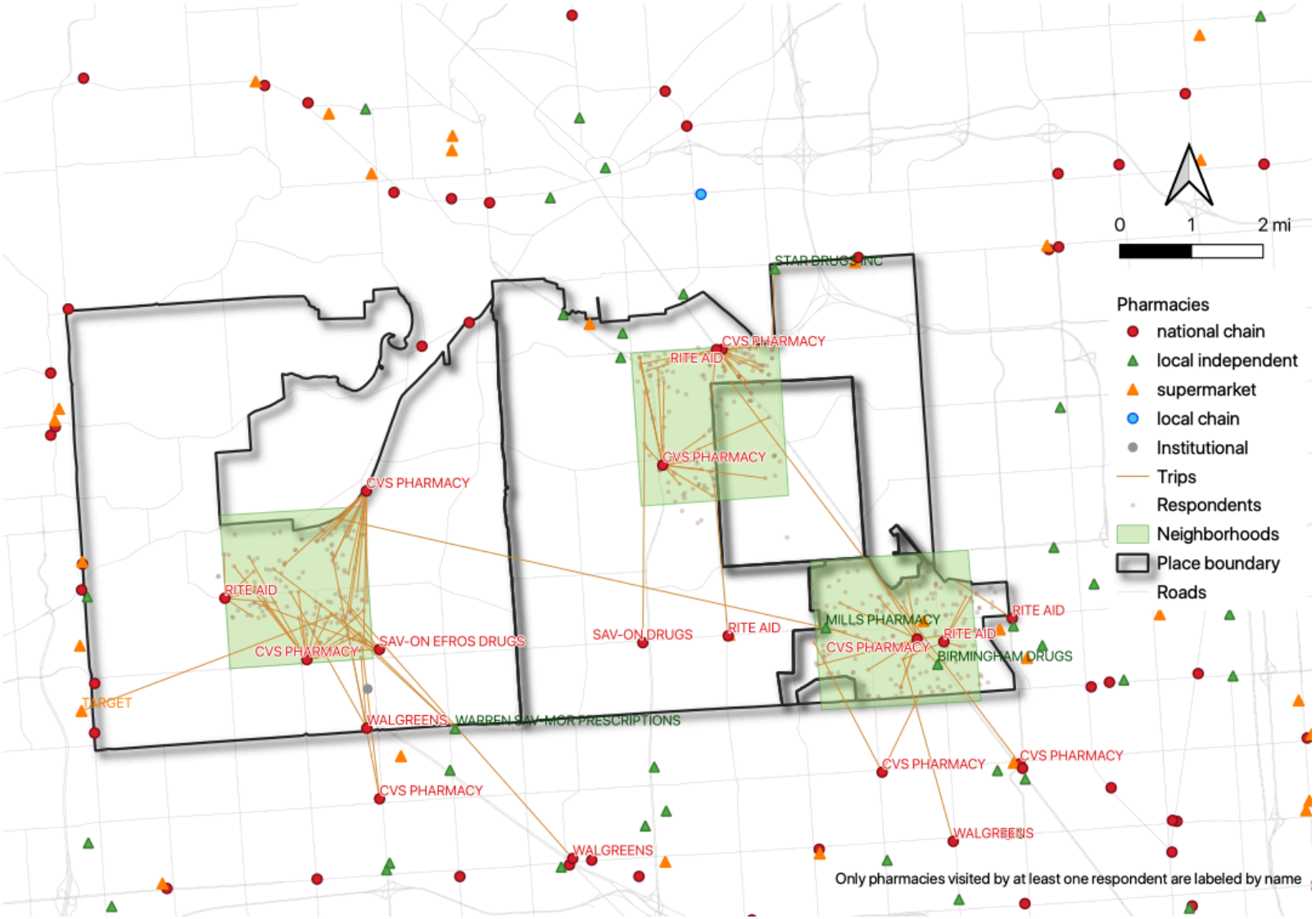


Figure 7-12. Pharmacy trips with origins and destinations in two Low-density Suburbs (neighborhoods on the left and upper middle) and one high-density suburb (Birmingham, neighborhood on the right)

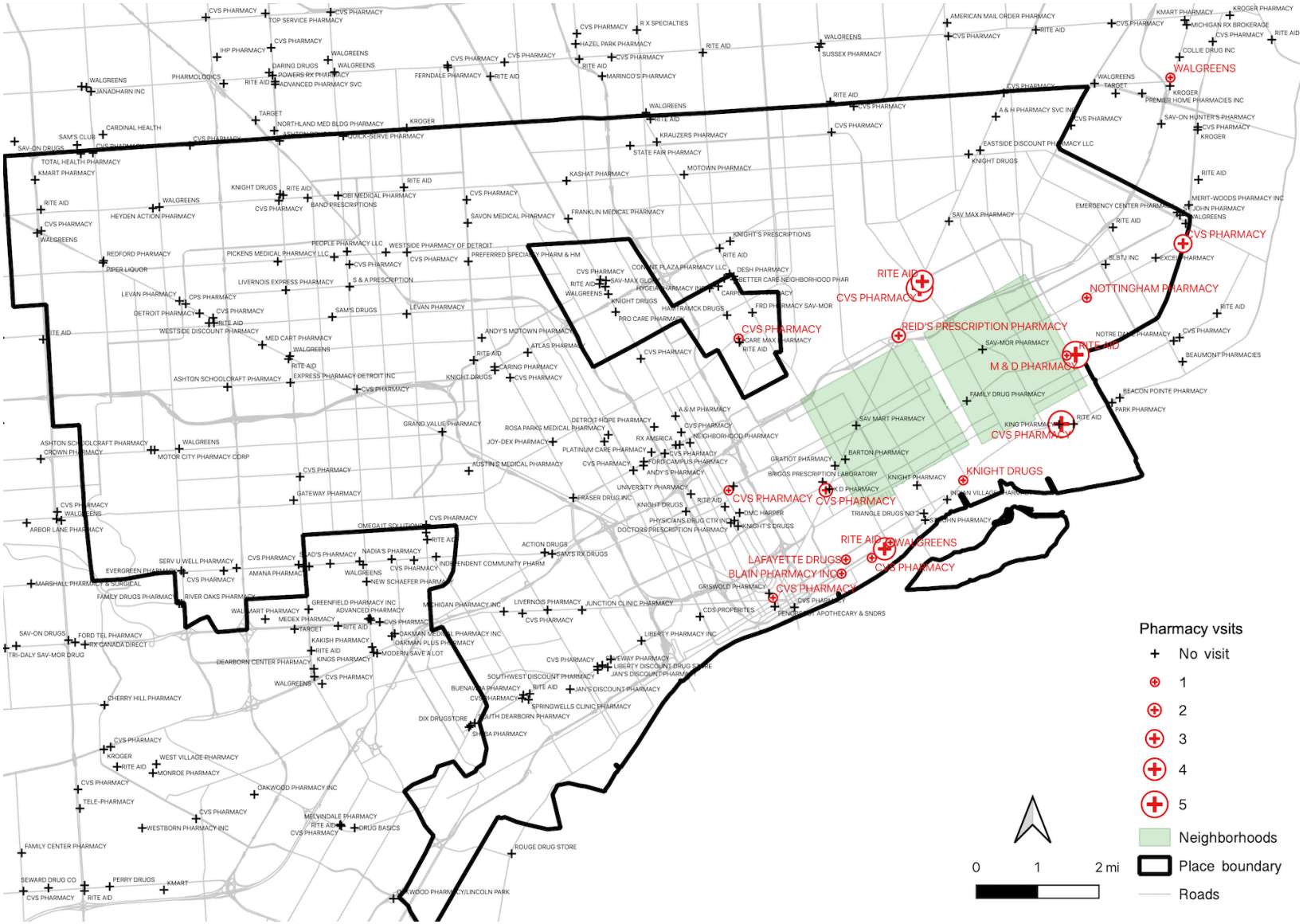


Figure 7-13. Distribution of pharmacies in the city of Detroit; varying sizes of red circles – how many respondents reported visiting the pharmacy; black cross – pharmacies not visited by respondents

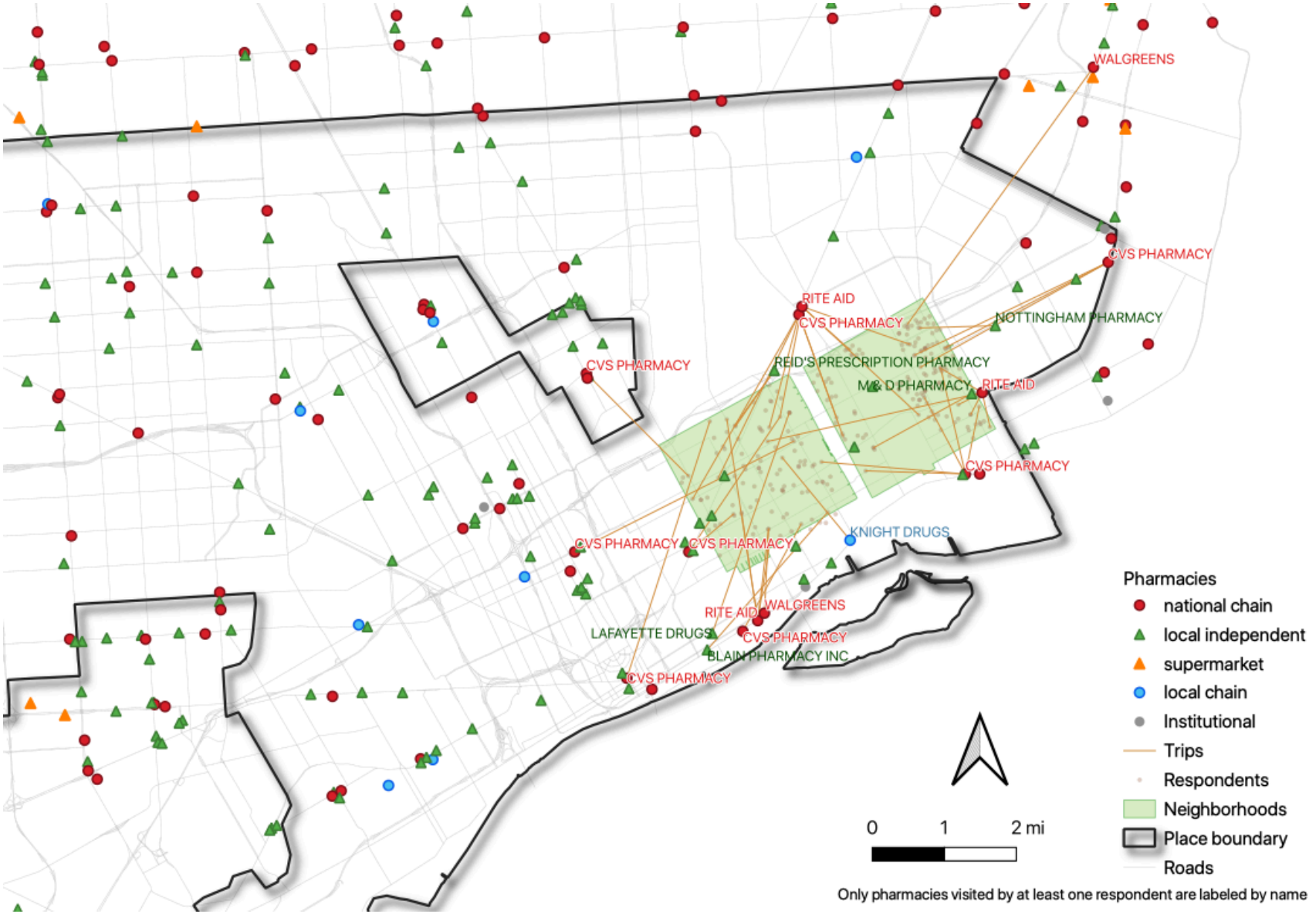


Figure 7-14. Pharmacy trips with origins and destinations in the city of Detroit

Maps of pharmacy destination choices

Destination choices were mapped by destinations and by pharmacy trips (Figures 7-9 to 7-14). Figures 7-9, 7-11, and 7-13 show pharmacies near the six sampled neighborhoods and Figures 7-10, 7-12, and 7-14 map the exact origins and destinations of pharmacy trips reported by respondents in different neighborhoods. In the four suburban neighborhoods, most respondents visited nearby pharmacies, predominantly national chains of CVS, Walgreens, and Rite Aid. Residents in the High-density Suburbs limited their destinations to pharmacies within or close to their communities. Most residents chose national chain pharmacies nearby. In Ann Arbor, one CVS store on the west boundary of the sampled neighborhood served significantly more customers than all other pharmacies. In Birmingham, there were multiple pharmacies that were located within the neighborhood boundary. Two national chain stores (one CVS and one Rite Aid) located in the center of the neighborhood served the most customers.

In the Low-density Suburbs of West Bloomfield and Bloomfield Hills, a few national chains located along the neighborhood boundaries served the majority of the residents (Figure 7-11). Trips by residents in the Low-density Suburbs showed two different patterns (Figure 7-12). Most residents visited national chain pharmacies close to their homes. But a few residents traveled much longer distances, outside of the neighborhoods, to reach pharmacies at greater distances from their homes. One possible explanation for this pattern of pharmacy visits was due to trip chaining with other activities, such as shopping or banking. A person might visit a grocery, bank or be on the way back from work, making a stop along the way at a pharmacy. Some destinations that were far from the resident's home address were located on major highways that connected to their community. For example, Figure 13 shows that a CVS south of Birmingham located on a northwest-southeast freeway was used by a resident in Bloomfield Hills. Another possible

explanation was the need for specific personalized services, which might be the case for two trips to local independent pharmacies (Mills pharmacy and Warren Sav-Mor) that were much longer in distance.

In Urban Detroit, the trip destinations were mostly national chains such as CVS or RITE AID (Figures 7-13 and 7-14). Compared to the suburban neighborhoods, Urban Detroit residents reported visiting slightly more local independent pharmacies. But the number of residents in Urban Detroit who reported visiting these stores was considerably less than their visits to national chains. This is particularly interesting given the high density of local independent pharmacies within and in proximity of their neighborhoods. Instead of relying on nearby local independent pharmacies within the neighborhood boundaries, Urban Detroit residents traveled considerable distances to get to pharmacies, and mostly to national chains, but also occasionally to local independent pharmacies, outside their neighborhoods (Figure 7-14). These selection decisions might be motivated by better services and access to products, in terms of the variety, quality, convenience and/or costs, which are provided in these more distant pharmacies.

Proximity ranking of destination pharmacies

Most residents in the four suburbs chose nearby pharmacies, while Urban Detroit respondents tended to bypass nearby pharmacies and travel great distances to access pharmaceutical services outside of their neighborhoods, as indicated by proximity rankings (K) of pharmacy desinations (Figures 7-15 to 7-16). On average, residents in both the High-density Suburbs and in the Low-density Suburbs picked the pharmacy that was the 4^{th} closest pharmacy to them, while residents in Urban Detroit picked the pharmacy that was the 14^{th} closest pharmacy to their home. Furthermore, the medians of proximity rankings (K) of pharmacy desinations for the three

neighborhood types suggest that a typical resident in the High-density Suburbs and in the Low-density Suburbs chose the 2nd and 1st closet pharmacy to them, respectively, while a typical resident in Urban Detroit selects the 11th closest pharmacy. These differences in destination choice between Urban Detroiters and the suburbanites were substantial. It means that most residents in the suburbs picked the nearest or the next nearest pharmacy to use, while Urban Detroiters typically bypassed several pharmacies and traveled considerable additional distance to reach a pharmacy. These selection patterns are seen in the maps (Figures 7-10, 7-12, and 7-14).

Since most residents chose to shop at national chain pharmacies (national chains consisted of 90% of all pharmacy trip destinations), they sometimes bypassed nearby local independent pharmacies or supermarket pharmacies. It was necessary to explore the destination choices among national chains only. When limiting pharmacy trips to visits to national chains only, more than half of the residents in the suburbs picked the nearest national chain pharmacy and many others picked one of the national chains in close proximity to their home (Figure 7-17). However, the majority of residents in Urban Detroit did not choose the nearest pharmacy. On average, residents in both the High-density Suburbs and in the Low-density Suburbs picked the national chain pharmacy that was the 2nd closest to them, while residents in Urban Detroit picked the one that was the 5th closest. Furthermore, the medians of proximity rankings (K) of pharmacy desinations for the three neighborhood types suggested that, a typical resident in both High-denstiy and Low-density Suburbs picked the nearest national chain pharmacy, while a typical resident in Urban Detroit picked the 3rd closest national chain.

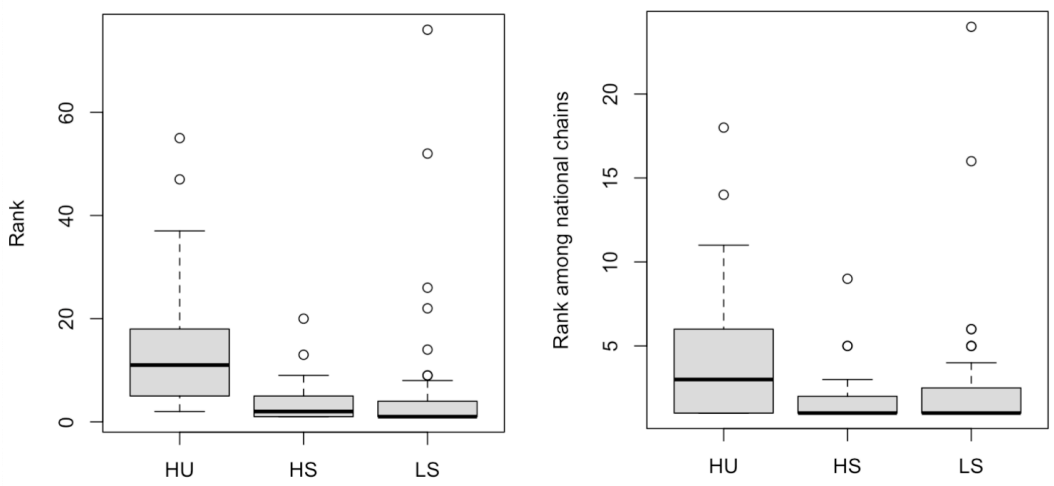


Figure 7-15. Boxplots of destination pharmacy's rank (*K*) in proximity to the respondent home among all pharmacies (from nearest to farthest) for all pharmacy trips, by neighborhood type. Left – proximity rank among all pharmacies; right – proximity rank among national chains only

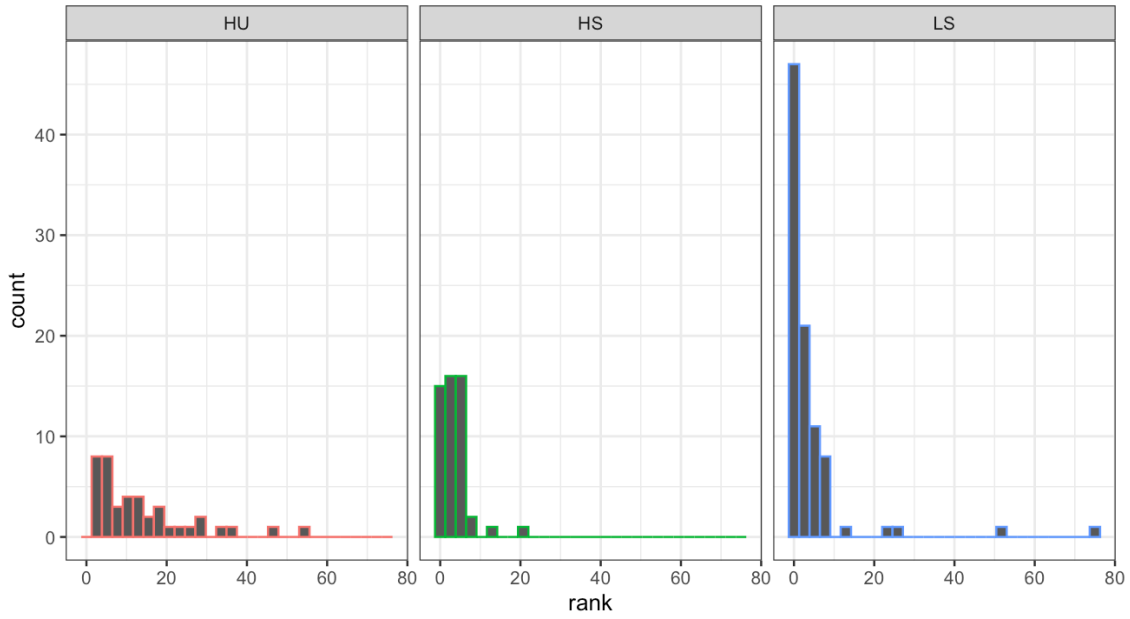


Figure 7-16. Histogram of destination pharmacy's rank (*K*) in proximity to the respondent home among all pharmacies (all types), by neighborhood type

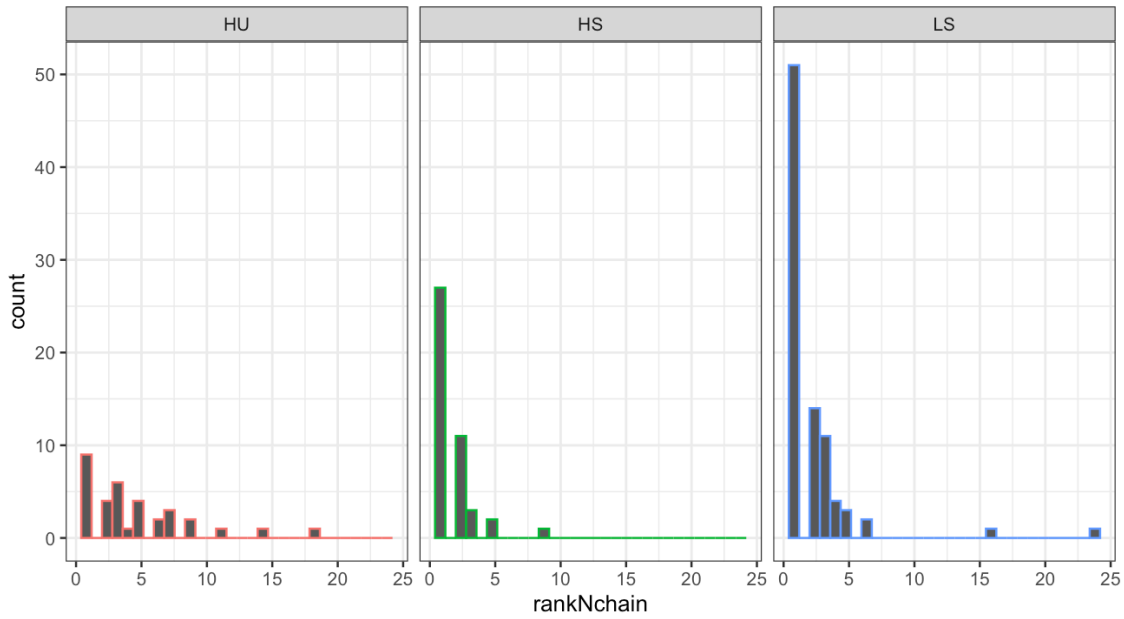


Figure 7-17. Histogram of destination pharmacy's rank (*K*) in proximity to the respondent home among all pharmacies (National chain only) , by neighborhood type

Further analyses were done to verify the difference in the proximity ranks (*K*) of pharmacy destinations among residents in different types of neighborhoods. First, Mann-Whitney U tests were performed to test if proximity ranks (*K*) of destinations were significantly different among residents in different types of neighborhoods. Proximity ranks of destinations (*K*) by residents in Urban Detroit were significantly lower (higher in numeric value) than that by residents in both the High-density Suburbs (p-value <0.000) and the Low-density Suburbs (p-value <0.000). This applied to both proximity rank among all pharmacies and among national chains only. This means Urban Detroiters were more likely than residents in the suburbs to choose far-away pharmacies, confirming previous findings. However, the difference of proximity ranks of desitnations between residents in the High-density and the Low-density Suburbs were not statistically significant at the confidence level of 0.05 (p=0.057). This indicates that despite a few outlier cases, residents in the

High-density Suburbs did not substantially differ from residents in the Low-density Suburbs in terms of destination choices and both tended to use nearby national chains,.

Second, an ordered logit regression was built to evaluate the impacts of various predictors on proximity ranks of the destination pharmacies (Table 7-3). Predictors tested in the model included accessibilty (measured as the shortest road network distance to the nearest pharmacy of any type), neighborhood type, car ownership and sociodemographic variables. The results showed that residents with lower accessiblity (longer distance to reach any pharmacy) were less likely to choose the nearest pharmacy. With a one mile increase in the distance to the nearest pharmacy, a resident was 4.9 times (odds ratio = $e^{1.585}$) more likely to choose a pharmacy that was further away instead of one closeby.

Also, the neighborhood type affected the proximity ranks of the destination pharmacies. More specifically, residents in Urban Detroit were 13.5 times (odds ratio = $1/e^{-2.604}$) more likely to choose a farther pharmacy instead of one closeby compared to residents living in the High-density Suburbs, and 34 times (odds ratio =$1/e^{-3.526}$) more likely compared to residents of the Low-density Suburbs (Table 7-3). None of the other predictors – car ownership and sociodemographic variables – were significant. A likelihood ratio test was performed to evaluate the model and the result showed that the model was significant compared to a null model without any predictor (p=0.000).

Table 7-3. Ordered logistic regression of proximity ranks (*K*) of destination pharmacies among all pharmacies

	Coefficient	SE	P-value		Odds ratio	95% Confidence interval	
						2.50%	97.50%
Access	1.585	0.473	0.001	***	4.879	1.951	12.495
Neighborhood type							
HU (reference)							
HS	-2.604	0.509	0.000	***	0.074	0.027	0.198
LS	-3.526	0.524	0.000	***	0.029	0.010	0.081
Age	0.014	0.010	0.150		1.015	0.995	1.035
Female	0.137	0.363	0.705		1.147	0.565	2.360
Household income							
>50k (reference)							
0~20k	-0.277	0.601	0.645		0.758	0.233	2.487
20~50k	-0.744	0.387	0.055		0.475	0.218	1.001
Car ownership							
no car	-0.866	0.644	0.179		0.420	0.115	1.462

Note: Accessibility was measured as distance to the nearest pharmacy of any type

In summary, destination choices differed fundamentally between Urban Detroiters and suburban residents, even after controlling for sociodemographic differences like income and car ownership. Residents in Urban Detroit tended to bypass both nearby local independent pharmacies and the closest national chains, and chose to use pharmaceutical services in other national chains that were farther away from their neighborhoods. Proximity was not the priority in how they chose their destinations. It has been documented that poor minority areas face greater price variation and lower quality of pharmaceutical services (Erickson and Workman 2014; Gellad et al. 2009; Green et al. 2005; Moshtaghi et al. 2017). Residents may choose to travel longer distances to access pharmacies that have more medications in stock, better consulting, longer business hours and/or cheaper prices.

Also, a biased perception of distance might inhibit people from choosing closer pharmacies. The survey data showed that the correlation of reported one-way trip distances and actual one-way trip

distances for pharmacy trips was the lowest in Urban Detroit (r = 0.50), compared to the High-density Suburbs (r = 0.74) and the Low-density Suburbs (r = 0.66). This means the perception of trip distance is biased by 75% in Urban Detroit, which might have reduced the impact of distance on the decision in choosing a pharmacy destination. In contrast, most suburban residents tended to choose nearby national chains for their pharmaceutical services. The only difference between residents in the High-density Suburbs and the Low-density Suburbs was that a few residents in the Low-density Suburbs chose to travel far and use pharmacies in more distant communities, possibly due to trip chaining with other activities or special needs. But these cases were the outliers, rather than the norm.

Also, it is worth noting that destinaiton chocies – in terms of how much people were willing to travel beyond the nearest store for more options – varied with accessiblity levels. People became more desensitized to distance variation when all the avaialble options were far away.

One-way trip distance

One-way trip distances to pharmacies, which indicates how far people traveled to reach pharmaceutical services, were shown to vary by neighborhood type. Urban Detroiters traveled the longest one-way distances for their pharmacy trips on average (2.2 miles). Residents in the High-density Suburbs traveled the shortest one-way distances on average (1.2 miles), while residents in the Low-density Suburbs traveled the second longest one-way distances on average (1.6 miles) amongst the three neighborhood types. This means that, despite the higher densities, mixed land uses and connected street networks – built environment characteristics that are supposed to facilitate accessibility – Urban Detroit residents traveled the longest distances to reach their pharmacies of choice.

Across all three types of neighborhoods, accessibility significantly predicted actual trip distances (Figures 7-17 and 7-18). However, accessibility as measured by the distance to the nearest national chain was a much better predictor of actual trip distance, compared to accessibility as measured by distance to the nearest pharmacy (of any type). This was due to the fact that more than 90% of pharmacy trips were visits to national chains. Also, the relationship of accessibility and actual trip distance to pharmacies was the strongest in the High-density Suburbs (Figures 7-18 and 7-19). This confirms the patterns seen in the origin-destination maps of trips (Figures 7-10, 7-12, and 7-14), which showed that residents tended to choose the nearest pharmacy or at least one of the nearby pharmacies. The relationship was much weaker in both Urban Detroit and the Low-density Suburbs, but due to different reasons.

In Urban Detroit, few residents chose to visit the nearest pharmacy or the nearest national chain pharmacy. Instead, they tended to select pharmacies at great distances from their homes, as already shown. In the Low-density Suburbs, many residents who reported pharmacy trips actually did visit the nearest national chains. The much lower R^2 was due to the decisions of a few residents that chose to visit pharmacies very far away, possibly due to trip chaining with other activities (as various businesses were scattered across the region) or special medication needs that required personalized pharmaceutical services. Further analysis shows that when removing these outliers in the Low-density Suburbs, R2 increased and was comparable to the High-density Suburbs, indicating that the strength of the relationship between trip distance and accessibility in the Low-density Suburbs was similar to the High-density Suburbs if excluding a small number of extremely long-distance trips (results not shown). These findings verified patterns seen in the destination choices for pharmacy trips discussed in the previous section. Finally, it was also worth noting that sociodemographic variables, such as gender, income and age, as well as car ownership were also

tested, both within each of the three neighborhood types and with all data together, but none showed any significant relationship with actual trip distances to pharmacies (results not shown).

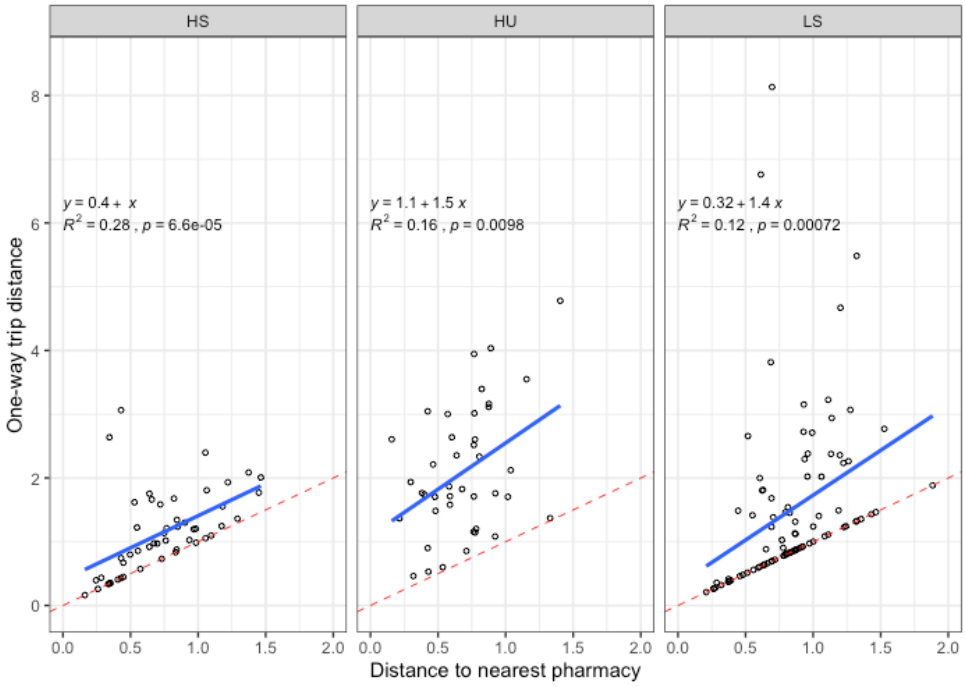


Figure 7-18. One-way trip distance versus accessibility measured as distance to nearest pharmacy; blue line is the regression line and red dashed line is the y=x reference line when a resident visited the nearest pharmacy

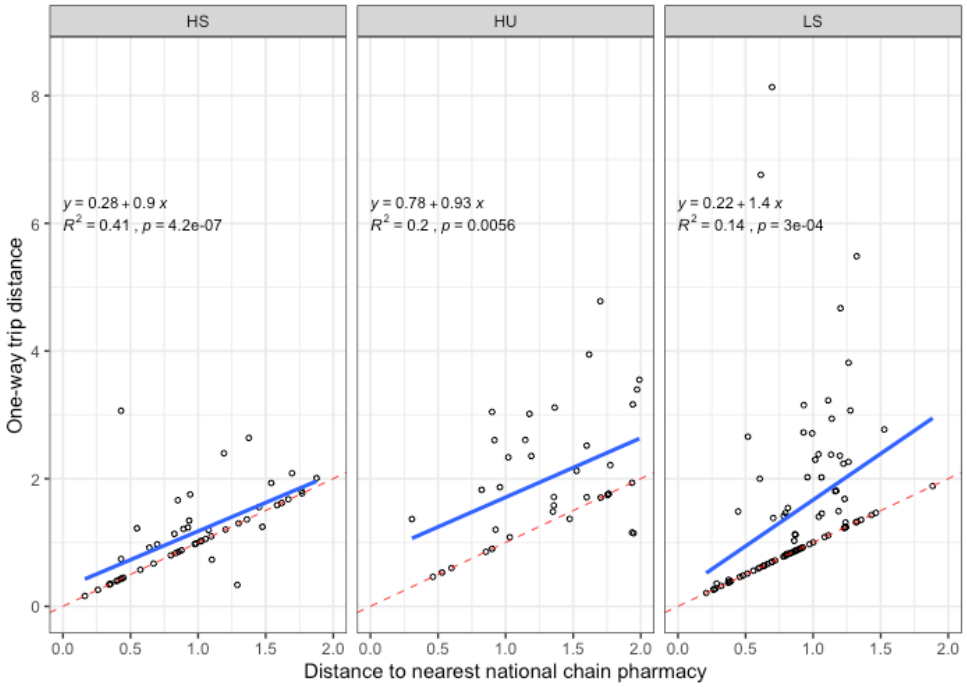


Figure 7-19. One-way trip distance versus accessibility measured as distance to nearest national chain pharmacy; blue line is the regression line and red dashed line is the y=x reference line when a resident visited the nearest pharmacy

Travel mode for pharmacy trips

Eighteen-point nine percent of reported pharmacy trips involved the use of one of the non-auto transport modes (walking/biking or public transit), which was higher than the percentage for all personal service trips together (15.8%). More specifically, 3.4% of reported pharmacy trips used public transit (as the only transport mode or combined with other travel modes), and 17.6% of reported pharmacy trips involved walking or biking (as the only transport mode or combined with other travel modes). This could be explained by the fact that pharmacy trips tended to have shorter one-way distances (average 1.8 miles), compared to other personal service trips (average 3.3 miles).

The results of the logistic regression on the use of non-auto mode in pharmacy trips (Table 7-4) showed that, first, longer one-way trip distances significantly reduced the likelihood to use non-

auto modes, which was expected. Second, neighborhood type did not affect mode choice for pharmacy trips. When controlling for one-way trip distance, the likelihood to use non-auto modes for pharmacy trips by residents in the Low-density Suburbs did not differ significantly from residents living in the High-density Urban and Suburban neighborhoods. This was in contrast to the significantly higher tendency to use cars by residents in the Low-density Suburbs in travelling for other personal services, as found in the previous chapter on trip frequency, total distance and mode. This suggests that the effect of the built environment on mode of travel for pharmacy trips is not as important, possibly due the relative convenience to reach pharmacies even in the Low-density Suburbs. The average trip distance to pharmacies was 2.2 miles for Urban Detroit residents, 1.2 miles for the High-density Suburban residents and 1.6 miles for the Low-density Suburban residents, while the average trip distance to personal services in general was 4.4 miles, 2.9 miles, and 5.4 miles for residents in the three types of neighborhoods respectively. Third, when controlling for one-way trip distance, car ownership was the only significant factor that affected the mode of travel for pharmacy trips. Having no access to a car in the household significantly increased the likelihood to use a non-auto mode of travel, by 25 times ($e^{3.222}$) for a pharmacy trip. This is expected, as owning a car induces more car use (Van Acker and Witlox 2010). The lack of significance for other sociodemographic factors, such as age and gender, could indicate either no effect or very weak effects that were not detected with the use of a small sample. In summary, mode choice for pharmacy trips was associated with car ownership and trip distance, but not neighborhood type or individual-level sociodemographic factors.

Table 7-4. Logistic regression of the likelihood to use non-auto modes for pharmacy trips

	Coefficient		SE
Intercept	-0.384		0.940
Log trip distance	-1.559	***	0.412
Neighborhood type			
HS (reference)			
HU	-0.952		0.892
LS	-0.877		0.546
Age	-0.016		0.016
Female	0.287		0.564
Household income			
>50k (reference)			
0~20k	1.072		0.886
20~50k	-0.611		0.720
Car ownership			
no car	3.222	**	1.015
Efron's R2 = 0.229			
N = 167 pharmacy trips			

7.5. Discussions

7.5.1. Spatial distribution and accessibility to pharmacies

The spatial distribution of pharmacies varied greatly across different types of pharmacies. Local independent pharmacies tended to locate in the city of Detroit, where lower-income minorities – largely African Americans – concentrated, while national chains and supermarket pharmacies tended to concentrate in the inner suburbs just outside the city boundary. As discussed in previous chapters, the costs of running businesses in the city of Detroit were higher due to higher taxes, higher crime rates and insurance costs, and there was a lack of wealthy customers locally. As a result, major supermarkets avoided the city all together (LeDoux and Vojnovic 2013), as with the distribution of supermarket pharmacies seen in Figure 7-4. National chain pharmacies were also less likely to locate within the city, probably due to the same reasons.

The spatial distribution patterns determined the variation in spatial accessibility to pharmacies (as measured by the distance to the nearest pharmacy) across the three types of neighborhoods. Despite having the highest accessibility to local independent pharmacies, Urban Detroiters lived the farthest from national chains, compared to residents in the suburbs. This finding was important because national chains were actually the main pharmacies that Urban Detroit residents used. This means that proximity to local independent pharmacies did *not* translate to good access to pharmaceutical services in Urban Detroit. Rather, the low spatial accessibility to national chains had a more significant impact on local residents. Urban Detroiters faced spatial barriers in obtaining pharmaceutical services they needed. This might potentially lead to negative health consequences, as people might choose to skip medications or consultations due to lack of access even when they actually need it. In fact, lower accessibility to pharmacies was found to decrease the likelihood to make a trip for pharmaceutical services (Table 7-2). The findings show that it is critical to evaluate accessibility by different types of pharmacies, as accessibility may vary greatly by type, and some might be more important for local populations than others.

7.5.2. Travel patterns to pharmacies

Across all neighborhoods, the likelihood to visit any pharmacy in a typical week was affected by the spatial accessibility to pharmaceutical services, i.e., the distance from home to the nearest pharmacy. Residents with lower accessibility to pharmacies were less likely to visit any pharmacy at all in a typical week. This means that spatial accessibility is an important factor in pharmacy utilization. Pharmacies offer important health care services, ranging from prescription filling and consultations, health screenings and tests, to vaccinations. Identifying pharmacy deserts and improving access to pharmaceutical services in these neighborhoods is important for the effective delivery of health services.

Also, the likelihood of visiting pharmacies varied by neighborhood type. Residents in the High-density Suburbs were less likely to visit pharmacies in a typical week, compared to residents in Urban Detroit and the Low-density Suburbs, which reflected a lower pharmacy utilization rate. This could be linked to healthier lifestyles as indicated by engaging in more physical activity and having healthier diets (the least visits to fast food restaurants), along with healthier weight ranges, as indicated by the BMI values. These were personal data that were collected in the survey.

However, respondents living in Urban Detroit were not significantly more likely to use pharmacies, despite a lack of healthy lifestyles. This suggests that residents in Urban Detroit might not use pharmacies even when they need to. This is likely due to various disadvantages faced collectively by residents in these highly segregated low-income African American neighborhoods. Residents in these neighborhoods may lack comprehensive medical insurance coverages compared to residents in high-income white neighborhoods. Paying for medical services, including medications, without or with partial insurance coverage can be overwhelming. In fact, skipping medications due to the inability to pay has been well documented in previous studies (Gill 2018; SingleCare Team 2020). Also, they may lack easy access to health care providers or informal health information through social networks (Gaskin et al. 2012). Moreover, cultural norms and values in such segregated communities might discourage people from utilizing health care services (Gaskin et al. 2012). Lastly, residents in declining low-income neighborhoods might simply have too much to deal with, in terms of basic survival needs, and neglect their health, which might be of a lower priority.

The travel patterns from the survey data reveal that in more than 90% of the pharmacy visits, residents in the Detroit region used national chains, rather than local independent pharmacies (the second most common pharmacy type that consists of 37% of all pharmacies in the Detroit region).

This applied to all six sampled neighborhoods of different built environments and sociodemographic composition. There are two possible reasons for the preference for national pharmacy chains. First, national chain pharmacies tend to be larger in scale and offer more services, such as more medications carried, more categories of services such as screenings and tests, and longer hours of operation (Doucette et al. 2017; Qato et al. 2017). In fact, employee size and sales volume data of pharmacies in the Detroit region from ReferenceUSA indicate that, the size of national chains tends to be three times the size of local independent pharmacies. National chains offer a one-stop-for-all shopping experience, which is attractive to many. Also, national chains may offer cheaper and more stable drug prices compared to other pharmacies (Gellad et al. 2009; Luo et al. 2019)

The maps of pharmacy trips (Figures 10 to 15) and statistical analysis of rankings of destination pharmacies in terms of proximity to respondents reveal that while residents in the suburbs mainly chose to use the nearest national chain for pharmacy services, residents in Urban Detroit were much less likely to choose nearby pharmacies. Instead, Urban Detroit residents tended to shop at pharmacies that were located at considerable distances from their homes. Even among different national chain pharmacies, they sometimes chose to travel longer distances from their homes to shop at more distant pharmacies. More specifically, Urban Detroit residents shopped at the 5th closest national chain pharmacy with a trip distance of 2.2 miles on average, while residents in the High-density and in the Low-density Suburbs shopped at the second closest national chain pharmacy on average, with a mean trip distance of 1.2 miles and 1.6 miles respectively.

Existing literature has suggested that lower-income and minority neighborhoods tend to suffer from higher means and larger variations for drug prices (Gellad et al. 2009; Moshtaghi et al. 2017). Also, studies have found evidence that pharmacies in minority areas and lower-income areas are

more likely to have insufficient drugs being stocked, less variety of services, higher cost, and shorter operation hours (Erickson and Workman 2014; Green et al. 2005). These findings indicate that Urban Detroit residents might need to shop at greater distances in order to reach their more preferred pharmaceutical services. This pattern is similar to what LeDoux and Vojnovic (2013) found for grocery shopping among Detroit urban residents, in the sense that they avoided both food and pharmacy opportunities within their neighborhoods that were of lower quality and/or higher prices.

Another factor that possibly contributed to the tendency to shop at more distant pharmacies was that residents in Urban Detroit were more likely to be biased in trip distance estimation. As indicated by the correlation of reported and actual one-way trip distances, the perception of trip distance is biased by 75% among Urban Detroit residents, which is much higher when compared to residents in the suburbs.

In addition, the map of trips (Figure 15) suggests that some Urban Detroit residents chose to shop at a farther national chain store even when there was a closer one under the same brand name. For instance, a resident may bypass a few CVS stores closer to home and choose a CVS store that was farther away. This finding was unexpected, as one would assume CVS branches offer similar services. One factor might be the biased perception of distances that prohibited residents from choosing the nearest one as discussed earlier. Instead of going for the nearest pharmacy, they may choose the one that is the easiest to reach in their mental map or that is on a bus line. Other possible factors might be different business hours, relationship with a particular pharmacist, and habit. More information on pharmacy services would be needed to get a clear answer.

It is also worth noting that accessibility impacts destination choices in terms of how far people are willing to travel. When all the pharmacies were far from the home, the differences in the distances to various pharmacies became less important, and the respondents were more likely to choose one that was not the closest. Therefore, lower accessibility to a service may promote even greater than necessary travel distances, indirectly through reducing the importance of proximity in the destination choice decision.

With lower accessibility to national chains and a higher likelihood of shopping at greater distances from home, being dependent on pharmacies far from their neighborhood, Urban Detroit residents tended to have the longest one-way trips to reach pharmacy destinations. This means that the burden of travel, as indicated by longer trip distances by Urban Detroit residents, is not solely due to the lower spatial accessibility to services, but also in all likelihood, related to lower satisfaction of the local services provided, whether related to costs and/or the variety and quality of service. These are similar patterns evident in travel for grocery shopping and dining in the same lower eastside Detroit neighborhoods (Eckert and Vojnovic 2017; LeDoux and Vojnovic 2013).

7.5.3. Limitations and future directions

There are some limitations to this study. First, the sample size of pharmacy trips was small (N=290 trips[5] reported for a typical week). This poses reliability issues when evaluating destination choices

[5] As noted earlier, this number was a count of total trip destinations reported, without weighting by weekly trip frequency.

and one-way trip distances for each type of neighborhood separately, especially in Urban Detroit (N=75 pharmacy trips). But the distinctions of travel behavior between residents in Urban Detroit and in the suburbs were significant, with the former going beyond the nearest pharmacy and travelling much longer distances and the latter focusing on the rich diversity of nearby options and travelling shorter distances. This offers confidence in the findings.

Second, the data used in this study did not cover the particular pharmaceutical services provided in each pharmacy. More information about the quality and variety of pharmaceutical services in Detroit is needed to better understand destination choices and how the quality of services had affected pharmacy choices. This can help answer questions such as why people visited national chains but few other types of pharmacies or why exactly Urban Detroit residents shopped at significantly distant pharmacy options. Lastly, the distribution and accessibility of pharmacies was evaluated for the year 2008. It has been more than ten years and the distribution of pharmacies should have changed. A future step will be adding an evaluation of the distribution of current pharmacies in the Detroit region and a comparison between the two time points of 2008 and now to capture the up-to-date access to pharmacies and the changes in pharmacy service provision over the years.

7.6. Conclusion

In this chapter, the spatial distribution and accessibility to pharmacies and the actual travel patterns to reach pharmaceutical services were examined for six neighborhoods in the Detroit region (two neighborhoods in each of Urban Detroit, the High-Density Suburbs, and the Low-Density Suburbs). There are two key findings: first, the spatial accessibility to pharmacy services varied by pharmacy type in the Detroit region. Compared to the upper-income white-dominant suburbs, Urban Detroit,

the lower-income African America neighborhoods – despite having good access to local independent pharmacies – had poor access to national pharmacy chains that most residents traveled to for their pharmaceutical services. This confirmed previous findings that low-income and minority neighborhoods had lower access to pharmacy services, but further demonstrated how low accessibility levels and the presence of pharmacy deserts, can be masked when the evaluation of accessibility to pharmacies did not consider pharmacy types, such as independent versus major national chains. The implications of these locational patterns in pharmacies across the region are significant and have considerable impact particularly on the most marginalized populations. For example, since the beginning of 2020, Covid-19 has spread to the entire world and took millions of lives. Covid-19 testing and vaccination is critical in the efforts to combat the virus. National chain pharmacies such as CVS and Walgreens have been major venues to deliver these services to communities. The low accessibility to national chain pharmacies in the city of Detroit, and especially in the lower-income minority neighborhoods, is of serious concern and is likely contributing to major detrimental health impacts to the city's poor African American population.

Second, the study found that residents in Urban Detroit were actually more selective in terms of which pharmacy to use. This was likely associated with more limited range and quantity of medications being stocked, service quality, and price variation with pharmacies in the low-income neighborhoods experiencing decline. The burden of travel faced by residents in Urban Detroit, as indicated by the long one-way trip distances, was a combined result of both lower access to national chain pharmacies and more shopping around for variety, quality and cost-saving. The fact remains that despite the higher densities, the greater mix of land uses, and the more connected street networks in urban Detroit, its residents travel greater distances to access pharmacies than the residents of the isolated, low-density, secluded wealthy suburban enclaves within the region.

Chapter 8. Conclusion

Daily travel has been extensively studied in the effort to increase the efficiency of transport systems, reduce car use and carbon emissions, encourage healthy active travel, and promote equity in access and mobility. As evident from this research, personal service and leisure trips account for more than a third of all daily travel, constituting an important dimension of people's daily life. Despite the significance of these trips, daily travel behavior for personal services and leisure activities are underexplored in the existing literature, and especially when compared to travel behavior for work. In particular, there has been a paucity of research on travel patterns for pharmacies, a critical personal service with extensive potential impact on healthcare provision. This dissertation addresses this relatively underrepresented dimension of travel behavior research. It offers a nuanced understanding of the different types of personal service and leisure trips with an added focus placed on pharmacies, and the associations with sociodemographic characteristics and neighborhood environments. This research provides valuable insight and a more complete understanding of daily travel behavior.

This dissertation focuses on the Detroit region, which is characterized by a high degree of class and racial segregation, with a sharp contrast between a city experiencing disinvestment and decline, with a highly concentrated African American population and surrounding wealthy suburbs, largely occupied by whites. This allows comparisons of spatial access and daily travel to amenities across different neighborhood contexts, both urban and suburban. The inclusion of highly segregated lower-income communities confronting severe disinvestment – the urban Detroit neighborhoods – is particularly important, as these communities are relatively less understood in the existing literature on neighborhood built environment and travel.

Focusing on two high-poverty, declining inner-city neighborhoods, characterized by high-densities, and four high-income suburban neighborhoods – two high-density and two low-density – in the Detroit region, I have examined daily travel patterns for personal service and leisure destinations, with an added emphasis placed on pharmaceutical services, and how these patterns were influenced by individual attributes and neighborhood environments. There were two sets of overarching research questions. The first set of questions were covered in Chapters 5 and 6 and included a number of specific points of inquiry. How far, how frequent, and in which mode do residents travel for personal services and for leisure activities, and how does this vary by individual-level sociodemographic characteristics, and neighborhood-level built environment and socioeconomic conditions? Are there any population subgroups that have challenges in accessing personal services or reaching leisure destinations? These questions were addressed in Chapter 5, which examined one-way trip distances, and Chapter 6, where the analysis focused on frequency and total distance traveled by mode. The second set of overarching questions was dedicated to a particular personal service destination, access and travel to pharmacies. What are the spatial distributions of and accessibility to pharmaceutical services and how does this vary by neighborhood-level built environments and socioeconomic conditions? In addition, what are the travel patterns for pharmacies and what are the associated factors? These questions were answered in Chapter 7.

8.1. Key findings and implications

8.1.1. Travel patterns of personal service and leisure travel

Chapters 5 and 6 in this dissertation examined different aspects of travel behavior for personal services and leisure activities. This analysis advanced a number of important findings. First, one-way trip distances are significantly associated with purpose and neighborhood type. Leisure trips

tended to be substantially longer (average 6 miles)[6] than personal service trips (average 3 miles). This indicates that leisure facilities generally serve larger market areas and people tend to be more selective rather than only using leisure opportunities nearby. Also, trip distance is significantly impacted by neighborhood type and this effect is stronger for leisure trips than personal service trips. Generally, residents in the High-density Suburbs had short trip distances due to a compact built environment and the concentration of amenities offered in Ann Arbor and Birmingham. But residents in urban Detroit, with a similar compact built environment, traveled much longer distances, comparable to the trip lengths that residents were travelling in the Low-density Suburbs. This was a result of disinvestment in the city, which led to much lower accessibility levels to amenities than what would be typically expected given the characteristics of the built environment—the high densities, mixed land uses and connected street networks. This speaks to the fact that urban disinvestment and decline leads to added transportation burdens for low-income minority residents living in highly segregated urban neighborhoods (Vojnovic et al. 2014).

Second, travel mode was found to be associated with purpose, neighborhood type, and individual sociodemographic characteristics. People were more likely to utilize non-automobile travel modes for accessing leisure activities than for personal services. Also, while the effect of the neighborhood built environment on reducing car use is demonstrated in this research – higher density, mixed land use and connected neighborhoods promote non-automobile travel – the

[6] The types of leisure destinations that had the one-way trip distances include museums, performance arts centers, leisure education and shopping malls, averaging to 20 miles, 18 miles, 8 miles and 7 miles respectively.

socioeconomic conditions of the neighborhood influence which alternative modes are used. The percentage of trips by non-automobile modes is much higher in the High-density Urban and Suburban neighborhoods than the Low-density Suburbs. However, while residents in the high-income, High-density Suburbs predominantly walk or bike when not driving, these modes are less often used in the high-poverty, high-density Urban Detroit neighborhoods, despite the similar built form. This can be attributed, in part, to greater concerns with personal safety in the city of Detroit, with the survey data indicating greater fears of crime within the urban neighborhoods. Instead, Urban Detroit residents tend to rely relatively more on public transit, which is rarely used in the suburbs. These findings suggest that, when the policy goal is to promote active travel using walking and biking in the neighborhood, it is important to both ensure safety on the streets and attract various leisure amenities, such as city parks, bars, cafes and fitness facilities. According to Jane Jacobs, the two are closely related and can be synergistic – a bustling street with cars parked alongside, and people talking, relaxing and having fun, will be a safer street for walkers and bikers than a street with just cars and parking lots (Jacobs 1961).

In addition, aging was found to be associated with an increase in car dependence to both leisure and personal service destinations. In particular, the likelihood of using public transit decreases linearly with age. Seniors may find it physically and mentally challenging to rely on transit services. Providing senior apartment options in a safe and walkable neighborhood environment and offering programs for easy and affordable door-to-door rides are crucial steps to help the elderly maintain mobility when they have to stop driving at some point in their lives.

Third, sociodemographic characteristics affect weekly trip frequency, but the actual effects are contingent on neighborhood type and trip purpose. The negative effect of aging on leisure travel is strongly felt in urban Detroit, which has a high concentration of poverty and limited access to

amenities. In contrast, age does not affect travel to leisure destinations in the high-income suburbs. Lack of leisure activities is associated with adverse health consequences for the elderly. This finding highlights one of the challenges seniors confront in poor urban communities experiencing disinvestment.

8.1.2. Accessibility and travel to pharmacies

As an essential part of the health care system, accessibility and travel patterns to pharmacies is a critical consideration in the study of access to personal services. Chapter 7 in this dissertation found that the spatial distribution of pharmacies varies not only by neighborhood, but also by pharmacy type. Residents in the two low-income urban Detroit neighborhoods had good accessibility to local independent pharmacies, which mostly concentrated in the city, but had poor access to national chains and supermarket pharmacies. This demonstrates the importance of examining accessibility to pharmaceutical services by type of pharmacy. Across different neighborhoods in the Detroit region, national chains (such as CVS) were the pharmacy type that people relied on in more than 90% of the cases, likely due to larger quantities and more variety and convenience of services provided in these pharmacies, as compared to the other types. In fact, despite having local pharmacies nearby, residents in the urban Detroit neighborhoods bypassed these proximate independent pharmacies and traveled longer distances to shop at national pharmacy chains. This indicates that accessibility to national chain pharmacies should be a major focus in evaluating pharmacy access and identifying pharmacy deserts, and particularly in regions experiencing disinvestment and declines, as in Detroit.

The results also show that lower accessibility to pharmacies means higher chances that residents will not visit any pharmacy at all. Lower access to national chains in lower-income minority

neighborhoods, as in Detroit, could have significant health impacts on marginalized populations. Residents in these neighborhoods could be less likely to visit pharmacies for medications and various other health services. The Covid-19 pandemic since 2020 has impacted low-income minority families particularly hard. They are more likely to lose their jobs and at greater risk of getting infected and hospitalized due to Covid-19 (Kantamneni 2020; Mein 2020). The lower accessibility to major national chains is particularly worrisome, as it might inhibit them from visiting for a Covid-19 test or getting vaccinated, further exacerbating their health risks.

Moreover, residents in Urban Detroit showed different patterns in destination choices for locations of national chain pharmacies, when compared to suburban residents. While residents in the suburbs typically chose the closest locations of national chains, Urban Detroit residents often bypassed closer branches of national chains to access more distant locations. This might be attributed to factors such as the larger price variation and limited quantity and variety of medication and services provided by national chain pharmacies that serve low-income, minority communities.

Despite living in a high-density, mixed-use built environment, Urban Detroit residents traveled much longer one-way trip distances to reach their pharmacy destinations when compared to residents living in the suburbs. This was a combined result of lower accessibility to national chain pharmacies and more shopping around as residents were likely seeking out pharmacies that offered a greater variety and quality of service, and potentially lower costs, compared to the pharmacies located closer to their homes. It demonstrates how disinvestment and decline within neighborhoods could result in added burdens of travel for residents as they attempt to access something as basic as pharmaceutical services.

8.1.3. A general comment on Detroit

Overall, residents in the city of Detroit have shown distinct travel patterns, for both personal service trips – including trips to pharmacies – and leisure trips, when compared to residents in the suburbs. Urban Detroit residents travel in substantially different ways even when compared to those living in the High-density Suburbs, despite the similar built environments between these two neighborhood types. The dissertation confirms the importance of neighborhood-level socioeconomic conditions on various aspects of travel, including one-way trip distances, mode use, trip frequency and total distance traveled, for both personal service and leisure travel.

Research on the built environment and travel has historically overlooked the behavior of residents living in neighborhoods experiencing disinvestment and decline. The findings in this study suggest that the residents in segregated low-income minority-dominant neighborhoods face an intersection of disadvantages – both from their individual socioeconomic status and from living in neighborhoods where people of similar characteristics cluster and experience disparities and discrimination as a community. This highlights the need to examine different urban contexts, especially under-studied low-income inner-city neighborhoods, in exploring the distinct burdens that population subgroups confront in their daily travels. The behavior of residents in such neighborhoods likely differs substantially from residents of major cities that are thriving economically, ones that tend to be disproportionately focused on transportation research.

8.2. Merits of the study

First, this dissertation has focused on three types of neighborhoods with very different built environments and sociodemographic characteristics, enabling a study of travel patterns in very different community conditions but within the same regional context. It is a more complex analysis

of the traditional urban/suburban comparison, in that it adds neighborhood sociodemographic composition to the study of travel. In particular, the dissertation includes highly-segregated urban neighborhoods experiencing extreme disinvestment and decline, which is underexplored in existing studies on travel and community planning and design. The findings in this dissertation provide insights not only to accessibility and the nature of travel across the Detroit Region, but also to other cities that have suffered a similar process of disinvestment and decline. This pattern of urban disinvestment and decline, in fact, is an imprint widely evident across the U.S. Midwest.

Also, this dissertation contributes to the understanding of trip characteristics for personal service and leisure activities. Personal service and leisure trips accounted for 37.4% of total trips by frequency in the Detroit Region survey data. Despite the significant shares in total travel, these trips have received only limited attention in the existing travel behavior research. This dissertation has found that the effects of neighborhood-level depend on the purpose of the trip, and that the effects of individual-level factors on travel behavior vary significantly among trips of different purposes and among different neighborhood contexts. This means that any finding on how various factors affect the travel for one purpose in one specific urban context cannot be automatically assumed to apply to other trip purposes or different neighborhoods. This study shows that to effectively address transportation policy--from ensuring equitable access to necessary daily amenities to reducing automobile dependence by encouraging more active travel--it is critical for planners and policy makers to understand travel behavior in a more nuanced way

8.3. Limitations

One limitation of the findings here is that, since the year 2008, when the survey data were collected, there have been some changes experienced in the sampled neighborhoods. First, the demographic

composition in these neighborhoods, and in the city of Detroit more widely, has changed. The U.S. Decennial Census data shows that the decline in population has slowed down between 2010 and 2020, with a 10.5% loss, as compared to a 25.0% loss for the previous decade, between 2000 and 2010. Also, there has been a drop in the percentage of African American residents in the city of Detroit, from 82.7% to 77.7% between 2010 and 2020, accompanied by slight increases in the percentages of other racial/ethnic groups (White residents from 10.6% to 10.7%, Hispanic or Latino residents from 6.8% to 8.0%, and Asians from 1.1% to 1.6%). Meanwhile, the American Community survey 1-year estimates show that the median household income in the city of Detroit has increased from $28730 in 2008 to $33965 in 2019. These statistics indicate slight shifts in the racial/ethnic composition, and in the class structure, in the city.

Second, internet services have become more pervasive in our life over the last decade-and-a-half. Around 2008, internet had already entered people's lives in various dimensions, ranging from e-retailing, online banking, to social media. But the scales of those businesses were much smaller than they are now. Online/mobile banking and e-retailing have experienced significant growth since 2008, which is likely to have reduced the number of trips for banking and shopping. Nevertheless, I recognize that they might not be as pervasive in the low-income neighborhoods studied in Urban Detroit.

Also, ride-sharing apps, such as Uber and Lyft have gained popularity in recent years. These apps are essentially coordination platforms for taxis, but they offer rides at much cheaper prices and more conveniently than conventional taxis. These apps enable people who do not own a car to get a ride at a relatively low cost. So, it is possible that, using these apps, people travel more by car and less by public transit or walking, and visit more places by automobile than they did a decade-plus earlier. Nonetheless, some lower-income people may not be able to afford to use Uber and

Lyft at a significant frequency, or simply do not have a credit or debit card to pay in the app (Dillahunt et al. 2017). There are also some subgroups, such as the elderly, who may not feel comfortable using a cellphone app. Moreover, drivers might be reluctant to go to certain neighborhoods in Detroit for safety concerns. With limited empirical evidence so far, how much ride-sharing apps like Uber and Lyft may change travel patterns in the Detroit neighborhoods remains an open question.

Another round of surveys on travel behavior of residents in the city of Detroit and its suburbs will be able to reveal how all of these changes have impacted residents' daily travel behavior. The only major change in travel by residents from the same neighborhoods might be lower frequencies of trips to banking and retailing services, due to mobile banking apps and online shopping. The destination choices, the one-way trip distances, and the weekly frequencies of trips other than banking and retailing, as well as how these are influenced by neighborhood and individual factors, might remain similar given the inertia of human decision making.

A second limitation of the data from the 2008 Detroit travel survey is that information on trip chaining was not collected. The survey collected information based on individual trips done in a typical week. However, in some cases, people could visit multiple locations at one commercial area for leisure and shopping, or make a stop at an ATM or pharmacy on their way home. This means that some of the one-way trip distances and the weekly total distance traveled might be different than reported, likely shorter, since some trips were started from non-home locations. Therefore, the results on trip distances should be interpreted with caution. Nonetheless, by not requesting for a full travel diary, which placed a higher burden on respondents to recall information, the survey likely obtained a higher response rate, especially from Urban Detroit.

8.4. Future directions

There are some research directions that can be further pursued beyond this dissertation. One future direction is to study the activity spaces as reflected by people's daily travel patterns. As some studies have noted, segregation is not limited to residential separation, but also a separation of activity spaces among different population groups (Wang and Li 2016; Wong and Shaw 2011). Activity space is the geographical space people move around in accessing destinations for daily activities (Golledge and Stimson 1997), which is captured by daily travel and the set of geographical locations people visit. Examining whether the residential segregation translates to the segregation of activity space across the Detroit region would be a potentially important path of inquiry. Do low-income minority Urban Detroit residents have any destinations that overlap with higher-income white suburban residents? If people are surrounded by others who are similar in terms of class and race, and never see anyone different from themselves in either workplaces, stores or leisure destinations, the presence of other social groups would become irrelevant and a feeling of indifference or even intolerance towards these populations can easily grow. Also, differences in activity spaces may also happen among residents in the same neighborhoods who have different socio-economic standing. In Chapter 5, within the high-income, Low-density Suburbs, the lowest income residents were found to have longer one-way trip distances to leisure destinations compared to the highest-income residents. It was likely that the lower-income residents bypassed the nearby and expensive leisure facilities of West Bloomfield and Bloomfield Hills—destinations marketed to their high-income suburban residents—as they ventured to further locations to access cheaper leisure services. A study of activity spaces among residents by individual sociodemographic characteristics and by neighborhoods will reveal the complexity and diversity of segregation beyond that of the neighborhood where one lives.

Second, as an important part of leisure travel, social trips for visiting friends and families reflect the spatial distribution of respondents' ego-centric social networks. The frequency of such trips can serve as a measure of the strength of the social ties. It would be interesting to examine the distance of such trips and how it is related to the frequency, i.e., the strength of the ties, as well as whether respondents have ties with people living in areas that are socioeconomically and culturally different from themselves.

APPENDIX

Appendix. Classification of trips for personal service and leisure destinations

Table A1. Classification of personal service trips by purpose

purpose	Main category	Level-1 code	Level-2 code	NAICS code
ATM	Financial services	FI	ATM	522320
Bank	Financial services	FI	BK	522110-522190
Post office	Post office	PO	.	491110
Doctor; allergy shots	Health and social services	HS	DO	621111
Chiropractor	Health and social services	HS	CP	621310
Child day care services	Health and social services	HS	DC	624410
Senior support, adult care	Health and social services	HS	SN	624120
Mental health; substance abuse	Health and social services	HS	MA	623220
Individual and family social services, such as family welfare services, crisis intervention, substance abuse services.	Health and social services	HS	OT	624190
Church; any religious activity	Religion	R	.	813110
Cleaners	Maintenance	M	DR	812320
Barber shop	Maintenance	M	BB	812111
Beauty salons	Maintenance	M	BS	812112
Nail salons	Maintenance	M	NS	812113
Other personal care services, e.g., spa, eye wax	Maintenance	M	OT	812199
Photo services	Maintenance	M	PH	541921
Copy shop	Maintenance	M	CP	561439
Office stores, e.g., staples	Retail	RT	OF	453210
Electronics stores.	Retail	RT	ET	443142
Home improvement stores	Retail	RT	HI	444110; 444130
Book stores	Retail	RT	BS	451211

Table A1. (cont'd)

purpose	Main category	Level-1 code	Level-2 code	NAICS code
Music stores (music instrument)	Retail	RT	MS	451140
Pet store	Retail	RT	PS	453910
Gift store, party store	Retail	RT	GF	453220
Fabric store; sewing; quilt shop	Retail	RT	FS	451130
Department store	Retail	RT	DP	452210
Video stores	Retail	RT	VI	NA
Pharmacy	Pharmacy	P	.	446110

Table A2. Classification of leisure trips by purpose

purpose	Main category	Level-1 code	Level-2 code	NAICS code
Library	Information	L	.	519120
Mall	Mall	ML	.	531120
Drinking place: bar and night club	Beverage and drinks	AF	BR	722410
Snack and beverage, like coffee, tea	Beverage and drinks	AF	C	722515
Gym	Arts, entertainments & recreation: Fitness	PA	GY	713940
Exercises classes; dance centers (aerobic)	Arts, entertainments & recreation: Fitness	PA	AR	Same as above
Swimming	Arts, entertainments & recreation: Fitness	PA	SW	Same as above
Basketball	Arts, entertainments & recreation: Fitness	PA	BB	Same as above
Yoga	Arts, entertainments & recreation: Fitness	PA	YG	Same as above
Hockey	Arts, entertainments & recreation: Fitness	PA	IC	Same as above
Bicycle	Arts, entertainments & recreation: Fitness	PA	BI	Same as above
Karate	Arts, entertainments & recreation: Fitness	PA	KR	Same as above
Martial arts	Arts, entertainments & recreation: Fitness	PA	MA	Same as above
Baseball	Arts, entertainments & recreation: Fitness	PA	BS	Same as above
Biking	Arts, entertainments & recreation: Fitness	PA	BK	Same as above
Tennis	Arts, entertainments & recreation: Fitness	PA	TN	Same as above
Hiking	Arts, entertainments & recreation: Fitness	PA	HK	Same as above
Frisbee	Arts, entertainments & recreation: Fitness	PA	OT	Same as above
Lacrosse	Arts, entertainments & recreation: Fitness	PA	OT	Same as above
Running, jogging	Arts, entertainments & recreation: Fitness	PA	RN	NA
Walking	Arts, entertainments & recreation: Fitness	PA	WK	NA

Table A2. (cont'd)

purpose	Main category	Level-1 code	Level-2 code	NAICS code
Boating; marina	Arts, entertainments & recreation: Hobby	HB	BT	713930
Golf; country clubs	Arts, entertainments & recreation: Hobby	HB	GL	713910
Hunting	Arts, entertainments & recreation: Hobby	HB	HT	NA
Bowling	Arts, entertainments & recreation: Hobby	HB	BL	713950
Racetracks; motorcycling	Arts, entertainments & recreation: Hobby	HB	RC	711212
Casino; gambling	Arts, entertainments & recreation: Hobby	HB	GB	713210
Cards game (including bridge)	Arts, entertainments & recreation: Hobby	HB	CD	NA
Snooker	Arts, entertainments & recreation: Hobby	HB	PL	NA
Band practice	Arts, entertainments & recreation: Hobby	HB	BN	NA
Art classes	Educational services	ED	AR	611610
Music/instrument classes	Educational services	ED	MS	Same as above
Dance class, dance studios(non-aerobics)	Educational services	ED	DN	Same as above
Lectures; generic classes not specified	Educational services	ED	OT	NA
Park; woods	Arts, entertainments & recreation: parks, museums, zoos	RC	PK	712190
preservation and exhibition of live plant and animal life displays, such as arboretums and zoos	Arts, entertainments & recreation: parks, museums, zoos	RC	ZB	712130
Observatory; museum	Arts, entertainments & recreation: parks, museums, zoos	RC	MU	712110
Art performances, e.g., choir, concert	Arts, entertainments & recreation: Performance entertainment	PF	PA	711110, 711120, 711130
Movie	Arts, entertainments & recreation: Performance entertainment	PF	MV	512131
Sport event	Arts, entertainments & recreation: Performance entertainment	PF	EV	711211

Table A2. (cont'd)

purpose	Main category	Level-1 code	Level-2 code	NAICS code
Friend	Social visits	SV	FR	NA
Boyfriend; girlfriend	Social visits	SV	BG	NA
Family	Social visits	SV	FA	NA
Neighbor	Social visits	SV	NH	NA
Colleague	Social visits	SV	CL	NA
Children's activities	Miscellaneous	MI	CH	NA
Volunteer; organization activities	Miscellaneous	MI	V	NA
Visit downtown	Miscellaneous	MI	DT	NA
Social clubs	Miscellaneous	MI	SC	NA

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