IMPACT OF PUBLIC TRANSIT AND WALKABILITY ON QUALITY OF LIFE AND EQUITY ANALYSIS IN TERMS OF ACCESS TO NON-WORK AMENITIES IN THE UNITED STATES

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ABSTRACT

The past literature suggest that transportation can impact quality of life (QOL) both directly and indirectly. The first part of this dissertation attempted to comprehensively evaluate the impact of transportation (specifically public transit, and walkability) along with physical built environment, and sociodemographic indicators on community QOL, and overall life satisfaction (OLS) of an individual living in his community. The study used an advanced technique of structural equation modeling (SEM) to evaluate the impact of these factors on community QOL and individual's OLS. The study results revealed that physical built environment, public transit need for a community, perceived public transit importance for a community, quality of public transit services, quality of walkability conditions, ease of travel in a community (mobility indicator), and sociodemographic indicators significantly impact community QOL, and also individual's OLS either directly or indirectly through community QOL mediating variable.

The literature review suggests that accessibility to important non-work amenities improve people's QOL. So, it is important to examine social equity in terms of individual's ability to access non-work amenities that are important for their daily life interests. The second part of dissertation focused on equity analysis in terms of people's ability to access non-work amenities through public transit, and walk in the US. The non-work amenities considered in this study are: 1) grocery store or supermarket, 2) personal services, 3) other retail shopping, (4) recreation and entertainment, and (5) health care facility. It is concluded that equity in terms of public transit access to non-work amenities is regressive for the older age people, people without driving license, individuals who are covered under Medicare/Medicaid program (elderly, low income, people with disabilities), and non-metro area residents disadvantaged groups. In terms of walk access to non-work amenities, it is concluded that older age people, people without driving license, physically disable people,

unemployed and students, people living in non-metro areas, and females face injustice. These groups are already disadvantaged in society because of their financial, and physical health constraints and should be having sufficient and easy public transit and walk access to their daily needs.

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DEDICATION

Dedicated to my respected parents and grandparents who's love and unwavering support I can never repay. I also dedicate this study to my beloved sister who always supported me during difficult times.

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CHAPTER 1. INTRODUCTION

1.1. Background

Quality of Life (QOL) had been recognized as a multidimensional construct that comprise of objective life indicators (health, and education etc.,) and qualitative subjective measures of life (feeling positive or negative, and happiness etc.,). The factors that can impact QOL range from personal level, such as income, age, physical disability etc., to more broad societal level, such as culture, safety, environment, and physical infrastructure etc., (Delbosc, 2012) (Atkinson, 2013).

World Health Organization (WHO) defined QOL in the broadest of its context, and identified six domains of QOL. They are: 1) physical health, 2) psychological health, 3) social relationships, 4) level of independence, 5) environment, and 6) personal beliefs (WHOQOL, 1998). Among the six domains, environment comprise of home environment, transportation, social care and health, satisfaction with work, physical environment, and options for recreation/entertainment activities participation. Within transportation sector, Lee and Sener (2016) identified four QOL dimensions i.e. physical, social, mental, and economical dimensions that are influenced by built environment, mobility/accessibility, and vehicular traffic dimensions of the transportation system. The authors of the study also recommended QOL dimensions need to be included into future transportation planning process (Lee & Sener, 2016).

Evidence from the past literature suggests that transportation plays a key role in well-being of people and can impact QOL both directly and indirectly. Three of the most significant factors that can affect QOL are health, meaningful social relationships, and poverty/unemployment. All of these three factors can be affected directly by availability of proper transportation (Delbosc, 2012).

To include QOL impacts in transportation decision making process, transportation planners, and policy makers should first identify the relation between transportation system and QOL. Such an understanding of relationship between transportation and QOL can assist with better planning of communities by considering various dimensions of QOL; this strategy will simultaneously reduce the burdens related to urban congestion and also improve overall QOL (Lee & Sener, 2016).

Availability of good public transit service also plays a key role in improving QOL of people, especially for public transit dependent population that include elderly people, people with disability, individuals who cannot drive, and individuals with no private vehicle (Godavarthy & Mattson, 2016). Similarly, neighborhoods with better walkability conditions can improve physical health conditions of people through greater fitness, which inturn improve QOL of people (Frank, et al., 2007) (Delbosc, 2012). The first part of this study will attempt to evaluate the relationship between transportation (specificlly public transit, and walkability) and QOL at national level in the United States.

The next part of this study will focus on transportation equity analysis. Equity in transportation can be referred to as the fair distribution of transportation benefits and costs across different members of society, such as different age groups, income groups, and race etc., (Bills, Sall, & Walker, 2012). McCahill and Ebeling (2015) presented a transportation equity framework that outlined four key dimensions of equity. They are: 1) accessibility, 2) affordability, 3) health and safety, and 4) procedural equity. Accessibility in general, measures the ease of reaching important destinations, such as shopping, work, school, and to various services from a specific location within certain travel time/cost threshold. Affordability refers to the monetary out of pocket travel costs that transportation users have to spend rather than travel time or distance traveled.

Health and safety dimensions covers the possible impacts of transportation on health and safety incurred to different social classes of a community. The procedural equity dimension refers to the procedure of how the transportation projects are executed and delivered. This include participation of people from different social groups and providing their feedback to the agencies (McCahill & Ebeling, 2015).

In transportation system, accessibility has been considered as primary motivation for travel and is considered most valuable equity indicator tool because it adequately describes relationship between different locations and people (Brodie, 2015) (Grengs, 2015b). Sundquist et al., (2017) categorize accessibility in two general types: employment accessibility (ease of reaching job locations from home) and non-work accessibility (ease of reaching parks, grocery stores, schools and other such destinations from given origin point) (Sundquist, McCahill, & Dredske, 2017).

A good public transit system should provide better access to jobs, and other services because it is important to recognize that private automobiles are not equally accessible to everyone as a means of travel (Knox & Steven, 2010). Particularly, for people who cannot drive, or cannot afford an automobile leading to limited accessibility to perform their daily activities, especially if there is limited or no public transit services (Bertolaccini, 2015).

Walkability is defined as the level to which the built environment motivates walking by providing a safe, convenient, comfortable, and attractive travel corridor to pedestrians (Southworth, 2005). Walking in combination with other modes such as public transit, driving, etc., serve as a vital form of access particularly for people with disabilities, children, older age people, and low income people indicating walk access to services as an important indicator for equity assessment in transportation system (Litman, 2018a). The second part of this dissertation will investigate the social equity in terms of people's ability to access non-work amenities through public transit or walking.

1.2. Problem Statement

Research conducted in the past suggested that improved QOL should be the ultimate social goal in transportation policy, instead of improved accessibility or mobility. Without considering 'improved QOL' as a final goal, the transportation social policy may just end up encouraging enhanced accessibility or mobility for the sake of it, and without combining these policies with specific QOL objectives (Stanley & Stanley, 2007) (Stanley & Vella-Brodrick, 2009).

Despite QOL being identified as potential important contributor towards transportation planning, little attention has been given by researchers to evaluate QOL in transportation planning purposes. QOL is complex in nature and can be influenced by several different factors related to transportation e.g., quality of public transit services, traffic safety, walkability in community, and quality of roads conditions etc. Physical built environment components (e.g., availability of quality public schools, health care services, and parks and recreation facilities etc.,) also plays a critical role in improving QOL of people. Similarly, personal characteristics, such as age, income, and physical disability etc., can impact QOL of individuals irrespective of the facilities available. So, considering these factors within a single study can provide more accurate and comprehensive measure of QOL.

There have been no published studies available on how different aspects of transportation specifically public transit, and walkability along with other physical built environment, and sociodemographic/personal characteristics can impact QOL within a single framework. This study comprehensively evaluates the impact of transportation (specifically public transit, and walkability), physical built environment, and sociodemographic indicators on community QOL and overall life satisfaction (OLS) for an individual living in his community in the US.

Second part of the dissertation will focus on equity evaluation at national level by considering accessibility to non-work amenities through public transit or walking as an equity indicator. Accessibility is a valuable tool to evaluate equity because it adequately places importance on the relationship between people and different locations, thus making it a suitable indicator for direct comparison across different social groups (Grengs, 2015b). It is evident from the past literature that accessibility to important life activities plays a key role towards person's QOL and life satisfaction (Delbosc, 2012) (Schneider, Guo, & Schroeder, 2013). So, it is important to investigate social justice in terms of people's ability to access destinations that are important for their daily life activities.

Improvement in quality of public transit services, and ability of the people to reach their desired destinations are vitally important for people who are public transit dependent. The people's ability to conveniently access destinations of social, recreational, educational, and civic opportunity differs across income groups, age, and race which can further leads to significant consequences not only on individuals but on the whole communities. Similarly, support for non-motorized transportation improvement e.g. walking and biking is considered very important particularly for people with disabilities, low-income people, and people who cannot drive but no attention had been paid to it by policy makers at national level.

Currently, researchers started considering accessibility as an equity indicator in transportation equity analysis studies. Some studies considered accessibility to jobs through public transit as an equity indicator. Few research studies considered accessibility to different non-work amenities as equity indicators in general (mostly through automobile), but not specifically through public transit or walking. There exists a lack of research in evaluating social equity in terms of people's ability to reach non-work amenities specifically through public transit or walk at national level in the US.

This study will evaluate the social equity in terms of people's ability to access non-work amenities through public transit or walking in the US. The non-work amenities considered in this study are: 1) grocery store or supermarket, 2) personal services, 3) other retail shopping, (4) recreation and entertainment, and (5) health care facility. The equity evaluation results will provide useful insights to transportation planners and policy makers about social justice/injustice that exists in the U.S. in terms of people's ability to access non-work amenities through public transit or walking.

1.3. Study Objectives

The primary objective of this research is to evaluate impacts of public transit and walkability on community QOL and individual's OLS in the US. Results from this research effort will help planners and policy makers regarding direct and indirect impacts of public transit and walkability on community QOL and individual's OLS in the US. This research will also assess equity in terms of people's ability to access non-work amenities through public transit and walking. The equity analysis results will provide useful insights to transportation agencies about which social groups and geographic areas are disadvantaged in terms of their ability to reach non-work amenities using public transit and walking. To achieve these goals, following are the objectives set for this study:

1. Conduct a comprehensive literature review of impact of transportation on QOL, and life satisfaction, and equity analysis in transportation.

2. Evaluate the impact of public transit and walkability on community QOL and OLS for residents in US communities by using structural equation modeling (SEM) technique.
3. Evaluate equity in terms of access to non-work amenities through public transit and walking as equity indicators in the US.

1.4. Organization of Dissertation

This dissertation is comprised of seven chapters. Chapter 1 provides background for the need and importance of assessing public transit, and walkability impact on QOL, and equity analysis in terms of public transit, and walk access to non-work amenities in the US. The chapter then continues with the problem statement, and objectives set for the study. Literature review is presented in chapter 2 of this dissertation. This chapter includes a brief discussion about QOL definition, studies that evaluated transportation impact on QOL and life satisfaction, discussion on Karel Martens theory of transportation justice, and studies related to accessibility and equity analysis in transportation overall as well as public transit. The study used national level survey data called National Community Livability Survey (NCLS) to achieve desired objectives. The survey data is presented in chapter 3 of this dissertation. In chapter 4, the methodologies to evaluate public transit, and walkability impact on QOL, and equity analysis in terms of public transit and walk access to non-work amenities is presented. SEM was developed to evaluate public transit, and walkability impact on QOL, while for equity analysis purpose the logistic regression models were developed for assessing likelihood of access to non-work amenities through public transit and walking. The SEM model results along with its implications for transportation professionals and researchers are discussed in chapter 5. The equity analysis results are presented in chapter 6 of this dissertation. Chapter 7 provides a summary of dissertation, overall conclusions, limitations, and directions for future research.

CHAPTER 2. LITERATURE REVIEW

2.1. Defining Quality of Life

Early QOL definitions fall under four general categories: Objective, subjective, combination of objective/subjective and domain specific (Lee & Sener, 2016). Objective level QOL indicators include crime rate, household income, and divorce rate etc. These objective indicators were appropriate for community/societal level QOL assessment but, failed to apprehend individual level life perceptions (Farquhar, 1995) (Felce & Perry, 1995) (Sirgy, et al., 2006). Subjective component comprises positive and negative feelings, and overall life satisfaction has been acknowledged and validated against objective indicators (Diener, 2000) (Oswald & Wu, 2010). However, subjective indicators also insufficiently capture state of one's QOL through measures of overall life satisfaction and being independent of objective indicators (Lee & Sener, 2016).

More recently, researchers have agreed that QOL is comprised of both objective indicators of life and qualitative overall life satisfaction measurement (Atkinson, 2013) (Ferkany, 2012) (Sarch, 2012). This recognition of considering QOL as combination of both subjective and objective indicators provides a more comprehensive definition of QOL. It covers both objective goals of life (e.g., employment gains, health, and reduction in crime rate etc.,) and subjective life measures, such as overall life satisfaction, and happiness that may vary based on individual's perceptions and circumstances. WHO also recognizes the QOL as combination of these subjective and objective indicators in its definition:

"WHO defines Quality of Life as individuals' perception of their position in life in the context of the culture and value systems in which they live and in relation to their goals, expectations, standards and concerns. It is a broad ranging concept affected in a complex way by the person's physical health, psychological state, level of independence, social relationships, personal beliefs and their relationship to salient features of their environment" (World Health Organization, 1997).

The fourth and final class of definition captures impacts of QOL within specific disciplines or domains. Researchers from social sciences, health, and transportation have discovered relationships between QOL and housing, job-related impacts on QOL, impact of health conditions on QOL of an individual, and increase in car pricing impact on QOL (Kyle & Dunn, 2008) (Drobnič, Beham, & Präg, 2010) (Bize, Johnson, & Plotnikoff, 2007) (de Groot & Steg, 2006). Researchers argued that domain specific QOL measures/definitions can be more useful to experts within their respective disciplines. It will help researchers in more accurately identifying the possibilities about how specific domain-related variables interact with QOL (Lee & Sener, 2016) (Atkinson, 2013). The next section describes past studies that evaluated transportation's impact on QOL and life satisfaction.

2.2. Transportation, Quality of Life, and Life Satisfaction

Three of the most significant factors that can affect QOL are health, meaningful social relationships, and poverty/unemployment (Delbosc, 2012). All of these three factors can be affected by the transportation system. The transportation system can impact health of an individual in a number of ways. Basset et al., (2008) conducted a study to investigate the impact of active transportation (walking and cycling) on obesity rates in North America, Europe, and Australia. The authors used survey data conducted between 1994 and 2006. The study results revealed that obesity is inversely related to active transportation in these countries (Basset, Pucher, Buehler, Thompson, & Crouter, 2008).

In UK, Jones et al., (2008) found that survival rates of cancer are higher in areas where people have better access to health care facilities (Jones, et al., 2008). Similarly, air and noise pollution, and road collisions can lead to hypertension, post-traumatic stress disorder, depression and anxiety problems (Mayou, Bryant, & Ehlers, 2001) (Barregard, Bonde, & Ohrström, 2009). Traffic safety is recognized as the most direct connection between transportation and physical well-being (Lee & Sener, 2016). According to WHO, traffic accidents are the leading cause of fatality among young people worldwide aged between 15 to 29 years (WHO, 2013). In the US, over two million individuals are injured every year in traffic accidents (NHTSA, 2014). Such traffic crashes often involve severe financial and psychological burdens, and can be physically overwhelming for crash victims (Lee & Sener, 2016).

Some studies linked increase in public transit use with better health conditions. Sener et al., (2016) conducted a review study focused on relationship between public transit use and physical activity. The past literature consistently emphasizes that increase in public transit use is directly associated with increased physical activity and improved health conditions. The authors also concluded that despite general agreement of past researchers regarding health and increased physical activity benefits of public transit use, there is still uncertainty regarding the magnitude of these public transit use benefits (Sener, Lee, & Elgart, 2016).

Reuda et al., (2012) estimated the benefits and health risks of modal shift from car to public transit and cycling in the greater metropolitan area of Barcelona, Spain. The authors conducted Health Impact Assessment (HIA) by creating 8 different scenarios based on replacing long and short car trips by bike and/or public transit. The primary outcome measure used was change in life expectancy and all-cause mortality based upon two assessments: 1) traveler's exposure to physical activity, road traffic fatality, and air pollution to particulate matter (PM2.5); and 2) the general population exposure to PM2.5. The study results revealed that interventions to replace car trips by public transit and bike can produce significant health benefits for both general population and travelers of the city. These interventions can also help in reducing greenhouse gas emissions (Reuda, Nazelle, Teixido, & Nieuwenhuijsen, 2012).

Studies also consider social life impacts of transportation along with physical health. An efficient transportation system provides access to different recreation and social activities which help people building social networks and improve their relationships. Although, many of the socializing activities can be accomplished through online means now a days, transportation provides greater life participation which in turn enhances QOL (Metz, 2003). Delbosc (2012) suggested that transportation systems that severely restrict people, especially older adults from maintaining social networks should target policies that remove these barriers and help improve their well-being (Delbosc, 2012).

A study by Hart and Parkhurst (2011) found that higher traffic volume on streets have considerable negative influence on social life and physical environment. People living in higher traffic volume streets were associated with fewer number of friends and social relationships, compared to people living in low and medium traffic volume streets (Hart & Parkhurst, 2011). Newman and Matan (2012) stated that disconnected land use, and incompetent transportation systems results into creating car dependent and un-walkable environments, that causes loneliness, lack of social inclusion with family and friends, and a lack of belonging which further leads to major health problems (Newman & Matan, 2012).

Velho (2018) conducted a qualitative study to evaluate the accessibility of public transit to wheelchair users and its impact on their social life and health. The interviews were conducted in London for the qualitative analysis. The study describes the social and physical barriers that wheelchair users face in the public transit network and also the negative emotions that these barriers incurred on the wheelchair users. The article highlighted the problem solving techniques that these wheelchair users have developed to cope with these barriers. The study also discusses the impact of these barriers on wheelchair users in terms of access and social life. At the end, the article considers the importance of wheelchair user's responses to physical and social barriers for policy makers and transportation engineers to take insights for public transit network accessibility improvement (Velho, 2018).

The third component, that was mentioned earlier that can significantly impact QOL was poverty/unemployment. Transportation policies that support finding and keeping of employment are likely to enhance QOL. A lack of efficient transportation system has been cited as a major obstacle to finding employment (Social Exclusion Unit, 2003). Also, transportation system should provide less expensive transportation options such as public transit, walkability etc. to reduce the burden on poor people and unemployed (Delbosc, 2012).

The research regarding direct and/or indirect impact of transportation on QOL or life satisfaction as a holistic measure is very limited (Delbosc, 2012) (Lee & Sener, 2016). Early work in transportation related QOL dimension by Banister and Bowling (2004) evaluated the influence of mobility on QOL of elderly people using categorical analysis in Britain. The survey data used in the study was derived from the three Omnibus Surveys in Britain conducted in 2000 and 2001 as part of the Office for National Statistics (ONS). The authors found that older people experiencing longstanding illness and their inability to walk 400-meter distance were associated with lower level of QOL. However, study results also revealed that nearness to shops, and availability of higher quality local health care services, and social activities were related with higher level of QOL (Banister & Bowling, 2004).

De Groot and Steg (2006) conducted a study to examine the impact of transportation pricing policy on potential car use and how it may affect the QOL of individuals. The authors also investigated acceptability, and intention of respondents to change car use by implementing new transportation pricing policy. The study was based on questionnaire survey conducted in 2004/2005 in five countries: Sweden, The Netherlands, Italy, Austria, and Czech Republic. The authors also made comparisons across these five countries. The study results revealed that in general, a minor decrease in QOL of respondents was expected by doubling the car use price. Regarding the acceptability of the policy, the respondents were not sure about their reaction when proposed policy is implemented. Austria, Czech Republic, and Italy were more optimistic about the QOL consequences of the proposed policy, more motivated to reduce car use, and the policy was more acceptable compared to Sweden and The Netherlands (de Groot & Steg, 2006).

Stanley et al., (2011) explored the relationship between individual's travel patterns, social exclusion, and personal well-being in Melbourne metropolitan area, and at regional level in Victoria. The study results revealed that increased trip making (increased mobility) is significantly associated with reduced social exclusion risk at both metropolitan, and regional level. The authors also found that although, increased mobility or trip making does not have significant direct impact on personal well-being, it does have a significant indirect influence through the impact on social exclusion risk (Stanley, Hensher, Stanley, & Vella-Brodrick, 2011).

Bergstad et al., (2011) evaluated the direct and indirect impact of satisfaction with daily travel on subjective well-being (SWB) in Sweden. The study was based on a survey conducted in 2007 with a total sample size of 1330, which included measures of satisfaction with daily travel, car use and access, satisfaction with routine out-of-home activities, and cognitive and affective SWB. The study results revealed that satisfaction with daily travel have both direct impact on

SWB, and indirect influence through mediation of satisfaction with routine activities (Bergstad, et al., 2011).

Delbosc and Currie (2011a) explored both separate and combined influences of social exclusion and transportation disadvantage on well-being. The authors used empirical analysis (ANOVA) technique by using the survey data conducted in Victoria, Australia. In order to discover these relationships, SWB measures were compared across four different groups: 1) individuals who are neither socially excluded nor transportation disadvantaged, 2) only transportation disadvantaged, 3) only socially excluded, and 4) both socially excluded and transportation disadvantaged. The study results revealed that when social exclusion is combined with transportation disadvantage, it has a large negative impact on well-being, especially for people who are unemployed, who are strictly dependent on others for transportation, and/or individuals lacking social support (Delbosc & Currie, 2011a).

Carse (2011) presented a transport quality of life (TQoL) model that can be used to appraise TQoL on all transportation modes in a city. In the first stage of the TQoL model development, the author includes weighted scores for each indicator separately that impact TQoL and used the spider diagram in order to compare TQoL across different modes. In the second stage, Principal Component Analysis (PCA) using VARIMAX orthogonal rotation method was applied to validate the TQoL indicators. The model was applied to the case studies of Glasgow and Manchester by considering light rail, train, and bus public transit modes. The TQoL indicators validated in the study were access and availability, sustainable transportation, environment, transportation costs, and personal safety (Carse, 2011).

Kolodinsky et al., (2013) used Structural Equation Model (SEM) technique to evaluate the impact of amount of travel (number of trips), and unserved travel demand in particular along with other sociodemographic, seasonal, attitudinal, and built environment variables on QOL in rural New England. The authors concluded that unmet travel demand significantly negatively impact the QOL in rural New England while amount of travel taking place does not impact the resident's QOL indicating that, it is not the increased trip making that impact QOL, but the ability of the people to travel to reach their desired destinations. Other important variables that significantly impact QOL in direct or indirect way were walk access to grocery store, feeling of safety, and vehicle ownership (Kolodinsky, et al., 2013). Cao (2013) used SEM method to evaluate the Light Rail Transit (LRT) impact on satisfaction with life in the Minneapolis-Saint Paul twin cities. The author used public transit perception, accessibility perception, and satisfaction with travel as latent variables. It was revealed from the study results that LRT in the twin cities has significant positive impact on the resident's satisfaction with life (Cao, 2013).

Delbosc (2012) presented a conceptual model comprehensively linking transportation to QOL or well-being. The authors considered three major components of transportation system that can significantly influence well-being and they are: 1) accessibility to important life activities, 2) physical mobility in terms of freedom to travel, and availability of active transportation options, and 3) physical infrastructure of transportation system. The authors discussed methodological limitations existing in the literature regarding estimation of transportation impact on QOL. The author also discussed the wide-ranging opportunities for researchers in the area of transportation impact on well-being or QOL, and provide directions to the policy makers (Delbosc, 2012).

Schneider et al., (2013) conducted a study to evaluate the role of transportation in QOL in Minnesota. Three main conclusions were drawn from the study results, and they are: 1) QOL assessment is complex in nature and transportation plays a consistent and important role in it across Minnesota, 2) transportation system's ability to connect people to important destinations is critical to QOL, and 3) residents of Minnesota readily determined the performance of state within the realm of transportation services (Schneider, Guo, & Schroeder, 2013).

Lee and Sener (2016) developed a conceptual framework describing how transportation links to QOL. The framework identified four QOL dimensions i.e. physical, social, mental, and economical that are influenced by built environment, mobility/accessibility and vehicular traffic dimensions of the transportation system. The authors then conducted content analysis of the 148 long-range transportation plans in the U.S. in order to assess the extent to which QOL is being considered in the transportation planning process. The authors concluded that metropolitan planning organizations (MPOs) are inconsistently addressing QOL measure in their transportation plans. Most of the plans targeted primarily the physical well-being while ignoring the social, and mental well-being in their plans. The authors recommended to comprehensively include QOL in future transportation planning processes (Lee & Sener, 2016).

It can be concluded from the literature review that transportation has significant impact on QOL and life satisfaction. Limited research has been done exploring transportation impact on QOL and life satisfaction. Some empirical studies explicitly include separate transportation components in QOL evaluation e.g., transportation pricing, satisfaction with travel, number of trips, and travel demand however, public transit, walkability, and other built environment components within single study are missing. Although, some researchers provided theoretical frameworks that comprehensively discuss about how different transportation aspects, physical built environment, and sociodemographic/personal characteristics can influence QOL or life satisfaction but empirical study in this regard is missing. This study for the first time comprehensively evaluates the transportation, public transit, and walkability impact on community QOL and individual's OLS.

2.3. Karel Martens Theory of Transportation Justice

In this study, equity analysis methodology primarily relies upon Karel Martens' theory of transportation justice. Karel Martens criticized the traditional transportation justice evaluation method which is based on travel demand and cost benefit analysis (Martens, 2006) (Martens, 2017). Martens argued that traditional travel demand modeling method for transportation planning is mainly focused on distribution of infrastructure, rather than accessibility distribution. Travel demand models forecast future travel based on current travel patterns, which tend to predict travel growth for people facing least travel constraints, and stagnant travel for people experiencing the most travel constraints. This in turn leads to selection of future projects that support the groups facing least travel constraints and with the most resources, which ultimately worsens the social equity in transportation (Martens & Hurvitz, 2011) (Martens, 2017).

Similarly, traditional cost benefit analysis is also problematic in nature as it mainly links transportation project benefits to total number of trips. This result into bias prioritization of transportation planning projects supporting groups with most resources, especially in terms of private vehicle ownership (Martens, 2006) (Martens, 2017). In contrast to traditional transportation justice evaluation method based on travel demand, cost benefit analysis, and system performance, Martens proposed a method that is focused on accessibility, need, and people (Martens, Golub, & Robinson, 2012).

Karel Martens theory of transportation justice basically builds upon Walzer's spheres of distribution and Rawls' theory of justice (Walzer, 1983) (Rawls, 1971). According to Martens, Walzer argues that social meanings of goods varies across different members of society and therefore should not be distributed on a single criterion. As a result, the goods with distinct social meanings should be recognized in a society and distributed in their own sphere of distribution.

Most common examples of goods with distinct social meanings and separate distribution spheres include education and health (Martens, 2012) (Martens, Golub, & Robinson, 2012) (Martens, 2017).

Martens applied this idea of distinct distributive spheres from Walzer's theory to the transportation sector. He considered potential mobility and accessibility as two distinct social meanings for the transportation sector (Martens, 2012) (Martens, Golub, & Robinson, 2012) (Martens, 2017). Potential mobility refers to the ease with which an individual can overcome distance, while accessibility is understood as the person's ability to access desired opportunities (Sager, 2005) (Farrington & Farrington, 2005) (Dong, Ben-Akiva, Bowman, & Walker, 2006). Martens ultimately considered accessibility as the most insightful of its social meaning in transportation, as it better represents concepts of choice, freedom and opportunities for experience (Martens, 2012) (Martens, Golub, & Robinson, 2012). Martens builds upon this accessibility concept and summarizes that transportation is an essential resource that shape one's life path and has sufficiently distinct social meaning to be considered under separate sphere of distribution (Martens, 2012) (Martens, 2017).

After demonstration of separate sphere of distribution to be considered for accessibility in transportation justice evaluation, Martens then focusses on Rawlsian theory of justice to determine distributive principle for accessibility distribution. Rawls proposed four principles of distribution in equity evaluation: 1) maximizing the average level of access, 2) maximizing the average level of access with minimum floor constraint, 3) maximizing the average level of access with a range constraint, and 4) maximizing the lowest access level (Rawls, 1971). Martens finds the third principle most compelling, i.e., maximizing the average transportation accessibility while restricting the accessibility gap between the best-off and the worst-off groups of society to the minimum (Martens, Golub, & Robinson, 2012) (Martens, 2012). This principle of equity evaluation is also known as maximax criterion, which suggest that transportation investment projects that excessively benefit worse-off members of society should be considered fair (Martens, Golub, & Robinson, 2012).

In conclusion, Martens presented four principles of justice applied to transportation planning: 1) people experiencing insufficient accessibility in transportation system is unjust, 2) every individual is authorized to insure against insufficient accessibility risks, 3) insurance proceeds should be used to make accessibility sufficient for all people, and (4) the transportation improvement interventions are just if they do not decrease the accessibility levels for people who are already experiencing insufficient accessibility or decrease the number of individuals experiencing insufficient accessibility (Martens, 2017).

Martens discussion about transportation justice is consistent with a shift in United States transportation policy towards a wide-ranging set of equity evaluation measures and planning goals, beyond travel demand, congestion and system performance (Cervero, 1996) (Handy, 2008) (Litman, 2012) (Venter, 2016). The next section will discuss the studies that already considered accessibility and equity analysis in transportation and public transit.

2.4. Accessibility and Equity in Transportation and Public Transit

Accessibility in transportation has been defined initially by Hansen (1959) as the intensity of opportunities for interaction (Hansen, 1959). In the broadest context, accessibility is defined as "a measure of the ease of an individual to pursue an activity of a desired type, at a desired location, by a desired mode, and at a desired time" (Bhat, et al., 2000). Poor accessibility to transportation modes reduces the opportunities for recreation, work, health services, study, and social interaction, which ultimately have impact on economic development and people's social life causing social exclusion (Sanchez, Stolz, & Ma, 2003) (Lucas K. , 2006). Martens argues that accessibility captures connection between both land use and transportation that commonly used mobility measures such as travel time or LOS do not (Martens, 2012). The concept of accessibility has been introduced in transportation equity evaluation in order to account for both spatial and social factors in social welfare evaluation (Levitas, et al., 2007).

Equity indicators in transportation studies are usually selected on the basis of transportation priorities of the community such as accessibility to employment, health care resources, grocery stores, reduced travel time, traffic congestion, and improved walkability (Bills, Sall, & Walker, 2012). Public transit equity has gained significant attention in the past few decades in transportation planning and deals with the distribution of transportation resources among groups belonging to different socioeconomic status (Garrett & Taylor, 1999).

Martinelli and Medellin (2007) evaluated the bus public transit equity in terms of travel time per mile and amount of fare paid per mile for two metropolitan case study areas, i.e., Columbus and Seattle. The household travel survey data for the two metropolitan areas was used for equity analysis. Besides providing demographic information such as household size, household income, gender, age, and ethnicity, the data also includes travel time, distance, and fare paid per trip. The socioeconomic groups used for equity analysis were income class (lower, middle and high), ethnic groups (white, non-white), gender and age (youth, working, and seniors). The authors used t-test comparison approach to evaluate the statistical differences between the socioeconomic groups in resources spent. The inequity in terms of travel time per mile and fair paid per mile across socioeconomic groups was determined by estimating Gini coefficient, and Atkinson and Theil inequality indices. The study results for the two metropolitan areas revealed that, there exists significant difference between demographic groups in terms of resources spent. Also the results indicated inequality in terms of travel time per mile and fare paid per mile between socioeconomic groups. The equity results for public transit service showed that users who are younger, lower income, and female pay more per mile cost of public transit service, and also receive an inferior quality of service in terms of speed (Martinelli & Medellin, 2007).

Hamre (2017) conducted a comprehensive study to evaluate the transportation equity by considering employer-based public transit subsidies as performance measure. The author applied transportation justice theory developed by Karel Martens in order to assess the significance of variation of public transit subsidies across income groups, and significance of association between public transit subsidies and accessibility as a measure of daily trips. The author used the household travel surveys data at worker-level for 10 MPOs in the United States and organized them into 7 cases: 1) Atlanta, 2) Baltimore and Washington DC, 3) Denver, 4) Los Angeles and San Diego, 5) New York and Newark, 6) Philadelphia, and 7) San Francisco. The study results revealed that for all the 7 cases, the odds of public transit subsidy being offered were significantly lower for 1^{st} income quintile workers compared to 4^{th} and 5^{th} income quintile workers. The study results indicated lack of statistical evidence that public transit subsidies are associated significantly with accessibility. Based on the study results, the low income quintile group being least accessible to public transit subsidy in all the 7 cases, the author suggested reform alternatives for policymakers, such as refundable tax credit for expenses incurred due to commute, commuter benefit ordinances, or alternatives such as location- and income-based public transit subsidies (Hamre, 2017).

Some studies explicitly assessed the social equity in terms of transportation accessibility, and most of these studies focused on job accessibility. Wachs and Kumagai (1973) in one of the earliest studies compared the job accessibility among population by occupation and household income in Los Angeles. The study results revealed that higher income groups have more accessibility to their respective jobs compared to lower income. Also managerial, professional, and technical employees have better accessibility to jobs compared to other occupation categories (Wachs & Kumagai, 1973). Black and Conroy (1977) conducted a study to compare the accessibility to jobs between men and women in the suburbs of Sydney. The study results found that men have higher accessibility to jobs compared to women mainly because of more access to high speed travel modes (Black & Conroy, 1977).

Helling (1998) compared the accessibility to jobs in Atlanta by race and found that overall accessibility improved in the region between 1980 and 1990, but on average declined for African Americans (Helling, 1998). Grengs (2012) compared the ability of people to reach jobs by income, ethnicity, race, and poverty in Detroit. The authors found that low-income people and racial minorities have better access to jobs because of their disproportionate housing location near the metropolitan region center. On the other end, the authors also suggested that same groups can face extreme level of low accessibility to jobs by not owning their own vehicle in spite of living in the advantageous locations (Grengs , 2012).

Grise et al., (2018) evaluated the job accessibility to users with disability (people in wheelchair) compared to general population through public transit. The cities of Montreal and Toronto were considered as case studies for accessibility evaluation. The authors also investigated the job accessibility to wheelchair users through public transit in socially vulnerable areas. Travel time and number of jobs were the main data set used in the study. The travel time between census tracts was estimated using General Transit Feed Specification (GTFS) data from Toronto and Montreal. The study results revealed that on average, 46% and 75% of the jobs are accessible to wheelchair users, compared to others in Montreal and Toronto respectively. The study results indicate high job access disparity for wheelchair users compared to general population through public transit. The major limitations of the study include: 1) the study considered number of jobs as a whole available to society and did not distinguish by sector, nature or any other criteria, and 2) the job competition effect is not incorporated. According to authors, the second limitation falls beyond the scope of the study as focus of the study is to assess geographic job accessibility comparison between wheelchair users and general population in which competition is same for both categories. At the end, the authors recommended the decision makers to emphasize on improvement of levels of accessibility to wheelchair users in order to minimize their job inaccessibility (Grise, Boislojy, Maguire, & El-Geneidy, 2018).

Yeganeh et al., (2018) conducted social equity analysis in terms of people's ability to access jobs through public transit at national level in the US. The authors considered 45 largest Metropolitan Statistical Areas (MSAs) in the analysis. The accessibility to jobs via public transit was compared across income groups and race within MSAs. The study results revealed that within MSAs, minorities, and low income populations have the highest job accessibility through public transit (Yeganeh, Hall, Pearce, & Hankey, 2018).

Some studies compared the accessibility to non-work destinations among different social groups. Helling and Sawicki (2003) compared accessibility to personal services and retail trade by race in Atlanta. The study results showed that African Americans neighborhoods experience lower accessibility to both personal services and retail trade compared to white neighborhoods (Helling & Sawicki, 2003). Scott and Horner (2008) conducted a detailed study using accessibility measures and variety of destination types in Louisville. The authors found that four out of five underprivileged socioeconomic groups unexpectedly did not experience accessibility disadvantage in their ability to reach important destinations such as hospitals, grocery stores, and post offices (Scott & Horner, 2008).

Grengs (2015) conducted a comprehensive study to first explains a method for estimating non-work accessibility indicators and then evaluates social equity in terms of non-work accessibility in the Detroit Metropolitan Region. The author found that underprivileged social groups of the community including low-income households, Hispanics, African Americans, and households in poverty have advantage over more privileged groups in terms of physical accessibility especially to convenience stores, religious organizations, childcare facilities, and hospitals. However, these vulnerable groups have disadvantage in their ability to reach supermarkets and shopping. Also the author concluded that these vulnerable or underprivileged groups of community share a large proportion of households with extremely low level of accessibility, because of low vehicle ownership (Grengs, 2015).

Ahern and Hine (2015) evaluated the health care access to older age people in rural Ireland. It was evident from the study results that trips to health care services were the most important trips taken by older age people and meanwhile most difficult trips to take in rural areas. The authors concluded that this difficulty in accessing health care services was lack of synergy between health service providers, and transportation operators, and also lack of coordination among government bodies implementing health, and transportation policy (Ahern & Hine, 2015).

Dharmadhikari and Lee (2015) analyzed the public transit accessibility of grocery stores to students in university using a case study from Fargo, North Dakota. The authors incorporated three main components of travel time in accessibility analysis, i.e., walk time from home to closest bus stop, riding travel time from public transit stop to destination at grocery store, and walking time from bus destination stop to grocery store. The study results revealed that within 10 minutes walking time to reach bus stop, a large area can be considered accessible to public transit route. The authors concluded that overall Fargo has moderate public transit (MAT BUS) accessibility to grocery stores where majority of population is students or lower income group (Dharmadhikari & Lee, 2015).

Kim et al., (2018) investigated the health care accessibility in city of Seoul, Korea using Seoul Enhanced 2-Step Floating Catchment Area (SE2FCA) method. SE2FCA method used in this study is an extension of Enhanced 2-Step Floating Catchment Area (E2FCA) method. In SE2FCA method the authors incorporated two new measures to the E2FCA method: 1) in the first step the critical travel time for the catchment areas is used as function of hospital size, and 2) multiple travel modes are included in the analysis. Accessibility analysis was performed separately for public and private hospitals in Seoul region. The study results revealed that for both public and private hospitals, the trend of accessibility is same and there is high inequity in accessibility distribution to private health care facilities. The most vulnerable districts are located in the outskirts of the city, and comparatively central parts of the city have high accessibility. The authors recommended that enhancing the public transit system by optimally locating the public transit stops, and bus frequency improvement would increase the accessibility to health care facilities (Kim, Byon, & Yeo, 2018).

Aitken et al., (2018) conducted a study to analyze accessibility to public transit stops, and quality of walking environment in urban area of Santiago de Chile. The equity analysis was also performed across the city for these two indicators. The equity analysis was performed using Foster-Greer-Thorbecke (FGT) measure of poverty, Gini Coefficient and Lorenz curves. The study results revealed that 12 out of 34 municipalities in the city of Santiago are deprived in terms of one or both equity indicators considered and are not managing to attain minimum equity standards. The authors recommended that policy makers should give priority to the municipalities that lack in attaining sufficient level of access and quality of urban walking environment, especially those that have greater usage of walking and public transit (Aitken, Munoz, & Hurtubia, 2018).

It has been identified from literature review that accessibility plays a vital role in transportation equity evaluation as it adequately builds relationship between people and different locations. Recently, researchers started considering accessibility as an equity indicator in transportation justice evaluation studies. Some studies considered access to jobs specifically through public transit as equity indicator. Some studies considered access to non-work amenities such as hospitals, religious organizations, and grocery stores as equity indicators in general (mostly through automobile), but not specifically through public transit and walking. There exists a lack of research in evaluating social equity in terms of people's ability to access non-work amenities specifically through public transit and walking. This study will investigate equity evaluation in terms of people's ability to access important non-work amenities (grocery stores, personal services, retail shopping, parks and recreation areas, and health care facility) through public transit and walking at the national level in the US.

CHAPTER 3. DATA USED FOR THE STUDY

This study will use data collected through a national survey called National Community Livability Survey (NCLS). The survey was conducted from April to December in the year 2017 by Texas A&M Transportation Institute and North Dakota State University's Upper Great Plains Transportation Institute (UGPTI). The survey was conducted as a part of a research project that was aimed to analyze the livability of a community and evaluate the role of public transit on QOL and OLS of individuals in metro and non-metro areas (Godavarthy, et al., 2018). Copy of survey is provided in Appendix A. Stratified random sampling method was used to distribute the survey to ensure that survey distribution was proportional to U.S. adult non-institutionalized population. The survey was stratified based on four U.S. regions, nine Census Divisions, by age and by sex to ensure adequate adult participation from each major geographic areas of the US. Further, the survey was stratified by the U.S. Department of Agriculture (USDA): Economic Research Service (ERS) Rural-Urban Continuum Code (RUCC), so surveys were distributed to individuals living in all nine RUCC classifications. The NCLS study considered RUCC codes 1, 2, and 3 as metro areas, and RUCC codes 4-9 as non-metro areas. It should be noted that a roughly equal number of surveys were distributed in each of the nine RUCC classifications, which meant that rural communities were over-sampled to ensure a comparable size of returned survey responses for each RUCC code. This dissertation uses the same definition for categorizing the communities as metro, and non-metro areas. The surveys for NCLS study were sent out to 25,000 adults from all 50 U.S. states.

The response rate for the survey was 4% that counts for total of 994 completed responses received. This is one of the limitation of this study that response rate of the survey is low. The survey collected information from respondents about community livability (general and local), transportation, public transit, walkability, community QOL, individual's OLS, future transportation and technology, and sociodemographic characteristics. Sections of the survey data that are used in this research effort are described in the subsections below.

3.1. Accessibility Indicators

To understand the non-work accessibility indicators, the survey included two different questions – one question to understand the respondent's ability to access non-work amenities through public transit, and another question to understand respondent's ability to access non-work amenities through walking (see question numbers 16 and 17 in Appendix A). The non-work amenity options included in the survey questions are: 1) grocery store or supermarket (vegetables, fresh fruit, meat, and bread), 2) personal services (bank, laundromat, and hair/nail salon), 3) other retail shopping (pharmacy, clothes, and household goods), 4) recreation and entertainment (parks, museums, movies, and live theater), and 5) health care facility (hospital, doctor's office, and urgent care). Accessibility to non-work amenities through public transit and walking were measured as 0 (cannot access corresponding non-work amenity) and 1 (can access respective non-work amenity). Table 3.1 shows the percentage of respondents who can access the non-work amenities by using public transit (if public transit is available in their community) for metro, and non-metro areas. The sample size for public transit access to non-work amenities in metro and non-metro areas is 277 and 239, respectively. Accessibility to non-work amenities for metro areas is higher than non-metro areas. For both metro, and non-metro areas, close to half of the respondents mentioned that they cannot access respective non-work amenity using public transit, except for recreation and entertainment non-work amenity in non-metro areas.

Table 3.2 shows the percentage of respondents who can access non-work amenities mentioned through walk in both metro, and non-metro areas. The sample size for walk access to non-work amenities in metro and non-metro areas is 414 and 571, respectively. Accessibility to non-work amenities in non-metro areas is observed as much less than compared to metro areas.

Table 3.1. Accessibility to Non-Work Amenities through Public Transit

Type of Non-work Amenity	Yes		No	
	Metro Area	Non-Metro Area	Metro Area	Non-Metro Area
Grocery store or supermarket	60.5%	60.1%	39.5%	39.9%
Personal services	57.6%	54.2%	42.4%	45.8%
Other retail shopping	62.5%	56.5%	37.5%	43.5%
Recreation and Entertainment	54.5%	43.0%	45.5%	57.0%
Health care facility	60.1%	59.7%	39.9%	40.3%

Table 3.2. Accessibility to Non-Work Amenities through Walk

Type of Non-work Amenity	Yes		No	
	Metro Area	Non-Metro Area	Metro Area	Non-Metro Area
Grocery store or supermarket	54.0%	38.4%	46.0%	61.6%
Personal services	49.5%	36.5%	50.5%	63.5%
Other retail shopping	42.0%	28.4%	58.0%	71.6%
Recreation and Entertainment	40.1%	31.5%	59.9%	68.5%
Health care facility	31.1%	27.3%	68.9%	72.7%

Independent sample t-test was performed using SAS 9.4 software. The test was used to check whether the difference between the mean values in terms of public transit and walk access to non-work amenities was statistically significant between metro and non-metro areas. Table 3.3 shows the t-statistics and respective p-values results of the two-sample t-tests for Pooled (assuming equal variances) and Satterthwaite (assuming unequal variances) methods. Table 3.4 shows the test for equality of variances with test statistic value given under the column "F Value" and the respective p-value under the column "Pr > F". The alpha value or threshold value for statistical significance in this test is assumed as 0.05. If the respective p-value for the equality of variances test is greater than or equal to alpha, we perform Pooled t-test with the assumption of equal variances across two levels of categorical variable. If the corresponding p-value is less than the threshold alpha level, the Satterthwaite t-test is performed by assuming variance across two levels of categorical variable is unequal. In this study, the categorical variable considered is “area” with two levels of metro areas as 1 and non-metro areas as 2. The public transit and walk access to non-work amenities was measured on a scale of 0 (an individual does not have access to any of the five non-work amenities considered in the study) to 5 (an individual have access to all five non-work amenities considered in the study).

In terms of public transit access to non-work amenities the equality of variances p-value is 0.0055, which is less than the threshold alpha value of 0.05. This indicate that Satterthwaite t-test should be performed. The t-statistic value for Satterthwaite t-test is 5.99 with corresponding p-value of <0.0001. Since the p-value is less than the threshold alpha value of 0.05, it is concluded that on average public transit access to non-work amenities in significantly higher in metro areas compared to non-metro areas. The results in Table 3.3 and Table 3.4 indicate that the difference in access to non-work amenities using walk mode was not statistically significant between metro and non-metro areas.

Table 3.3. Public Transit and Walk Access to Non-Work Amenities - Pooled and Satterthwaite T-Test Methods

Access By Mode	Method	t-Statistic	p-value
Public Transit Access to Non-work Amenities	Pooled	6.11	<0.0001
	Satterthwaite	5.99	<0.0001
Walk Access to Non-work Amenities	Pooled	4.23	<0.0001
	Satterthwaite	4.25	<0.0001

Table 3.4. Public Transit and Walk Access to Non-Work Amenities - Equality of Variances

Access By Mode	Method	F Value	Pr > F
Public Transit Access to Non-work Amenities	Folded F	1.29	0.0055
Walk Access to Non-work Amenities	Folded F	1.07	0.4359

3.2. Quality of Transportation

In the NCLS, quality of five aspects of transportation in a community is requested. The five aspects include public transit services, bikeability, low traffic congestion, walkability, and condition of roads. The quality of these indicators were measured on a 5-point likert scale from 1 to 5 where 1 represents very poor, 2 represents poor, 3 represents acceptable, 4 represents good, and 5 represents very good. Table 3.5 shows the overall sample sizes, average scores, and standard deviations for each indicator representing quality of transportation for metro, and non-metro areas. The sample sizes for quality of public transit services, bikeability, low traffic congestion, walkability, and roads in good condition in non-metro area are 567, 565, 568, 563, and 571, respectively. The average scores for quality of available public transit services in metro and non-metro areas were observed as 2.8 and 2.2, respectively. The scores indicate that on average the quality of public transit services perceived by respondents in metro areas is close to acceptable, and just above poor for non-metro areas. The average scores for quality of walkability/accessibility in both metro and non-metro were estimated to be 3.2. The scores indicate that on average the quality of walkability/accessibility perceived by respondents in both metro and non-metro areas is just above acceptable. The average scores for quality of bikeability were estimated as 3.2 and 2.9 for metro and non-metro areas, respectively. The scores indicate that on average the quality of bikeability is rated as acceptable in both metro and non-metro areas. Low traffic congestion is rated as acceptable in metro areas, and close to being good in non-metro areas. The average scores for conditions of roads in both metro and on-metro areas were estimated to be 3.0. The scores indicate that on average the conditions of roads perceived by respondents in both metro and non-metro areas is acceptable.

Table 3.5. Quality of Transportation Indicators Rated by Respondents

Quality of Transportation Indicator	N Overall	Metro (Mean)	Metro (Std. Dev)	Non-Metro (Mean)	Non-Metro (Std. Dev)	Overall (Mean)	Overall (Std. Dev)
Public transit services	975	2.8	1.19	2.2	1.15	2.5	1.20
Bikeability	975	3.1	1.10	2.9	1.05	3.0	1.08
Low traffic congestion	978	3.2	1.01	3.7	1.00	3.5	1.03
Walkability/accessibility	973	3.2	1.06	3.2	1.10	3.2	1.08
Roads in good condition	983	3.0	1.02	3.0	1.01	3.0	1.02

Std. Dev represents Standard Deviation

3.3. Perceived Public Transit Importance and Public Transit Support/Need

Respondents were asked about their perceived importance of public transit for their community on a 5-point Likert scale with 1 (strongly disagree) to 5 (strongly agree). Results summarized in Figure 3.1 shows that the majority of the respondents either agree or strongly agree that public transit is important for their community in both metro and non-metro areas. The sample size used for perceived public transit importance distribution in metro and non-metro areas is 403 and 563, respectively. Most of the respondents in metro and non-metro areas either support the same amount of public transit currently available or more public transit in their respective communities (Table 3.6). The sample size for public transit support/need in metro areas is 406, while for non-metro areas the sample size used is 564.

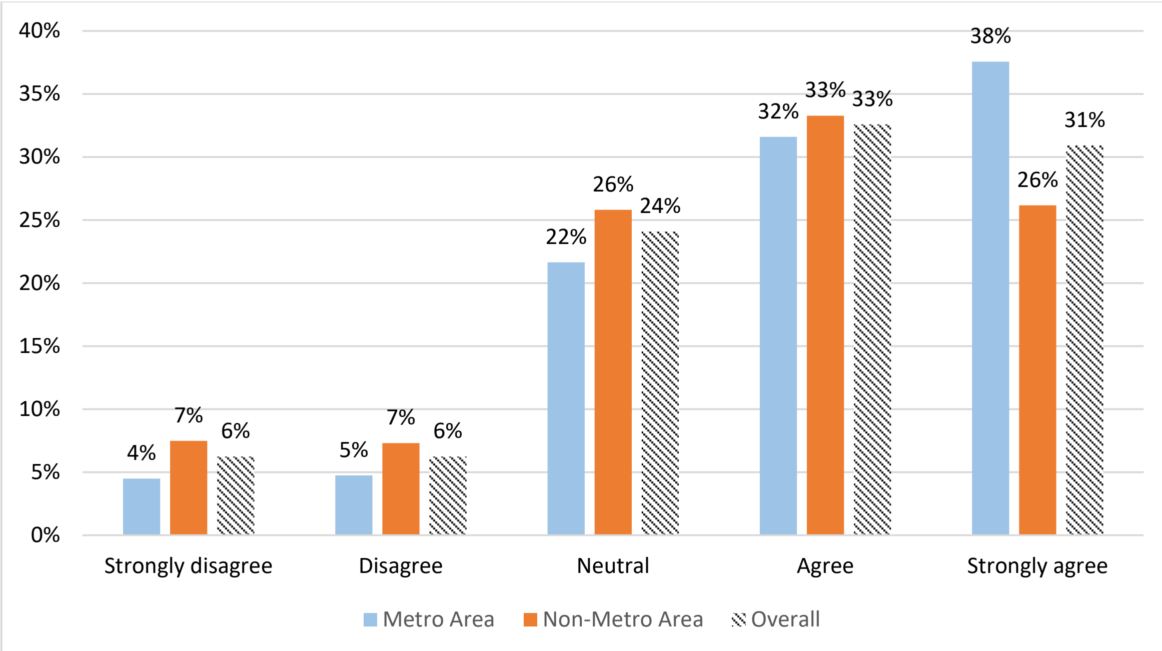


Figure 3.1. Respondents Perceived Public Transit Importance for a Community

Table 3.6. Respondents Support for Same, Less, or More Amount of Public Transit in their Community

Public Transit Support/Need	Metro Area	Non Metro Area	Overall
Less public transit	5%	7%	7%
Same amount of public transit	44%	47%	46%
More public transit	51%	45%	48%

3.4. Support for Transit Funding

Respondents were asked about their support for transit funding from federal, state, city, and county level sources. The variable "I support using (city, county, state and federal) funds for transit" were measured on a 5-point Likert scale with 1 (strongly disagree) to 5 (strongly agree). Table 3.7 shows that most of the respondents either agree or strongly agree for supporting transit funding using federal, state, county or city funds. Further, support from metro areas was more when compared to non-metro areas to fund public transit through various sources. The overall sample size used for supporting transit funding from city, county, state, and federal level external sources is 953, 962, 958, and 955, respectively.

Table 3.7. Respondents Support for Transit Funding

	Area Type	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
I support using city funds for transit	Metro	7%	8%	26%	38%	22%
	Non-metro	13%	10%	28%	35%	15%
	Overall	10%	9%	27%	36%	18%
I support using county (or equivalent to county) funds for transit	Metro	6%	9%	27%	38%	21%
	Non-metro	13%	9%	27%	35%	16%
	Overall	10%	9%	27%	36%	18%
I support using state funds for transit	Metro	6%	8%	20%	38%	27%
	Non-metro	11%	9%	22%	38%	20%
	Overall	9%	9%	21%	38%	23%
I support using federal funds for transit	Metro	7%	12%	20%	33%	28%
	Non-metro	13%	10%	23%	34%	20%
	Overall	10%	10%	22%	34%	24%

3.5. Mobility Indicator (Ease of Travel)

In the survey, respondents were asked about how easily they can travel to places they need to go using their current travel options. Ease of travel is measured on a 5-point Likert scale from 1 (strongly disagree) to 5 (strongly agree). Figure 3.2 shows that most of the respondents from both metro and non-metro areas either agreed or strongly agreed that they can easily travel to the places they need to go using current travel options in their communities. The sample size used for ease of travel distribution is 402 and 561 in metro and non-metro areas, respectively.

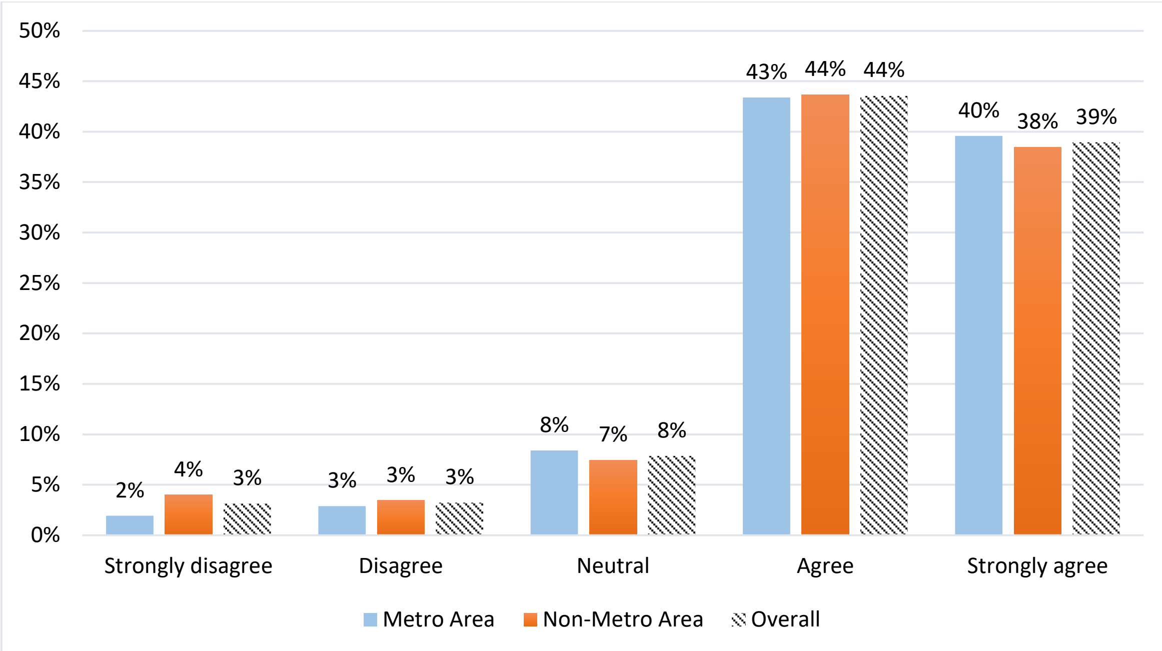


Figure 3.2. Respondents Perception about Ease of Travel in their Communities

Table 3.8 shows the t-statistics and corresponding p-values results for Pooled and Satterthwaite t-test methods. Table 3.9 shows the results for equality of variances test with F value and corresponding p-value under column "Pr > F". The p-value for equality of variances test is 0.008, which is less than threshold alpha value of 0.05. This indicate that assumption of unequal variances is valid and Satterthwaite t-test method should be applied. The estimated p-value for Satterthwaite method is greater than the threshold alpha value of 0.05. This result reveals that the difference in ease of travel for respondents between metro and non-metro areas is not statistically significant.

Table 3.8. Ease of Travel in Metro Vs Non-Metro Areas - Pooled and Satterthwaite T-Test Methods

Variable	Method	t-Statistic	p-value
Ease of Travel (Mobility Indicator)	Pooled	1.29	0.1962
	Satterthwaite	1.32	0.1871

Table 3.9. Ease of Travel in Metro Vs Non-Metro Areas - Equality of Variances

Variable	Method	F Value	Pr > F
Ease of Travel (Mobility Indicator)	Folded F	1.28	0.008

3.6. Built Environment or Livability Indicators

Livability indicators included in this study are affordable transportation options, quality health care, sense of community, overall cost of living, parks and recreation facilities, shopping and entertainment options, weather, jobs availability, affordable housing, quality public schools, clean environment, low crime, cultural institutions, and traffic safety. Respondents were asked about rating the quality of these livability indicators in their respective communities measured at a 5-point Likert scale from 1 (very poor) to 5 (very good). Table 3.10 shows the average rating and standard deviation of each livability indicator by respondents. The overall sample size for the given livability indicators range between 981 to 990. It can be observed in Table 3.10 that no livability factor has an average rating score above 4 for both metro and non-metro areas. On average, the top four rated livability indicators in metro areas were quality of health care, clean environment, parks and recreation facilities, and quality public schools. In non-metro areas, the top four livability indicators identified by respondents were clean environment, traffic safety, low crime rate, and sense of community.

Table 3.10. Quality of Livability Indicators Rated by Respondents in their Respective Community

Livability Indicators	Metro (Mean)	Metro (Std. Dev)	Non-Metro (Mean)	Non-Metro (Std. Dev)	Overall (Mean)	Overall (Std. Dev)
Available jobs	3.2	1.02	2.7	1.05	2.9	1.06
Affordable transportation options	3.0	1.07	2.5	1.05	2.7	1.08
Cultural institutions	3.2	1.05	2.8	1.07	2.9	1.08
Quality healthcare	3.8	1.03	3.3	1.05	3.5	1.07
Affordable housing	3.2	1.02	3.1	1.06	3.1	1.05
Quality public schools	3.6	0.99	3.5	1.06	3.6	1.03
Overall cost of living	3.4	0.93	3.3	0.98	3.3	0.96
Shopping and entertainment options	3.3	1.09	2.5	1.03	2.9	1.12
Parks and recreation facilities	3.7	0.97	3.4	1.08	3.5	1.04
Weather	3.6	0.85	3.5	0.83	3.6	0.84
Clean environment	3.7	0.87	3.8	0.91	3.7	0.89
Low crime	3.5	1.02	3.7	0.98	3.6	1.00
Sense of community	3.5	0.93	3.6	0.99	3.6	0.97
Traffic Safety	3.5	0.90	3.8	0.85	3.6	0.88

3.7. Community QOL and Individual's OLS

In order to assess the subjective QOL for community residents, respondents were asked about "How satisfied are you with the quality of life in your community" (Kahneman & Krueger, 2006). The satisfaction of the QOL was measured on a 5-point Likert scale from 1 (very dissatisfied) to 5 (very satisfied). The average values estimated for metro and non-metro areas were 4.0 and 3.8, respectively; these results indicate that respondents were satisfied with QOL in their communities. Figure 3.3 shows that most of the respondents from both metro and non-metro areas either respond as satisfied or very satisfied with their QOL in their community. The sample size used for community QOL distribution in metro and non-metro areas is 415 and 576, respectively.

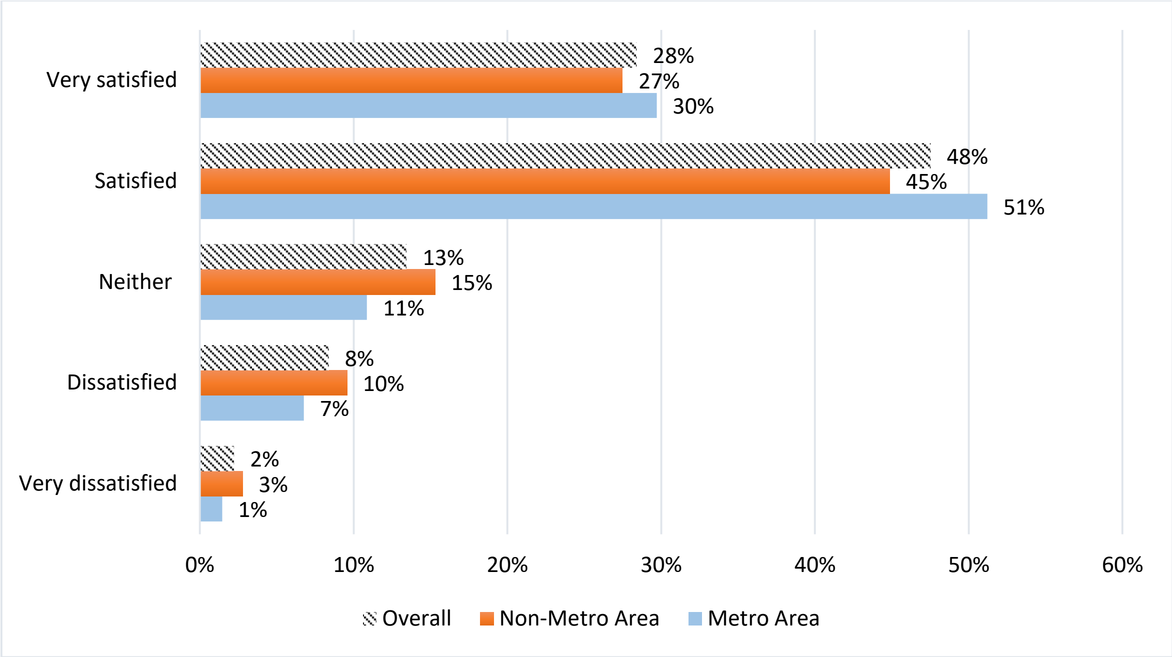


Figure 3.3. Respondents Satisfaction with Quality of Life in their Communities

The respondent's OLS was evaluated by asking following question: "All things considered, how satisfied are you with your life as a whole these days?'. The response of this question was measured on a scale of 0 to 10 with 0 considered as completely dissatisfied, and 10 as completely satisfied. The average response scores estimated were 7.79 and 7.65 for metro and non-metro areas, respectively. Figure 3.4 shows the distribution of the responses for metro, and non-metro areas. Higher percentage of respondents responded with their life satisfaction greater than 5 on the scale for both metro and non-metro areas. The sample size used for individual's OLS distribution is 417 and 576 in metro and non-metro areas, respectively.

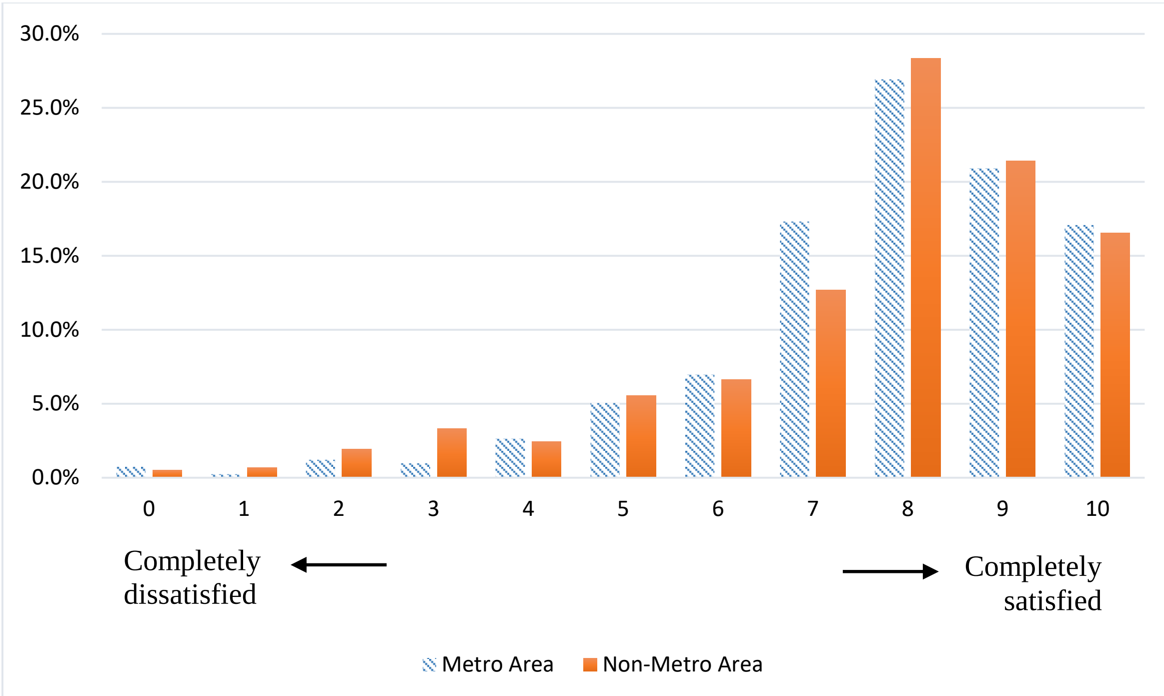


Figure 3.4. Respondents Overall Life Satisfaction Ratings

Table 3.11 shows the t-statistic and corresponding p-values results for Pooled and Satterthwaite t-test methods by considering community QOL and individual's OLS variables. Table 3.12 shows the equality of variances t-test results in the form of F values and respective p-values (Pr > F) for community QOL and individual's OLS variables. The test results reveal that on average the community QOL perceived by respondents in metro areas is significantly higher than non-metro areas. For individual's OLS variable, the difference between metro and non-metro area residents is not statistically significant.

Table 3.11. Community QOL and Individual's OLS in Metro Vs Non-Metro Areas - Pooled and Satterthwaite T-Test Methods

QOL Measure	Method	t-Statistic	p-value
Community QOL	Pooled	2.6	0.0095
	Satterthwaite	2.65	0.0081
Individual's OLS	Pooled	1.07	0.2861
	Satterthwaite	1.09	0.2781

Table 3.12. Community QOL and Individual's OLS in Metro Vs Non-Metro Areas - Equality of Variances

QOL Measure	Method	F Value	Pr > F
Community QOL	Folded F	1.29	0.0065
Individual's OLS	Folded F	1.23	0.0236

3.8. Socio Demographics

The sociodemographic characteristics of the respondents considered in this study are: gender, age, race, employment, level of education, household income, driving license, number of vehicles in household, Medicare/Medicaid, physical disability, and overall health condition. Among the total respondents of 994, 41.2% are male, and 58.8% are female. This percentage is comparable with the American Community Survey 2018 (ACS 2018) percentage of male and female. According to ACS 2018, the percentage of male and female above the age of 18 years is 48.7% and 51.3%, respectively in the US. Metro respondents have slightly lower percentage of female respondents (57.1% female, and 42.9% male) compared to non-metro respondents (60% female, and 40% male). Figure 3.5 shows the distribution of respondents by age group. For both metro and non-metro areas, the highest percentage of respondents belong to age group 55 to 64 years old, followed by the 65 to 74 years old, and then age group of 45 to 54 years old. The number of observations used for age group distribution are 992 with 575 for non-metro areas.

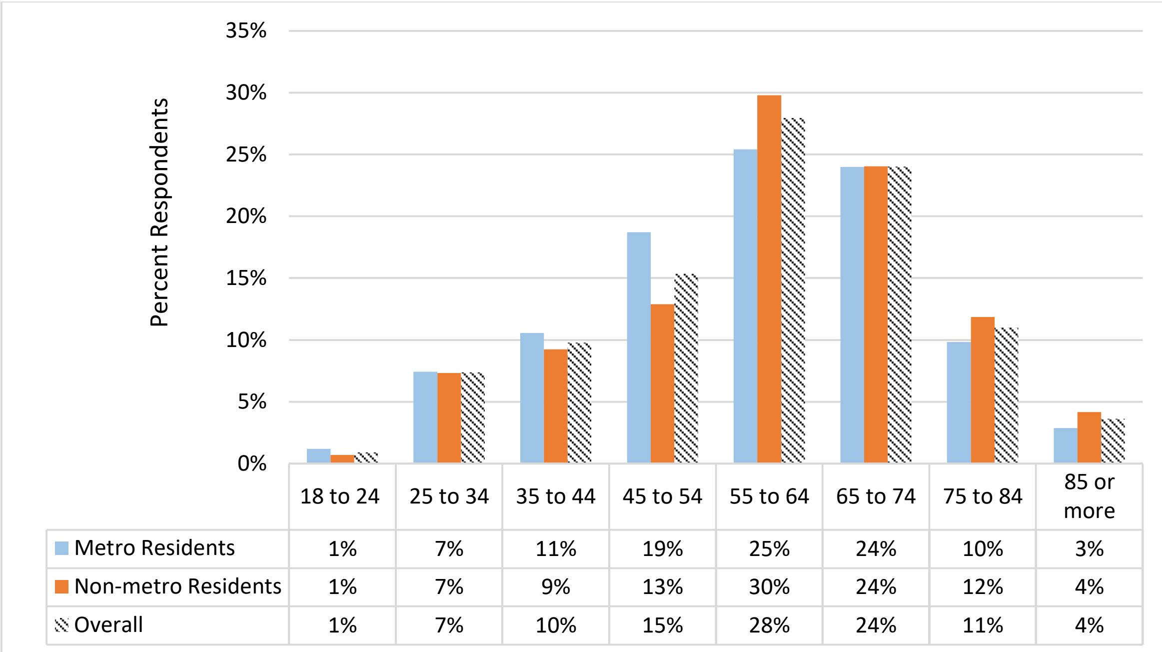


Figure 3.5. Respondents Percentage by Age Group

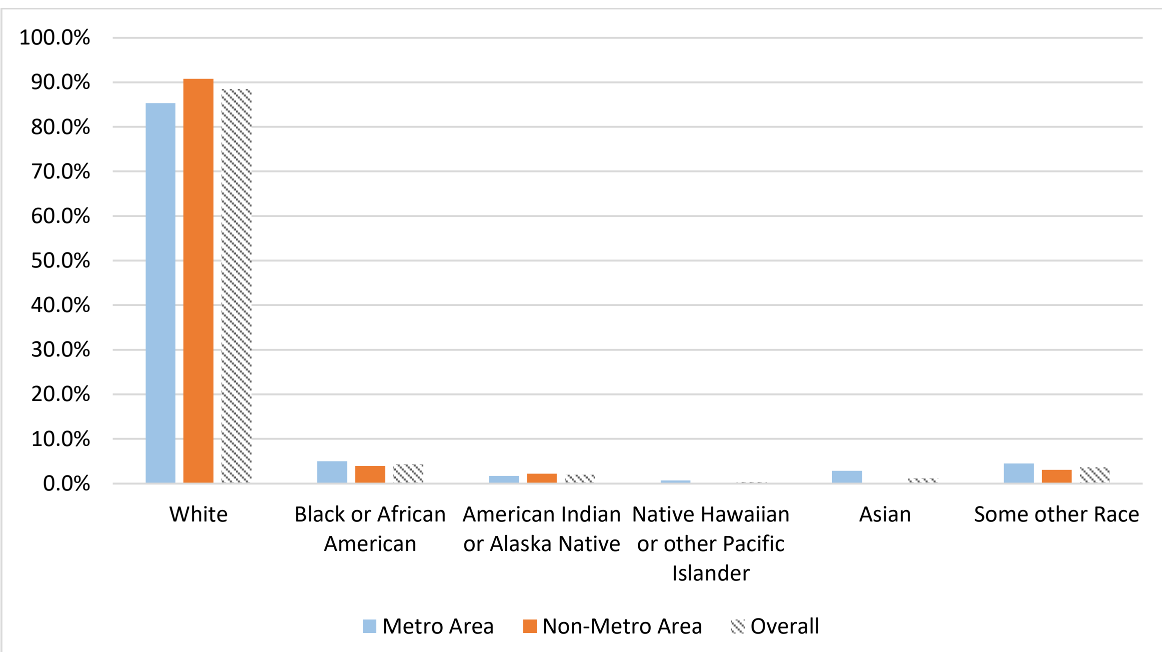


Figure 3.6. Respondents Percentage by Race

Majority of the respondents were white from both metro (85.3%), and non-metro (90.8%) areas (Figure 3.6). The next high proportion of respondents by race was black or African American followed by some other race for both metro and non-metro areas. The overall sample size used for race percentage distribution is 984 with 571 for non-metro areas. The percentage of respondents by different race categories is also compared with ACS 2018 percentages for corresponding race categories (Table 3.13). The data reveal that white population in the survey is overly represented while black or African American and Asian are underrepresented in the survey sample. The percentage for other categories of race in the survey sample are almost similar to the ACS 2018 data.

Table 3.13. Comparison between Survey Data and ACS 2018 Data for Different Race Categories

Race	Survey Data	ACS 2018
White	88.5%	75.10%
Black or African American	4.4%	14.10%
American Indian or Alaska Native	2.0%	1.70%
Native Hawaiian or other Pacific Islander	0.3%	0.40%
Asian	1.2%	6.80%
Some other Race	3.7%	5.50%

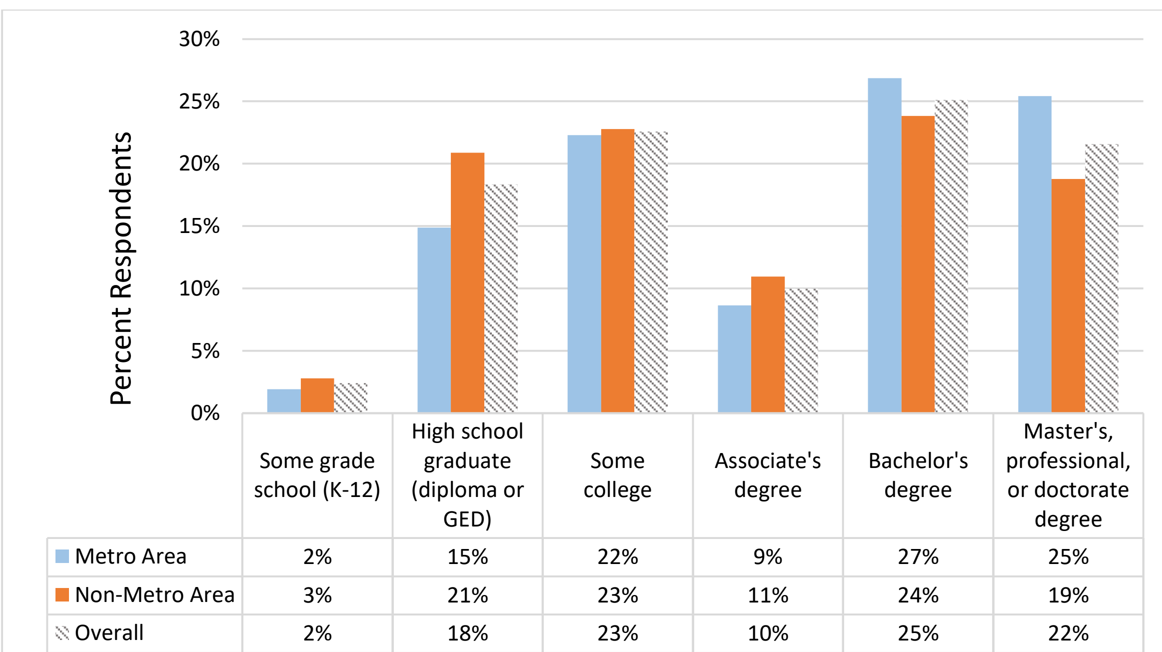
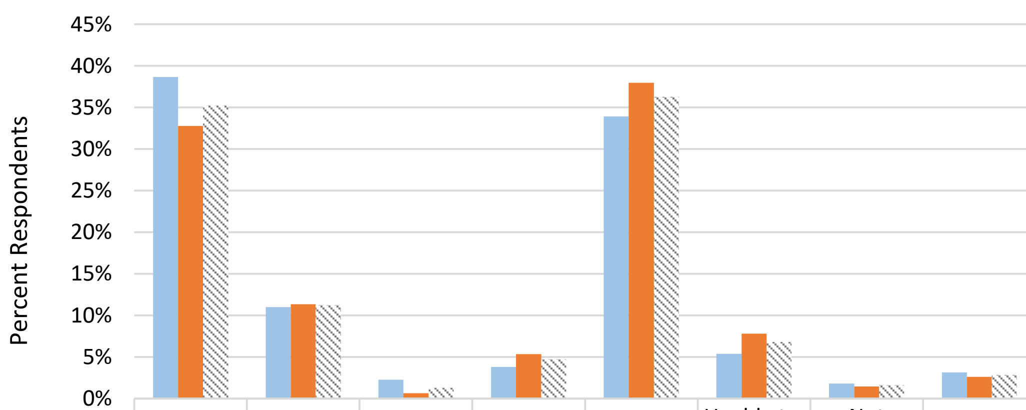


Figure 3.7. Respondents Percentage by Level of Education

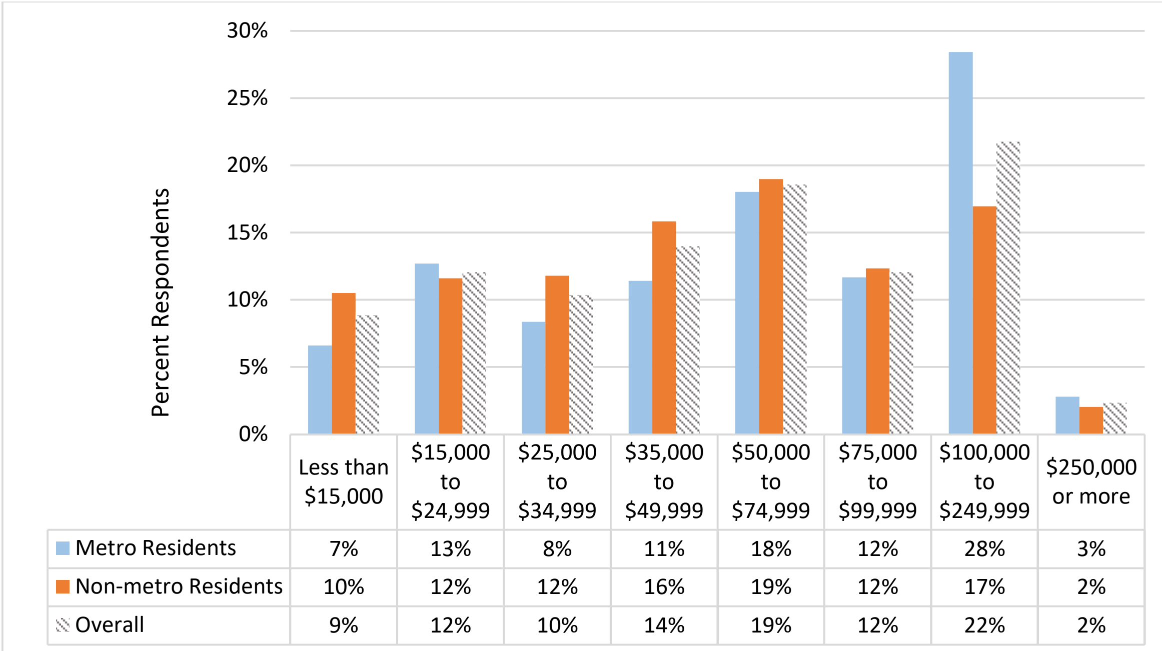
Respondents were asked about their highest level of education they have completed. Percentage of respondents were almost evenly distributed by level of education except lower percentage for grade school K-12 level education (Figure 3.7). The sample size used of level of education distribution is 994 with no missing value.

Most of the respondents from both metro and non-metro areas were either employed full time or retired (Figure 3.8). The overall sample size used for employment distribution is 989 with 573 observations for non-metro areas. Figure 3.9 shows the combined annual household income of the respondents in metro and non-metro areas. Combined annual income is fairly evenly distributed among the respondents in both metro and non-metro areas, except for the high income class of $100,000 to $249,999 for metro areas (28.4%). The sample size used for income distribution is metro and non-metro areas is 394 and 544, respectively.



	Employed Full-time	Employed Part-time	Student	Homema ker	Retired	Unable to Work due to Disability	Not Employed , Looking for Work	Other
Metro Area	39%	11%	2%	4%	34%	5%	2%	3%
Non-Metro Area	33%	11%	1%	5%	38%	8%	1%	3%
Overall	35%	11%	1%	5%	36%	7%	2%	3%

Figure 3.8. Percentage of Respondents by Employment Type



	Less than $15,000	$15,000 to $24,999	$25,000 to $34,999	$35,000 to $49,999	$50,000 to $74,999	$75,000 to $99,999	$100,000 to $249,999	$250,000 or more
Metro Residents	7%	13%	8%	11%	18%	12%	28%	3%
Non-metro Residents	10%	12%	12%	16%	19%	12%	17%	2%
Overall	9%	12%	10%	14%	19%	12%	22%	2%

Figure 3.9. Percentage of Respondents by Income Class

Most of the respondents from both metro (95.9%), and non-metro (95.5%) areas mentioned that they have driver's license (overall sample size = 992). Figure 3.10 shows the percentage of respondents by number of vehicles (motorcycles, cars, or trucks) in their households. The overall sample size used for number of working vehicles in household is 987 with 572 observations for non-metro areas. The largest portion of the respondents from both metro (37%), and non-metro (41%) areas mentioned that they have two working vehicles in their households. For metro areas, 44% of the respondents mentioned that they are covered under Medicare/Medicaid program, while for non-metro areas the percentage was slightly higher with 48% of the respondents covered under the program. There was no missing value for this variable with total sample size of 994.

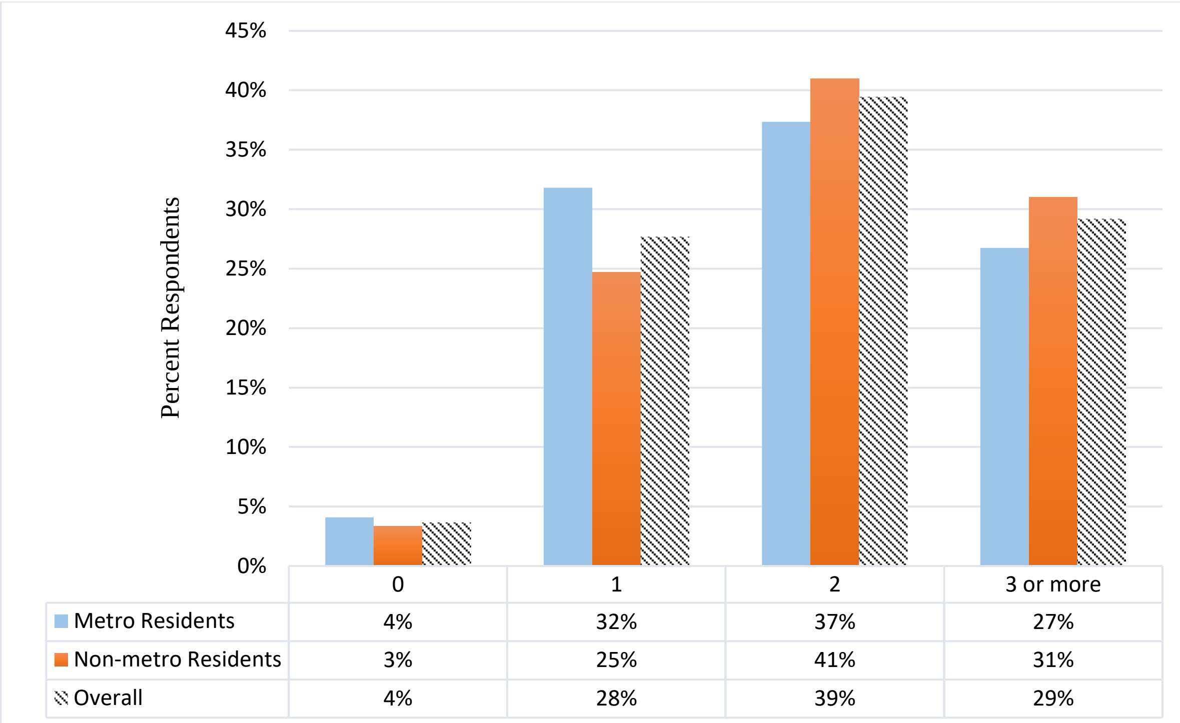


Figure 3.10 Percentage of Respondents by Number of Working Vehicles in their Households

The respondents were asked about their difficulty in walking or climbing stairs. For metro areas, 11.3% of the respondents mentioned that they have difficulty in walking or climbing stairs while for non-metro areas, the percentage was slightly higher i.e. 20% (overall sample size = 988). Similarly, the respondents were asked following question: “Do you use a wheelchair or other mobility assistive device to travel outside your residence”. Only 4.6% and 6.3% of the respondents from metro and non-metro areas, respectively, mentioned that they use a wheelchair or other mobility assistive device for outside travel. The overall sample size for wheelchair users is 986 with 571 observations for non-metro areas. Most of the respondents from both non-metro (68.6%) and metro (72.4%) areas stated that their overall quality of health is good in general (Table 3.14). The number of observations used for health are 417 and 574 in metro and non-metro areas, respectively.

Table 3.14. Respondents Quality of Health

Quality of Health	Metro Area	Non-Metro Area	Overall
Poor	2.9%	4.2%	3.6%
Fair	24.8%	27.2%	26.2%
Good	72.4%	68.6%	70.2%

CHAPTER 4. SEM AND EQUITY ANALYSIS METHODOLOGY

4.1. Study Basic Information

The proposed study framework in the first phase will investigate the impact of public transit and walkability on community QOL and individual's OLS in the US. In the second phase of the study, an equity evaluation will be conducted in the U.S. by considering non-work accessibility through public transit or walking as an equity indicator. The sections below explain the generalized methodologies to achieve proposed objectives.

4.2. Community QOL and OLS Impact Evaluation Conceptual Framework

This section of the study will comprehensively evaluate the impact of public transit and walkability on community QOL and individual's OLS in the US. Due to the complex nature of QOL and OLS estimation and a range of factors that can impact these important dimensions of life, SEM technique is used for analysis purpose in this study. The SEM will assess the direct and indirect impact of a range of factors related to public transit services, walkability, and other important contributors such as physical built environment, and social indicators on community QOL, and individual's OLS in the US.

4.2.1. Structural Equation Model (SEM)

SEM is a multivariate analysis technique that allows the modeling phenomenon in which relationships between observed indicators, and unobserved (latent) variables are established. Structural equation models comprise of two components. They are: 1) a measurement model that assess the relationship between latent variables and observed variables, and 2) a structural model or latent variable model that evaluates the strengths and direction of the relationship between latent exogenous and endogenous variables. The basic equation to describe the structural or latent variable model is as follows (Bollen, 1989):

$$\eta = B\eta + \Gamma\xi + \zeta \quad (1)$$

Where η (eta) is a m × 1 vector of latent endogenous variables, ξ (Xi) represents n × 1 vector of exogenous latent variables, ζ (zeta) is m ×1 vector of random variables, B (beta) represents m × m coefficient matrix for endogenous latent variables and Γ (gamma) is a m × n coefficient matrix for the exogenous latent variables.

The basic equations to describe the measurement model are as follows:

$$x = \Lambda_x\xi + \delta \quad (2)$$

$$y = \Lambda_y\eta + \varepsilon \quad (3)$$

Where x and y are the column q-vectors and column p-vectors related to the observed exogenous and observed endogenous variables, respectively; δ (delta) and ε (epsilon) are the errors related to observed exogenous and observed endogenous variables respectively; Λ_x (lambda) and Λ_y represents q × n and p × m structural coefficient matrices for the effects of the latent exogenous, and latent endogenous variables on the observed ones respectively.

SEM is basically a combination of factor analysis (measurement models) and path analysis or multiple regression (Hadiuzzman, Das, Hasnat, Hossain, & Musabbir, 2017). Path analysis in SEM is different from the regular regression models in a way that it comprises of multiple equations and the response variable in one equation can be an explanatory variable in another equation. Moreover, Maximum Likelihood (ML) method is usually used for SEM development. SEM is a covariance analysis while linear regression uses ordinary least squares technique (Cao, 2013). Along with most commonly used ML method, there are other methods that can also be used to estimate structural equation system, such as Weighted Least Squares (WLS), Generalized Least Squares (GLS) etc. The application of appropriate method depends upon the data characteristics, probability distribution assumptions, and complexity of SEM. The covariance analysis method is incorporated in all SEM methods, in which the difference between model implicit covariance and sample covariance is minimized by estimating the model parameters (Golob, 2003). SEM can also capture direct effects and total effects. Total effects comprise of direct and indirect effects measurement for example, if a variable X has an influence on variable Z without an intermediate variable, this is called direct effect from X to Z (X→Z); by contrast if variable X effects Z through Y (X→Y→Z), this phenomenon is called indirect effect of X to Z.

Figure 4.1 shows the conceptual SEM hypothesized for this study. The variables in the square box represents observed or manifest variables and the variables in circle represents latent variables. The latent variable is the one that is not directly measured in the study but can be formed from two or more observed/manifest variables using factor analysis. The three latent independent variables in this study (shown in circle) are physical built environment, quality of transportation, and support for transit funding. In the model, the final dependent variable is individual's OLS, which is observed endogenous variable. There is one mediating dependent variable i.e. community QOL and is also an observed endogenous variable.

The physical built environment latent factor is comprised of nine observed variables in the survey data and they are: available jobs, cultural institutions, quality health care, quality public schools, overall cost of living, shopping and entertainment options, parks and recreational facilities, public transit access to non-work amenities, and walk access to non-work amenities (see question numbers 6, 16, and 17 in Appendix A). The non-work amenities considered in this study

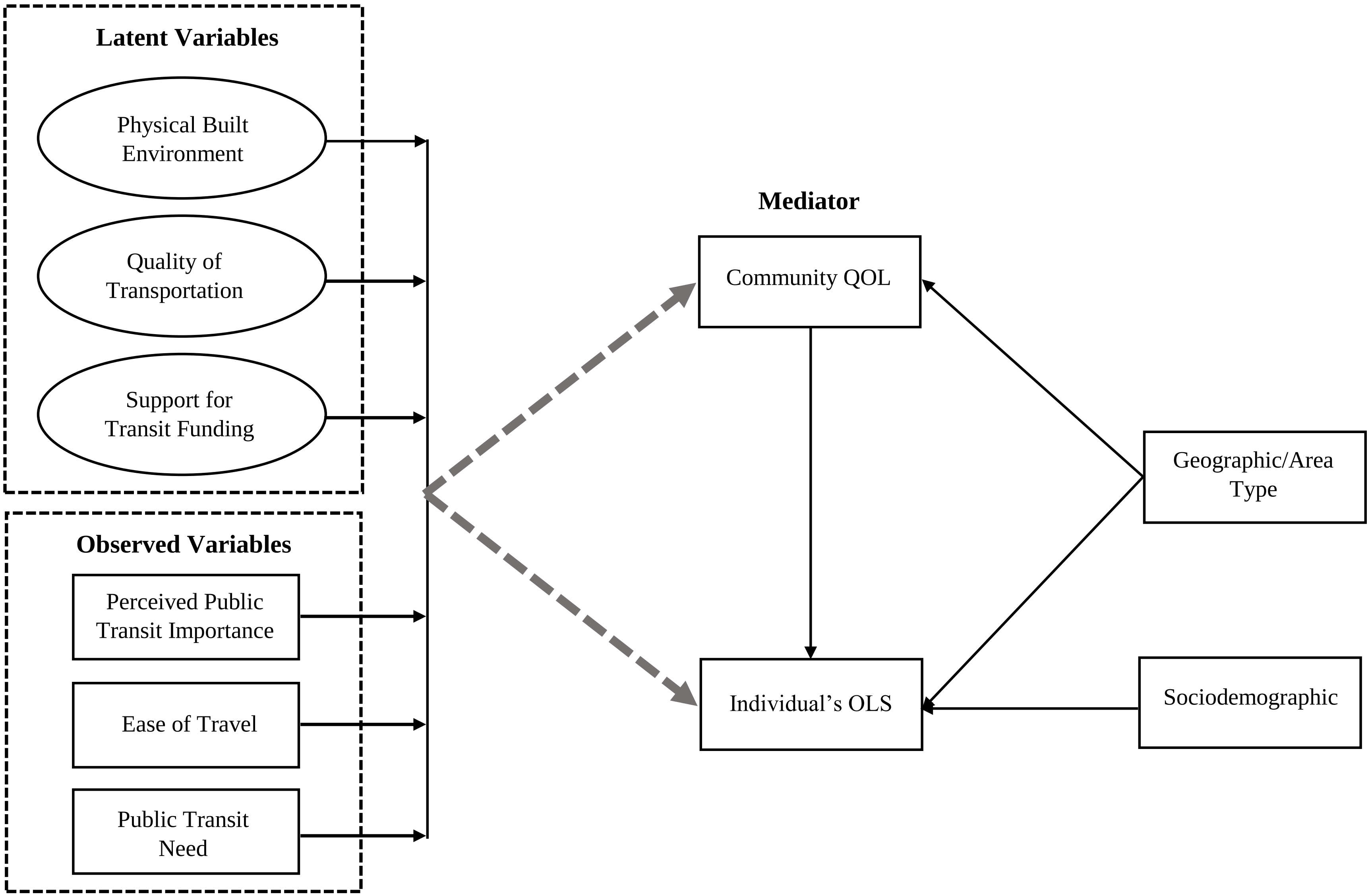


Figure 4.1. Hypothesized Conceptual SEM

are: 1) grocery store or supermarket (vegetables, fresh fruit, meat, bread), 2) personal services (bank, laundromat, hair/nail salon), 3) other retail shopping (pharmacy, clothes, household goods), 4) recreation and entertainment (parks, museums, movies, live theater), and 5) health care facility (hospital, doctor's office, urgent care). The public transit and walk access to these non-work amenities were measured on a scale of 0 (a person do not have access to any of the five non-work amenities mentioned) to 5 (person have access to all five amenities).

Latent factor 'quality of transportation' is formed from five observed variables. They are: quality of public transit services, bikeability, walkability, roads condition, and traffic safety (see question number 7 in Appendix A). The third and final latent factor 'support for transit funding' is made from four observed variables. The four observed variables were respondent's perception about supporting funding public transit systems from external sources at 1) city, 2) county, 3) state, and 4) federal levels (see question number 20 in Appendix A).

There are also three other observed exogenous variables identified for the proposed SEM, and they are ease of travel (mobility indicator), perceived public transit importance for a community, and public transit need/support for community (see question numbers 10, 18, and 21 respectively in Appendix A). The variable public transit need/support was measured on a scale of 1 to 3, where 1 represents respondent's support for less amount of public transit services than currently available, 2 represents support for same amount of public transit services currently available, and 3 represents the respondent's support for more amount of public transit services in their communities. The impact of these exogenous variables is evaluated directly on individual's life satisfaction and also indirectly through the mediating community QOL variable. Research has shown that type of area people living in has significant influence on QOL (Schneider, Guo, & Schroeder, 2013). This research will also evaluate the impact of area type (metro vs non-metro) on community QOL, and individual's OLS as shown in Figure 4.1. The other set of observed exogenous variables are sociodemographic variables also called controlled variables (Najaf, Thill, Zhang, & Fields, 2018). The sociodemographic variables included in this study are age, gender, employment, level of education, physical disability, health, income, and race.

Through development of this comprehensive SEM, the research will be able to evaluate the direct impact of physical built environment, quality of transportation, transit funding, ease of travel, public transit need for a community, and perceived public transit importance on OLS of an individual, and also indirectly through mediating community QOL endogenous variable. Public transit and walk access to non-work amenities are included in 'physical built environment' and will cover the accessibility to important life activities. The research will also evaluate the relationship between sociodemographic variables, and individual's OLS. The variables included in the analysis are described in detail with their descriptive statistics in chapter 3 of this dissertation.

4.3. Equity Evaluation Methodology

Transportation equity in general refers to fair distribution of costs and benefits across different socioeconomic groups (income, age, and race etc.,) associated to a transportation project. Equity indicators in transportation studies are usually selected on the basis of transportation priorities of the community, e.g., accessibility to employment, grocery stores, health care resources, traffic congestion, reduced travel time, and improved walkability (Bills, Sall, & Walker, 2012). All of these equity indicators in transportation system are important and should be evaluated by transportation planners based on their priorities and needs of the community. Accessibility in particular provides most comprehensive equity evaluation tool because it adequately provides information about people and location of important life amenities. Based on the past research evidence, Bereitschaft (2017) stated that there is a need to assess whether all sociodemographic groups have equal access to important life amenities because of the amount of benefits they provide (Bereitschaft, 2017).

This research effort will use Karel Martens' theory of transportation justice to evaluate equity and utilize logistic regression modeling technique to estimate odds of reaching non-work amenities among different sociodemographic groups. The methodology to evaluate equity in terms of people's ability to reach non-work amenities through public transit or walking is presented in this section.

4.3.1. Transportation Equity Categories

Equity in transportation has been categorized in three different types. They are: 1) horizontal equity 2) vertical equity with respect to income and social class and 3) vertical equity with respect to mobility need and ability (Litman, 2018b).

4.3.1.1. Horizontal Equity

The horizontal equity or also called egalitarianism and is based on the concept that distribution of transportation benefits and costs should be same between groups and individuals that are considered equal in need and ability. More specifically, in horizontal equity, the policy makers should not favor one group or individual over another.

4.3.1.2. Vertical Equity with Respect to Income and Social Class

Vertical equity with respect to income and social class is specifically related to transportation benefits and costs distribution among socially and economically disadvantaged people. By this definition of equity, transportation projects and policies are considered equitable if they support socially and economically disadvantaged groups of people in order to recompense for overall system inequities (Rawls, 1971). In other words, the transportation policies and projects are called regressive if they harm disadvantaged groups and progressive if they benefit such groups. While public transit services are used by people of all social/income classes, socially and economically disadvantaged people are generally more reliant on public transit services, and they are often referred as public transit dependent population.

4.3.1.3. Vertical Equity with Respect to Mobility Need and Ability

Vertical equity with respect to mobility need and ability is specifically related to distribution of transportation impacts between people that differ in mobility needs and ability; an example includes a person with physical disability, or someone who cannot drive. In this category, an equitable transportation system should support services and facilities that should be able to accommodate all users, particularly those with special needs.

Following the vertical equity concepts, past research recommended vertical equity for transportation sector where transportation benefits could be provided more favorably to disadvantaged groups of the community (Foth, Manaugh, & El-Geneidy, 2013) (Karner & Niemeier, 2013) (Martens, 2012) (Martens, Golub, & Robinson, 2012). This study will investigate the second and third type of equity categories i.e. vertical equity with respect to social class, income, mobility need, and physical ability in terms of people's ability to access non-work amenities through public transit and walking in the US.

4.3.2. Equity Evaluation Methods

In transportation sector, several different techniques have been used for equity analysis depending upon the scope of study, equity indicators, and kind of data available. The most common methods used for examining inequity that exists among different groups in terms of different transportation outcomes and attributes such as travel time, public transit fares, accessibility, quality of walking etc., are Gini coefficient, Lorenz curve, Atkinson index, Theil index and independent sample t-test (Martinelli & Medellin, 2007) (Aitken, Munoz, & Hurtubia, 2018) (Cheng, Gao, & Zhang, 2016) (Bereitschaft, 2017). Hamre (2017) used Karel Martens' theory of transportation justice to evaluate equity by considering employer-based public transit subsidies as performance measure (Hamre, 2017).

Martinelli & Medellin (2007) used independent-sample t-test, Gini coefficient, Atkinson index and Theil index to evaluate the bus public transit equity in terms of travel time per mile and fare per mile across socioeconomic groups for two metropolitan case study areas i.e. Columbus, OH, and Seattle, WA (Martinelli & Medellin, 2007). Bereitschaft (2017) used independent-sample t-test, binary logistic regression and mapping techniques to examine whether neighborhoods with high social vulnerability (SV) have the same high level of walkability available as of those with low SV (Bereitschaft, 2017). Similarly, Hamre (2017) applied logistic regression for social equity evaluation by considering employer-based public transit subsidies as performance measure (Hamre, 2017). This study will use Karel Martens' theory of transportation justice by employing logistic regression modeling technique to evaluate equity in terms of people's ability to access non-work amenities through public transit and walking.

4.3.3. Karel Martens' Theory of Transportation Justice: Application to Proposed Study

Martens criticized the traditional approach of equity analysis in transportation based on travel demand. Martens describes the traditional transportation justice approach as based on the concepts of equality embedded in the people's demand for travel. This traditional transportation justice evaluation approach leads transportation planners to focus on mobility-oriented transportation planning such as increase in speed and congestion reduction etc. Martens argues that this mobility enhanced transportation planning approach leads to worsening the existing inequalities in transportation system for low income people, people who cannot drive etc., and the approach will cause more hardships (Martens, 2006) (Martens & Hurvitz, 2011) (Martens, Golub, & Robinson, 2012) (Martens, 2017).

Martens proposed transportation justice method based on need to travel, accessibility, and people in contrast to traditional approach of transportation planning which takes into consideration factors such as mobility, travel demand, and system performance. More specifically, Martens' theory of transportation justice is primarily based on maximax criterion, which seeks to maximize the average transportation accessibility while restricting the accessibility gap between the best-off and the worst-off groups of society to the minimum (Martens, Golub, & Robinson, 2012) (Martens, 2012). Martens introduced four principles of justice applied to transportation planning. They are: 1) people experiencing insufficient accessibility in transportation system is unjust, 2) every individual is authorized to insure against insufficient accessibility risks, 3) insurance proceeds should be used to make accessibility sufficient for all people, and 4) the transportation improvement interventions are considered just if they do not decrease the accessibility levels for people who are already experiencing insufficient accessibility or decrease the number of individuals experiencing insufficient accessibility (Martens, 2017).

The equity analysis in this study is guided by Martensian theory of transportation justice which emphasize that underprivileged members of the society should be having sufficient access to different locations necessary for their daily activities. The equity analysis for this study will be performed based on access to non-work amenities through public transit and walking. The non-work amenities considered in this study are: 1) grocery store or supermarket, 2) personal services, 3) other retail shopping, (4) recreation and entertainment, and (5) health care facility.

4.3.4. Modeling Strategy for Equity Analysis

This study will use logistic regression technique to evaluate the equity in terms of access to non-work amenities through public transit or walking among different demographic/socioeconomic groups. The response/dependent variable in the proposed logistic regression models is people's ability to access respective non-work amenity through public transit or walking. The study will develop binary logistic regression models for equity evaluation because the considered response variable is dichotomous, i.e., 0 (cannot access respective non-work amenity through public transit or walk) and 1 (can access respective non-work amenity through public transit or walk). Demographic variables that include age, race, employment, area type (metro vs non-metro), number of vehicles in household, driving license, physical disability, individuals who are covered under Medicare/Medicaid program or not, and gender will be used as explanatory variables in each model.

The odd ratios will be established through development of each model in order to investigate the likelihood of access to respective non-work amenity by each demographic/socioeconomic groups. The odds of ability to access non-work amenities by socially disadvantaged groups compared to respective socially advantage groups will be determined. The socially disadvantaged groups considered in this study are older age people, minority population, unemployed and students, people living in non-metro area, people with no vehicle in their household, individuals with no driving license, physically disable people, individuals who are covered under Medicare/Medicaid program, and females. Past research suggest that women's daily travel patterns are different from men. Women are more likely to be traveling to non-work amenities than men, such as shops, childcare facilities, and health centers etc., due to their caretaking and household responsibilities. Women are also more reliant on public transit compared to men, especially those belonging to lower income families (UNECE, 2009) (Lecompte & Bocarejo S, 2017). The odds of ability of women to access non-work amenities compared to men will also be investigated in this study. The study considered people who are covered under Medicare/Medicaid program as disadvantaged because these people mostly belong to low income, physically disable, and older age people. McCahill and Ebeling (2015) considered rural populations under transportation specific disadvantaged group in their transportation equity framework (McCahill & Ebeling, 2015). The study will also compare access to respective non-work amenity across urban/metro and rural/non-metro areas. The generalized form of the logistic regression model incorporated in this study is given as:

$$\Pr(Y = 1) = \frac{e^{B_0+\beta_i X_i}}{1+e^{\beta_0+\beta_i X_i}} \tag{4}$$

Where,

$$Y = \begin{cases} 1, If\ people\ have\ access\ to\ respective\ non-work\ amenity \\ 0, Otherwise \end{cases} \tag{5}$$

Y is the binary response variable, β_0 is intercept to be calculated, β_i and X_i represent estimated vector of parameters, and vector of independent variables respectively. The maximum likelihood estimation technique is used in Equation (5) to estimate the parameters. The odds in logistic regression is calculated as:

$$Odds = \frac{Pr(Y=1)}{1-Pr(Y=1)} \tag{6}$$

CHAPTER 5. PUBLIC TRANSIT AND WALKABILITY IMPACT ON QOL RESULTS

SEM technique is used in this study to evaluate the impact of public transit and walkability along with other transportation, physical built environment and sociodemographic indicators on community QOL and OLS of an individual living in his or her community. The generalized methodology to develop SEM and conceptual model hypothesized for this study are presented in section 4.2 of this dissertation. Also, the data and variables used in the development of SEM were summarized in chapter 3 of this study. This chapter will present the statistical results of the SEM developed for this study.

5.1. SEM Fit Indices

The model fit indices refer to standard parameters that help recognize how best the developed model represents the observed data. Before describing the SEM results, it is important to discuss the fit indices for model finalized in this study. In SEM, the most important and commonly used fit indices are chi-square (χ^2 or CMIN), standardized root mean square residual (SRMR), root mean square error of approximation (RMSEA), and comparative fit index (CFI). These fit indices are considered ideal because they are easy to interpret, independent of sample size, and are accurate and flexible in evaluation of complexity of models (Marsh, Balla, & Mcdonald, 1988).

Hooper et al, (2008) distinguished the fit indices for SEM into three categories: 1) absolute, 2) parsimony, and 3) incremental (Hooper, Coughlan, & Mullen, 2008). Absolute fit indices determine how well the proposed model fit the sample data, and allow the model with the better fit indices to be chosen. The commonly used indices in this category are χ^2 test, the root mean square residual (RMR), and SRMR.

Parsimony fit indices are used to compare the complex models, because estimation process of such models depends upon the sample data. Even though, Hooper et al, (2008) included RMSEA in absolute index category, but the authors also favor to consider RMSEA as parsimony fit index as it will select the model with less number of parameters (Hooper, Coughlan, & Mullen, 2008). SAS 9.4 software had been used to develop SEM in this study. RMSEA fit index had been categorized under parsimony category in SEM developed by SAS software (O'Rourke & Hatcher, 2013). For reference to reader, the full model fit statistics developed using SAS 9.4 for this study are presented in Appendix D.

Incremental fit indices compare the chi-square value to a base line model instead of using raw chi-square value for rejecting the null hypothesis that all variables in the model are uncorrelated. The most commonly used fit indices in this category are the CFI, and the normed fit index (NFI).

Table 5.1 shows the fit indices for the SEM developed in this study. The χ^2 is an absolute measure of fit index indicating the extent to which the estimated model relates to the variances and covariances in the observed sample data. A χ^2 difference test is mostly used as a test measurement for invariance across groups. A significant value indicates a poor model fit. The χ^2 is more sensitive to sample size compared to SRMR, RMSEA, and CFI, and always turns out be significant for large sample sizes and hence reject the model fitness (Bentler & Bonett, 1980). As an alternative, researchers recommended to use χ^2 ratio which is measured by dividing χ^2 value by degrees of freedom (χ^2/df) and is less dependent upon sample size. The χ^2 ratios in the range of 2 to 5 are considered reasonable for model fitness (Hair, Anderson, Tatham, & Black, 1998). The chi-square ratio for the model developed in this study is 3.91 (shown in Table 5.1) which lies within the threshold range of adequate model fitness.

SRMR measures the standardized difference between observed and predicted correlations (Hooper, Coughlan, & Mullen, 2008). A model with SRMR value less than 0.08 is considered a good fit (Hu & Bentler, 2009). RMSEA measures the difference between degrees of freedom anticipated to occur in population. Acceptable values of RMSEA range between 0.05 and 0.08 (Medsker, Williams, & Holahan, 1994). For the SEM developed in this study, both SRMR, and RMSEA index values are within acceptable model fit index range (Table 5.1). The CFI index ranges from 0 to1 and value greater than 0.90 is considered good model fit (Medsker, Williams, & Holahan, 1994). The index value for CFI is little bit lower (0.88) than the threshold value of 0.90. These model fit indices (shown in Table 5.1) indicate that the SEM developed in this study has overall good model fit.

Table 5.1. SEM Fit Indices

Model Fit Indices	Index Type	Cut-off Value	Model Based Value
χ^2 – Ratio	Absolute	$2< \chi^2/df <5$	3.91
SRMR	Absolute	<0.08	0.062
RMSEA	Parsimony	<0.08	0.063
CFI	Incremental	>0.90	0.88

Df denote degree of freedom.

5.2. Measurement Model or Confirmatory Factor Analysis Results

Measurement model or confirmatory factor analysis (CFA) investigates the relationship between manifest/observed variables and latent factors. The purpose of CFA is to confirm the structural validity of the proposed latent factors that are hypothesized based on theoretical knowledge. Three latent factors were considered in this study and they are: 1) physical built environment, 2) quality of transportation, and 3) support for transit funding. After accounting for the missing values, the remaining sample size used for SEM was 742 out of 994 total observations in the survey (n=742). Table 5.2 shows the relationship between observed variables and latent factors participating in the CFA. The first and second columns of the table shows the latent factors, and observed variables, respectively. From third column to fifth column, different statistics of the relationships between these observed variables and latent factors are shown: the standardized regression weights (Std. R.W.), standard errors (S.E.), and the probability level (p-value).

Table 5.2. Measurement Model or CFA Results

Latent Variables	**Observed Variables**	**Std. R.W.**	**S.E.**	**p-value**
Physical Built Environment	Quality Health Care Services	0.68	0.023	<.0001
	Parks and Recreation Facilities	0.67	0.023	<.0001
	Quality Public Schools	0.53	0.029	<.0001
	Cultural Institutions	0.66	0.023	<.0001
	Shopping and Entertainment Options	0.76	0.019	<.0001
	Available Jobs	0.68	0.023	<.0001
	Overall Cost of Living	0.43	0.033	<.0001
	Public Transit Access	0.20	0.036	<.0001
	Walk Access	0.27	0.036	<.0001
Quality of Transportation	Quality of Public Transit Services	0.57	0.028	<.0001
	Quality of Bikeability	0.74	0.023	<.0001
	Quality of Walkability	0.72	0.023	<.0001
	Quality of Roads Conditions	0.46	0.033	<.0001
	Traffic Safety	0.45	0.033	<.0001
Support for Transit Funding	Support City Funds	0.89	0.011	<.0001
	Support County Funds	0.93	0.009	<.0001
	Support State Funds	0.84	0.014	<.0001
	Support Federal Funds	0.76	0.017	<.0001

Std. R.W. represents Standardized Regression Weights and S.E. represents Standard Error.

The structures of these latent factors are finalized through CFA process. The results from CFA revealed that all the manifest variables hypothesized for the proposed latent factors formation were statistically significant at 99% confidence level or significance level (p-value) less than 0.01.

Most of the standardized regression coefficients are reasonably high with a value greater than 0.5. The three latent factors validated through CFA are described below:

5.2.1. Physical Built Environment

Physical built environment latent factor is formed from nine observed variables (Table 5.2). Most of the observed variables have reasonably high standardized regression coefficient values with a value greater than 0.5, except for “overall cost of living” (0.43), “walk access to non-work amenities” (0.27), and “public transit access to non-work amenities” (0.20). The top three observed variables that best explains the physical built environment latent factor identified were “shopping and entertainment options” (0.76), “quality health care services” (0.68), and “available jobs” (0.68). Although “public transit access to non-work amenities”, and “walk access to non-work amenities” comparatively have minor effect on physical built environment, they are still statistically significant at less than 1% significance level (p-value <0.0001) and are also considered important indicators towards improving physical built environment.

5.2.2. Quality of Transportation

Quality of transportation latent factor is formed from five observed variables and these variables are listed in Table 5.2. The quality of transportation latent factor was best understood by “quality of bikeability” (0.74), “quality of walkability” (0.72) and “quality of public transit services” (0.57); while “quality of roads conditions” (0.46) and “traffic safety” (0.45) also have minor effects on this latent factor.

5.2.3. Support for Transit Funding

Support for transit funding latent factor comprised of four observed variables in which respondents were asked about their support for transit funding using city, county, state, and federal funds (Table 5.2). The CFA results revealed that all four sources of funding have a major effect on support for transit funding latent factor with standardized regression coefficients values greater than 0.75.

5.3. Structural Model Results – Direct Effects

The structural model component of the SEM investigates the direction and strengths of the relationships between latent exogenous and endogenous variables. In this study, the direct effects of latent exogenous variables (physical built environment, quality of transportation, and support for transit funding) on community QOL and individual's OLS have been evaluated. The study also investigates the direct effects of important observed exogenous variables (ease of travel, perceived transit importance, transit need/support, and area type) on both community QOL and individual's OLS. The variable area type in proposed SEM was measured on a scale of 1 to 5, where 1 represents more urban areas, and 5 refers to rural areas. The variable was measured based on RUCC from 1 to 9. Some of the values of the RUCC were combined to obtain adequate distribution of sample sizes for each value of area type variable scaled from 1 to 5. The RUCC value 1 represents value 1 on area type variable scale, RUCC values 2 and 3 refers to value 2 on area type variable scale, RUCC values 4, 5, and 6 represents 3 on area type variable scale, RUCC value 7 refers to 4 on area type, and RUCC values 8 and 9 represents value 5 on area type variable scale. The indirect effects of these latent and observed exogenous variables has also been estimated through mediating community QOL variable.

The model also takes into account the effects of respondent's sociodemographic characteristics on individual's OLS. The sociodemographic variables included in the proposed model are gender, age, income, employment, level of education, race, physical disability, and health. The impact of variable age on individual's OLS was measured on a scale of 1 to 4, where 1, 2, 3, and 4 represent 18 to 34 years, 35 to 54 years, 55 to 74 years, and 75 years or above age groups, respectively. Income was also measured on a scale of 1 to 4, where 1, 2, 3, and 4 represent income levels below $24,999, $25,000 to $49,999, $50,000 to $99,999, and $100,000 or above, respectively. The variable employment was measured on a scale of 1 to 3 with 1 indicating employed individuals, 2 represents retired, and 3 represents unemployed and students. The variable level of education was measured on a scale of 1 to 4, where 1 represents high school graduate, 2 represents associate's degree education, 3 represents bachelor's degree education, and 4 represents master's, or doctorate degree level education. Race was measured on a binary scale of 1 (white population), and 2 (non-white population). Physical disability was also measured on a binary scale of 1 (not physically disable individuals), and 2 (physically disable individuals). Another indictor i.e. health was measured on a scale of 1 to 3, where 1, 2, and 3 represent individual's health conditions as poor, fair, and good, respectively.

Table 5.3 shows the statistical results of the structural model developed for this study. The first column shows the dependent variables, i.e., community QOL and individual's OLS. The community QOL also serve as a mediator between final dependent variable called individual's OLS, and observed exogenous variables (both latent and observed). The second column shows the independent variables and it is clear from the table that community QOL serve as an independent variable (mediator) for individual's OLS final dependent variable. The third column of the table shows the strength, and direction of the effects of independent variables on respective dependent variables and are called standardized regression weights. The fourth column shows the standard error, while the fifth column shows the statistical significance of the relationship between corresponding independent and dependent variables in the form of probability level (p-value).

Physical built environment latent factor has the highest direct effect (Std. R.W. = 0.517) on community QOL and is also significant at less than 1% significance level (p-value < 0.0001),

Table 5.3. Direct Effects on Community QOL and Individual's OLS – Structural Model Results

Dependent Variables	**Independent Variables**	**Std. R.W.**	**S.E.**	**p-value**
Observed En. (Mediator)	**Latent Ex. Variables**			
Community QOL	Physical Built Environment	0.517	0.059	<.0001**
	Quality of Transportation	0.132	0.060	0.028*
	Support for Transit Funding	-0.038	0.045	0.407
	Observed Ex. Variables			
	Ease of Travel	0.085	0.033	0.011*
	Perceived Transit Importance	-0.097	0.040	0.015*
	Transit Need/Support	0.024	0.038	0.524
	Area Type	0.073	0.035	0.038*
Observed En. (Final)	**Observed En. (Mediator)**			
Individual's OLS	Community QOL	0.297	0.040	<.0001**
	Latent Ex. Variables			
	Physical Built Environment	0.055	0.077	0.476
	Quality of Transportation	-0.075	0.067	0.266
	Support for Transit Funding	0.118	0.047	0.011*
	Observed Ex. Variables			
	Ease of Travel	0.168	0.034	<.0001**
	Perceived Transit Importance	0.020	0.041	0.619
	Transit Need/Support	-0.125	0.039	0.001**
	Area Type	0.031	0.037	0.409
	Sociodemographic			
	Gender	-0.050	0.031	0.106
	Age	0.160	0.034	<.0001**
	Income	0.112	0.038	0.003**
	Employment	-0.017	0.035	0.632
	Level of Education	-0.094	0.036	0.009**
	Race/Ethnicity	-0.079	0.032	0.013*
	Disability	-0.044	0.034	0.195
	Health	0.252	0.034	<.0001**

En. denote Endogenous and Ex. denote Exogenous.

**, * denote significance at 1%, and 5% levels respectively.

while has insignificant direct effect on individual's OLS. Quality of transportation latent factor has moderate effect on community QOL (Std. R.W. = 0.132) and significant at 5% significance level (p-value = 0.028), while this latent factor also has insignificant direct effect on individual's OLS. The third latent factor i.e. "support for transit funding" has statistically insignificant effect on community QOL, while significant (p-value = 0.011), and moderate direct effect on individual's OLS (Std. R.W. = 0.118). These findings are intuitive as physical built environment and quality of transportation represents broad societal indicators and hence have significant direct impact on community QOL. The effects were also positive which indicates that providing better quality of transportation and improved physical built environment can enhance community QOL. Support for transit funding latent factor represents an individual's level perception about supporting public transit funding from external source (city, county, state, or federal) and has significant direct effect on individual's OLS dependent variable.

Ease of travel is the only observed exogenous variable that have significant direct effect on both community QOL, and individual's OLS. The effect is higher on individual's OLS (Std. R.W. = 0.168), while minor effect on community QOL (Std. R.W. = 0.085). The results are intuitive as improvement in ease of travel to places the community residents need to go will improve community QOL, and individual's OLS. Perceived public transit importance have a significant negative effect on community QOL. This means that residents in communities who perceived that public transit is more important for their community have low QOL. In other words, providing more efficient public transit services to these communities might improve their QOL. Public transit need/support have significant negative impact (Std. R.W. = -0.125) on individual's OLS while insignificant impact on community QOL. The negative impact of public transit need on individual's OLS can be interpreted in a way that people who supported more public transit services in their community might feel deficiency in existing public transit services in order to fulfil their daily travel needs and hence are experiencing lower OLS. Providing more and efficient public transit services in their communities might enhance their satisfaction with life.

The impact of people living in urban vs rural areas in the form of geographic variable (area type) on community QOL, and individual's OLS was also investigated. This variable has significant positive effect on community QOL. In other words, people living in more rural areas have better community QOL. The impact of community QOL on individual's OLS as mediating variable is also significant, and high (Std. R.W. = 0.297). Clearly, a better community QOL will also enhance OLS of individuals living in their respective communities.

The other set of variables included in the model were sociodemographic variables. The impact of these sociodemographic variables on individual's OLS was also investigated in the model. Age, income, and health have significant positive impact on individual's OLS. These findings indicate that older age people, people with higher income, and individuals with better health conditions are more satisfied with their life compared to their counterparts. Level of education, and race/ethnicity have significant negative impact on individual's OLS, which indicate that individuals with higher level of education, and non-white population have lower OLS. Figure 5.1 shows the graphical representation of the results shown in Table 5.3 for more clear understanding. The variables that have significant relationship are only shown in Figure 5.1. The values in the figure represents standardized regression weights with negative sign indicating negative effects of independent variables on respective dependent variable. The signs "*", and "**" denote significance levels at 5% and 1%, respectively.

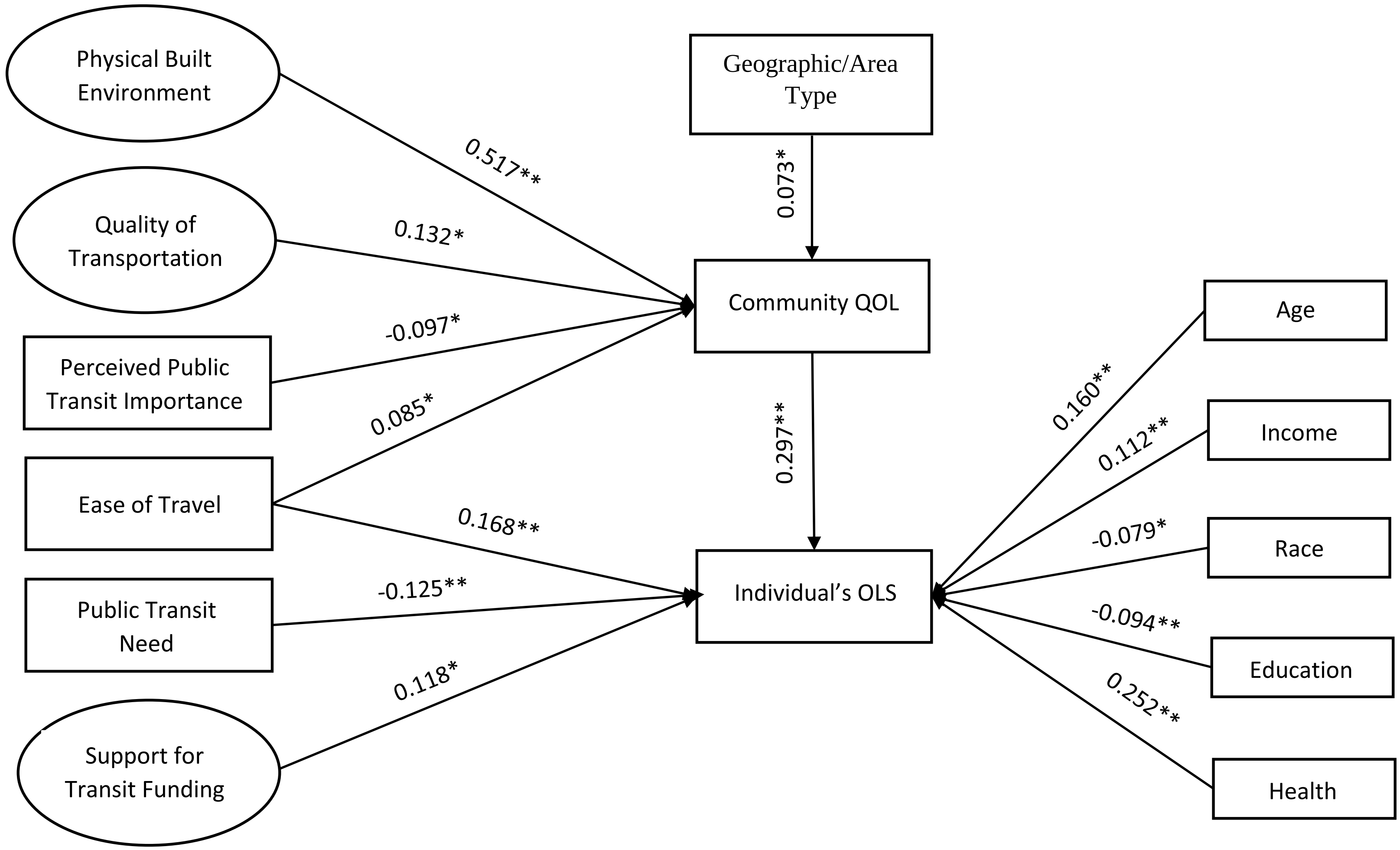


Figure 5.1. Calibrated SEM

"*", and "**" represent significance levels at 5%, and 1%, respectively.

5.4. Structural Model Results – Indirect, and Total Effects on Individual's OLS

As described in section 4.2.1 that SEM can measure both direct and indirect effects through mediating variable. The mediator for individual's OLS in this study is community QOL. There are three conditions that need to be satisfied for mediation to incorporate and they are: 1) the independent variable should be significantly related to mediating variable, 2) mediating variable should be significantly related to final dependent variable, and 3) the relationship of independent variable to final dependent variable should diminish after incorporating mediating variable (Baron & Kenny, 1986). Along with these three conditions, the mediating variable should theoretically make sense. All of these conditions were satisfied for the hypothesized mediating variable (community QOL). The statistical significance of the indirect effect was estimated by using the formula given by (Sobel, 1982).

$$Z = \frac{\propto \times \beta}{\sqrt{(\propto^2 \times SE_{\propto}^2 + \beta^2 \times SE_{\beta}^2)}} \quad (5.1)$$

Where "α", and "β" are the unstandardized regression weights and "SE" represents standard error related to respective regression weight. The unstandardized regression weights along with respective standard errors for the model developed in this study are given in Appendix D. The result of the equation 5.1 is interpreted as Z-score, where $Z>1.96$ represents significance at 5% level (p-value <0.05), and $Z>2.58$ is significant at 1% level (p-value <0.01). Moreover, if all the paths between independent variable, and final dependent variable are significant, the indirect effect is assumed to be statistically significant. The indirect effect is estimated by the product of "α", and "β" parameters ($\alpha\times\beta$) *(Preacher & Hayes, 2008)*. The total effect is the summation of the direct, and indirect effects.

Table 5.4 shows the direct, indirect, and total effects on individual's OLS. The first column shows the variables that were tested for indirect effects through mediating community QOL variable in the hypothesized model. All the indirect effects shown in table are statistically significant at less than 1% significance level (p-value <0.01). Physical built environment, and quality of transportation latent factors have moderate, and minor indirect effects on individual's OLS. These variables do not have direct significant effect on individual's OLS, so the total effect is the same as indirect effect. Support for transit funding latent factor does not have statistically significant indirect effect through community QOL mediating variable. Ease of travel observed variable has both direct, and indirect effects on individual's OLS with the highest total effect of 0.193. Perceived public transit importance, and area type have marginal indirect effects of -0.029, and 0.022 respectively. Public transit need does not have statistically significant indirect effect on individual's OLS. By considering total effects, ease of travel, physical built environment, and support for transit funding have high positive effects on individual's OLS. This indicate that by improving physical built environment, providing affordable and efficient travel options to enhance ease of travel in communities, and providing more funding to public transit services from external sources will improve individual's OLS. Public transit need/support for a community has high negative total effect on individual's OLS. This finding can be interpreted as people who perceived that their community need more public transit services are experiencing lower OLS at individual level. Providing more public transit services in their respective communities might improve their satisfaction with life.

Table 5.4. Direct, Indirect, and Total Effects on Individual's OLS through Mediating Community QOL Variable (α = .05)

Independent Variables	Direct Effect	Indirect Effect	Total Effect
Latent Exogenous Variables			
Physical Built Environment	---	0.154	0.154
Quality of Transportation	---	0.039	0.039
Transit Funding	0.118	---	0.118
Observed Exogenous Variables			
Ease of Travel	0.168	0.025	0.193
Perceived Public Transit Importance	---	-0.029	-0.029
Public Transit Need	-0.125	---	-0.125
Area Type (Metro vs Non-Metro)	---	0.022	0.022

5.5. Summary of Findings, and Implications

By using advance technique of SEM, this study evaluates the impact of public transit and walkability along with physical built environment, and sociodemographic characteristics on community QOL and individual’s OLS. The study results are based on an aggregate national level survey data and has important implications for policy makers and researchers. The policy makers and researchers at state and local level can use more disaggregate data sets for their analysis and may come up with different results. The results in this study indicate that improvement in physical built environment has the highest direct effect on enhancing community QOL. With-in physical built environment, observed indicators such as shopping and entertainment options, quality health care services, available jobs, and parks and recreation facilities were identified with highest effects on improving physical built environment. More emphasis should be given by policy makers to improve these attributes of physical built environment.

Quality of transportation latent factor also has high direct impact on community QOL. The top three indicators with highest effects on quality of transportation identified were quality of walkability, quality of bikeability, and quality of public transit services. The improvement in the quality of these three domains of transportations system will significantly improve the community QOL. The government, and transportation agencies should invest more on improving these three aspects of transportation. The third latent factor used in the analysis was support for transit funding. This latent factor does not have significant direct effect on community QOL but have significant direct effect on individual's OLS. The finding reveals that government at city, county, state, and federal level should provide needed funding to public transit agencies in order to provide optimal service for public transit users and hence improve their satisfaction with life.

Ease of travel was found with significant direct effect on both community QOL and individual's OLS. Providing efficient and more easily accessible travel options that can fulfill their daily travel needs in their community will improve the QOL of its residents at both community and individual level. Perceived public transit importance by community residents have negative direct effect on community QOL. This finding can be interpreted in a way that people who recognize public transit is more important for their daily life have lower community QOL. Most probably these include transit dependent population such as lower income people, people who cannot drive, and people with disabilities, and individuals without their own vehicle (Godavarthy & Mattson, 2016). Providing efficient public transit services might improve their QOL. Similarly, public transit need/support have direct negative effect on individual's OLS. This finding can also be attributed to transit dependent population who might be in need of public transit services in their communities in order to fulfil their daily travel needs. Providing more public transit services might improve their satisfaction with life.

People living in rural areas have better community QOL compared to people living in more urban areas but the effect estimated was marginal. The other set of the variables who's impact on individual’s OLS was evaluated were sociodemographic characteristics. Elderly people, people with higher income, and individuals with better health conditions are more satisfied with their life. Level of education and race/ethnicity have significant negative effects, which indicate that people with lower level of education and white population are more satisfied with their life. The association of higher level of education with lower life satisfaction might be due to their higher goals and aspirations of life that sometimes could be difficult to achieve.

CHAPTER 6. EQUITY ANALYSIS RESULTS

This chapter includes the equity analysis results in terms of public transit and walk access to non-work amenities as an equity indicator. The non-work amenities considered in this study are grocery stores, personal services, retail shopping, recreation and entertainment, and health care facility. Binary logistic regression models were developed separately for each non-work amenity category and odds ratios were estimated as a result for equity analysis purpose. The explanatory variables in the logistic regression models developed were age, race, employment, area type (metro vs non-metro), number of vehicles in household, driving license, physical disability, individuals who are covered under Medicare/Medicaid program or not, and gender.

The disadvantaged groups for whom the equity analysis was performed are older age people, non-white population, unemployed and students, people living in non-metro area, people with no vehicle in their household, individuals with no driving license, physically disabled people, individuals who are covered under Medicare/Medicaid program, and females. The odds of reaching the respective non-work amenity through public transit and walking for disadvantaged groups to other groups are compared for equity analysis. The data used for the equity analysis is summarized in chapter 3 of this dissertation. The generalized methodology to develop binary logistic regression models is presented in section 4.3.4 of this study.

6.1. Public Transit Access to Non-Work Amenities – Equity Analysis Results

This section includes the equity analysis results in terms of public transit access to non-work amenities in the US. For equity analysis purpose, separate binary logistic regression models were developed for assessing likelihood of public transit access to each non-work amenity considered in this study. The next subsections describe the logistic regression models goodness-of-fit, statistical significance of individual explanatory variables, and odds ratios estimates. For reference to the reader, full logistic regression results for likelihood of accessing five categories of non-work amenities through public transit are presented in Appendix F. The results of the logistic regression models in the following subsections are presented alongside each other for compactness.

6.1.1. Logistic Regression Results – Sample Sizes and Models Goodness-of-fit

Table 6.1 summarizes the sample sizes and measures of goodness-of-fit for the five individual binary logistic regression models developed which were used to measure likelihood of accessing respective non-work amenity using public transit. Sample sizes used to develop logistic regression models range between 849 and 853, which were adequate for models development. SAS 9.4 software was used to develop logistic regression models parameters. The software uses Schwarz criterion (SC), and Akaike information criterion (AIC) to test the model goodness-of-fit. In both AIC and SC methods, smaller values of criterion statistic indicate a better model fit. Fitting was done to generate parsimonious and robust models for each non-work amenity category (Table 6.1).

Table 6.1. Sample Size and Models Fit Indices for Public Transit Access to Non-Work Amenities

Non-work Amenity	Sample Size	AIC (Intercept Only)	AIC (Intercept and Covariates)	SC (Intercept Only)	SC (Intercept and Covariates)
Grocery Stores	853	1110.754	1080.919	1115.503	1152.150
Personal Services	851	1077.321	1051.322	1082.067	1122.519
Retail Shopping	851	1101.646	1062.515	1106.392	1133.712
Recreation/Entertainment	849	1016.813	972.643	1021.557	1043.804
Health Care Facility	851	1106.592	1080.842	1111.339	1152.038

Note: AIC is used to compare the models with same sample size. The model with the smallest value is selected. Similar to AIC, SC penalizes the model for the number of predictors, and smallest SC value is desirable for the model selection. Both AIC, and SC values in themselves are not meaningful. The columns with AIC, and SC values with “Intercept Only” term refers to the corresponding criterion statistics with no explanatory parameters in the model. AIC, and SC criterion statistics with the term “Intercepts and Covariates” corresponds to the fitted model with all explanatory variables and the intercept.

6.1.2. Logistic Regression Results – Statistical Significance of Explanatory Variables

Table 6.2 shows the results of binary logistic regression models developed for each non-work amenity category. The table shows the statistical significance of the association between explanatory variables and respective dependent variable (access to five types of non-work amenities) in the form of p-values.[1] The results shown in the table indicate that age significantly improve the model fit for likelihood of public transit access to grocery store, retail shopping, and recreation and entertainment amenities at less than 5% significance level, while for personal services, and health care facility at significance levels of 10% and 1%, respectively.

Table 6.2. Individual Variables Significance – Public Transit Access to Non-Work Amenities

Explanatory Variables	**Grocery Stores**	**Personal Services**	**Retail Shopping**	**Recreation and Entertainment**	**Health Care Facility**
Age	0.0215**	0.0776*	0.0451**	0.0170**	0.0079***
Race	0.1596	0.2376	0.2250	0.2432	0.2584
Employment	0.1847	0.3701	0.3551	0.2162	0.3228
Area	<.0001***	<.0001***	<.0001***	<.0001***	<.0001***
Household Vehicles	0.0004***	0.0013***	<.0001***	0.0012***	0.0019***
Driving License	0.0873*	0.0837*	0.0580*	0.1454	0.1151
Physical Disability	0.3138	0.7050	0.8471	0.9961	0.4647
Medicare/Medicaid	0.2550	0.3419	0.3149	0.0899*	0.6162
Gender	0.1632	0.6577	0.5665	0.2920	0.9974

*, **, *** represents significance at 10%, 5%, and 1% levels, respectively.

Area (metro vs non-metro) explanatory variable significantly improve the model fit for all five non-work amenities considered in this study at less than 1% significance level. The explanatory variable "number of vehicles in household" significantly improve the models fit

[1] In SAS 9.4 logistic regression output results, there is a section called "Type 3 Analysis of Effects" which identify the significance of individual explanatory variables in terms of chi-square t-statistics, and p-values.

developed for all five amenities considered at less than 1% significance level. A person with or without driving license also have a significant association with likelihood of public transit access to grocery stores, personal services, and retail shopping amenities. The explanatory variable Medicare/Medicaid significantly improve the model for likelihood of public transit access to only recreation and entertainment amenity at less than 10% significance level. The remaining variables that include race/ethnicity, employment, physical disability, and gender did not contribute significantly to improve the models fitness for all the non-work amenities considered in this study.

6.1.3. Logistic Regression Results – Odds Ratios Estimates

Table 6.3 shows the odds ratios, and respective p-values for people's ability to access grocery stores, personal services, and retail shopping through public transit. The results of these three non-work amenities are presented together as they are related to some form of daily shopping or personal needs. Table 6.4 shows the odds ratios and p-values estimates for public transit access to recreation and entertainment and health care facility non-work amenities. The odds ratios and p-values presented in this section are similar to estimates presented in full logistic regression models results in Appendix F.[2] The first column in Table 6.3 and Table 6.4 shows the explanatory variables considered for equity analysis. The variables in bold represent reference group or disadvantage group. The p-value indicate the statistical significance of the estimated odds ratios. The odds ratio estimates that significantly differ from the reference group are described in the following subsections. The threshold p-value for significance level is set to 0.10 or significance at 10% level. In the subsequent subsections, the equity results in the form of odds ratios will be described separately for each non-work amenity considered in this study.

[2] The full logistic regression results for public transit access to grocery store, personal services, retail shopping, recreation and entertainment, and health care facilities are presented on page number 145, 146, 147, 148, and 149 respectively.

6.1.3.1. Public Transit Access to Grocery Stores

Table 6.3 shows the odds ratios along with relevant p-values estimates for public transit access to grocery stores. The odds of reaching grocery store through public transit was significantly higher (3.241, p-value = 0.0083) for younger age group (18 to 34 years) compared to older age people in the reference group (75 years or above). Even though, the other two age groups (35 to 54 years), and (55 to 74 years) also have higher odds of access to grocery stores compared to older age group (75 years or above), their relationship however was insignificant. The odds of accessing the grocery stores using public transit was significantly lower (0.790, p-value = 0.0719) for full time employed compared to unemployed and students.

The other significant variable was area type (metro vs non-metro) with p-value less than 0.01. The result indicates that the odds of getting access to grocery stores using public transit is 1.918 times higher in metro areas compared to non-metro areas. The people who owns two or more vehicles in their households have significantly lower odds (0.210, p-value = 0.0002) of reaching grocery stores by using public transit compared to people with no vehicle in their household. This could be because people without a car may tend to live near public transit route, and so they could access transit easily. The individuals having driving license have significantly higher odds (2.214, p-value = 0.0873) of reaching grocery stores via public transit compared to individuals with no driving license.

6.1.3.2. Public Transit Access to Personal Services

Table 6.3 shows the odds ratios estimate for public transit access to personal services. The personal services here include bank, hair/nail salon, and laundromat. The odds of accessing personal services through public transit was significantly higher (2.698, p-value = 0.0520) for younger age people (18 to 34 years) compared to older age (75 years or above). The odds of having

Table 6.3. Odds Ratios Estimates - Public Transit Access to Grocery Stores, Personal Services, and Retail Shopping

Explanatory Variables	Grocery Stores		Personal Services		Retail Shopping	
	O.R	p-value	O.R	p-value	O.R	p-value
Age Group (75 Years or Above)						
Age Group (18 to 34 Years)	3.241	0.0083***	2.698	0.0520*	2.828	0.0140**
Age Group (35 to 54 Years)	2.184	0.2573	2.164	0.1952	1.910	0.3557
Age Group (55 to 74 Years)	1.568	0.2131	1.630	0.5489	1.367	0.1288
Race (Non-White)						
Race (White)	0.734	0.1596	0.768	0.2376	0.763	0.2250
Unemployed and Students						
Employed Full Time	0.790	0.0719*	0.722	0.0943*	0.783	0.1301
Employed Part Time	1.124	0.6227	0.980	0.7734	1.003	0.9303
Retired	1.323	0.1305	1.088	0.3531	1.221	0.1931
Area (Non-Metro)						
Area (Metro)	1.918	<.0001***	2.056	<.0001***	2.199	<.0001***
No Household Vehicle						
1 Household Vehicles	0.351	0.3287	0.591	0.9354	0.308	0.2827
2 or more Household Vehicles	0.210	0.0002***	0.334	0.0023***	0.172	<.0001***
No Driving License						
Have Driving License	2.214	0.0873*	2.272	0.0837*	2.499	0.0580*
Physically Disable						
No Physical Disability	0.794	0.3138	0.915	0.7050	1.047	0.8471
Medicare/Medicaid (Covered)						
Medicare/Medicaid (Not Covered)	1.280	0.2550	1.233	0.3419	1.247	0.3149
Gender (Female)						
Gender (Male)	1.240	0.1632	1.072	0.6577	1.093	0.5665

O.R denote odds ratio.

*, **, *** represents significance at 10%, 5%, and 1% levels, respectively.

access to personal services by public transit was significantly lower (0.722, p-value = 0.0943) for individuals with full employment status compared to unemployed and students in the reference group.

The people living in metro areas have significantly higher odds (2.056, p-value <.0001) of reaching personal services through public transit compared to non-metro area residents. The individuals living in households with two or more vehicles have significantly much lower odds (0.334, p-value = 0.0023) of having access to personal services using public transit compared to individuals with no private vehicle in their households. The variable "Driving License" was also significant at 10% significance level (p-value = 0.0837). The result indicates that people with driving license have 2.272 times higher odds of accessing personal services using public transit compared to their counterparts with no driving license.

6.1.3.3. Public Transit Access to Retail Shopping

The equity results for public transit access to retail shopping were similar in pattern to the results for personal services non-work amenity (Table 6.3). The retail shopping options in this study comprise of clothes, pharmacy, and household goods. The odds of having access to retail shopping by using public transit is 2.828 times higher for younger people (18 to 34 years) than older age group (75 years or above) in the reference group and significant at less than 5% level (p-value = 0.0140).

The people living in metro areas have 2.199 times higher odds of reaching retail shopping through public transit than non-metro areas residents and at less than 1% significance level (p-value <0.0001). Similar to the logistic regression output result for personal services amenity, the odds of having access to retail shopping via public transit was significantly far lower (0.172, p-value <0.0001) for people who live in households with two or more vehicles compared to individuals who do not have any private vehicle in their households. The variable "driving license" was significant at less than 10% level (p-value = 0.0580). The odds of having access to retail shopping by using public transit was 2.499 times higher for individuals who have driving license than their counterparts with no driving license.

6.1.3.4. Public Transit Access to Recreation and Entertainment

Table 6.4 shows the odds ratios estimate along with relevant p-values for public transit access to recreation and entertainment. The recreation and entertainment facilities here include parks, museums, movies, and live theatre. Based on the logistic regression model results, the odds of accessing recreation and entertainment facilities was 3.744 times higher for younger people (18 to 34 years) than older age people (75 years or above) and this difference was statistically significant at less than 5% significance level (p-value = 0.0104). For explanatory variable "Employment" the difference of odds ratios between observed group and reference group was significant (p-value = 0.0554) for retired group unlike public transit access to other non-work amenities. For other non-work amenities considered, this difference was significant for individuals who were full time employed only. This finding is not surprising as mostly retired people have enough free time and retirement benefits to go for recreation and entertainment activities and the relationship hence is significant. The odds of having access to recreation and entertainment facilities using public transit was 1.773 times higher for retired people compared to unemployed and students.

Similar to other non-work amenity categories, the odds of having public transit access to recreation and entertainment facilities was significantly higher (2.475, p-value <0.0001) for metro area residents than people living in non-metro areas. The individuals with having two or more vehicles in their households have significantly lower odds (0.364, p-value = 0.0042) of public transit access to recreation and entertainment facilities compared to people having no vehicle in their households. The variable "Medicare/Medicaid" have significant association only in logistic regression model developed for public transit access to recreation and entertainment non-work amenity. The individuals who are covered under this Medicare/Medicaid program are mostly older age people, individuals with disabilities, and low income people. People who are not covered under Medicare/Medicaid program have 1.484 times higher odds of access to recreation and entertainment facilities through public transit compared to the individuals who are covered under this program.

6.1.3.5. Public Transit Access to Health Care Facility

The odds ratios and p-values estimates for public transit access to health care facility are also presented in Table 6.4. The health care facility here includes doctor’s office, hospital, and urgent care. Similar to other non-work amenities odds ratios estimates, the odds of having access to health care facility through public transit was significantly higher (3.829, p-value = 0.0053) for younger age group individuals (18 to 34 years) compared to older age people (75 years or above). The odds of accessing health care facility using public transit by full time employed was significantly lower (0.723, p-value = 0.0904) than the unemployed and students.

Similar to other four categories of non-work amenities, the variable “area type” have significant association with public transit access to health care facility at less than 1% significance level (p-value <0.0001). The people living in metro area have 1.896 times higher odds of accessing health care facility using public transit compared to people living in non-metro area. Individuals with having two or more vehicles in their households have significantly lower odds (0.234, p-value = 0.0007) of access to health care facility via public transit compared to individuals having no vehicle in their households.

Table 6.4. Odds Ratios Estimates - Public Transit Access to Recreation and Entertainment, and Health Care Facility

Explanatory Variables	**Recreation and Entertainment**		**Health Care Facility**	
	O.R	**p-value**	**O.R**	**p-value**
Age Group (75 Years or Above)				
Age Group (18 to 34 Years)	3.744	0.0104**	3.829	0.0053***
Age Group (35 to 54 Years)	2.672	0.1443	2.538	0.2219
Age Group (55 to 74 Years)	1.904	0.4801	1.966	0.6143
Race (Non-White)				
Race (White)	0.762	0.2432	0.780	0.2584
Unemployed and Students				
Employed Full Time	1.094	0.3499	0.723	0.0904*
Employed Part Time	1.355	0.7140	0.940	0.9810
Retired	1.773	0.0558*	1.130	0.2325
Area (Non-Metro)				
Area (Metro)	2.475	<.0001***	1.896	<.0001***
No Household Vehicle				
1 Household Vehicles	0.681	0.6644	0.361	0.2834
2 or more Household Vehicles	0.364	0.0042***	0.234	0.0007***
No Driving License				
Have Driving License	2.103	0.1454	2.077	0.1151
Physically Disable				
No Physical Disability	1.001	0.9961	0.845	0.4647
Medicare/Medicaid (Covered)				
Medicare/Medicaid (Not Covered)	1.484	0.0899*	1.114	0.6162
Gender (Female)				
Gender (Male)	1.190	0.2920	1.001	0.9974

O.R denote odds ratio.

*, **, *** represents significance at 10%, 5%, and 1% levels, respectively.

6.2. Walk Access to Non-Work Amenities – Equity Analysis Results

This section comprises equity analysis results in terms of walk access to non-work amenities in the US. For equity analysis purpose, separate logistic regression models were developed in order to evaluate likelihood of walk access to five different non-work amenities considered in this study. The full results of the logistic regression models developed for evaluating likelihood of accessing non-work amenities using walk mode are given in Appendix G. As described before, the results of the logistic regression models are presented here alongside each other for compactness and easy to comprehend.

6.2.1. Logistic Regression Results – Sample Sizes and Models Goodness of Fit

Table 6.5 shows the sample sizes and models fit statistics for the five binary logistic regression models developed to assess the likelihood of accessing respective non-work amenity through walk. The sample sizes used were higher than models developed for evaluating likelihood of accessing non-work amenities using public transit. The sample sizes range between 947 and 950, which were good enough for models development. As mentioned in section 6.1.1, SAS 9.4 software was used to develop the logistic regression models. The software uses AIC, and SC criterion statistics for overall model fitness with smallest values representing best model fit. Fitting was done to develop robust and parsimonious models for walk access to respective non-work amenities considered (Table 6.5).

Table 6.5. Sample Size and Models Fit Indices for Walk Access to Non-Work Amenities

Non-work Amenity	Sample Size	AIC (Intercept Only)	AIC (Intercept and Covariates)	SC (Intercept Only)	SC (Intercept and Covariates)
Grocery Stores	950	1308.434	1255.139	1313.290	1327.986
Personal Services	949	1292.818	1254.500	1297.674	1327.331
Retail Shopping	947	1218.782	1183.968	1223.635	1256.768
Recreation/Entertainment	947	1230.172	1192.442	1235.025	1265.242
Health Care Facility	948	1142.028	1127.691	1146.882	1200.506

6.2.2. Logistic Regression Results – Statistical Significance of Explanatory Variables

Table 6.6 shows the logistic regression results for the models developed in order to evaluate the likelihood of accessing each non-work amenity considered in this study using walk mode. The table shows the statistical significance of the association between explanatory variables and corresponding dependent variable (access to corresponding non-work amenity through walk). The values shown in the table are the output p-values for each of the logistic regression model developed.[3] The threshold value for significant association of given explanatory variable to corresponding dependent variable is set at 10% significance level (p-value <= 0.10). The results in the table below indicate that "age" significantly improve the models fit for likelihood of walk access to all five non-work amenities considered in this study. "Race" significantly improves the models fit for likelihood of accessing grocery stores and retail shopping non-work amenities. The explanatory variable "employment" has significant association in the models developed for likelihood of accessing three non-work amenities through walk which include grocery stores, personal services, and retail shopping.

Table 6.6. Individual Variables Significance – Walk Access to Non-Work Amenities

Explanatory Variables	**Grocery Stores**	**Personal Services**	**Retail Shopping**	**Recreation and Entertainment**	**Health Care Facility**
Age	0.0686*	0.0170**	0.0235**	0.0414**	0.0899*
Race	0.0160**	0.3598	0.0385**	0.4502	0.2425
Employment	0.0223**	0.0020***	0.0206**	0.2330	0.1667
Area	<.0001***	0.0009***	0.0002***	0.0956*	0.9033
Household Vehicles	0.0006***	<.0001***	0.0105**	0.1503	0.0036***
Driving License	0.1046	0.0669*	0.1157	0.3289	0.1769
Physical Disability	0.0009***	0.0408**	0.0267**	0.0001***	0.0010***
Medicare/Medicaid	0.4620	0.2089	0.1973	0.8658	0.3493
Gender	0.9467	0.1612	0.0816*	0.1253	0.3993

[3] In SAS 9.4 logistic regression output results, there is a section called "Type 3 Analysis of Effects" which identify the significance of individual explanatory variables in terms of chi-square t-statistics, and p-values.

The variable "area" significantly improves the models fit for all non-work amenities considered except health care facility. Number of vehicles in household have significant association with likelihood of accessing four non-work amenities considered in this study with the exception of recreation and entertainment. The explanatory variable "driving license" significantly improve the model fit for likelihood of accessing only personal services non-work amenity at less than 10% significance level (p-value = 0.0991). Unlike public transit access to non-work amenities, the "physical disability" significantly improve the models fit for likelihood of accessing all five non-work amenities through walk. The variable "gender" has significant association with likelihood of accessing only retail shopping non-work amenity using walk mode. "Medicare/Medicaid" explanatory variable does not have significant association in any of the five models developed.

6.2.3. Logistic Regression Results – Odds Ratios Estimates

Table 6.7 shows the odds ratios along with their respective p-values estimates for likelihood of accessing grocery stores, personal services, and retail shopping through walk. Table 6.8 shows the odds ratios and respective p-values estimates for walk access to recreation and entertainment and health care facility non-work amenities. The full results of the logistic regression models developed for assessing likelihood of reaching non-work amenities using walk mode are presented in Appendix G.[4] Again, the odds ratios and p-values estimates presented in this section are same as given in Appendix G. The threshold value for statistical significance of the odds ratios estimates is set at 10% significance level (p-value <= 0.10). The explanatory variables in bold represent reference group or disadvantaged group considered in this study. The equity results in

[4] The full logistic regression results for walk access to grocery store, personal services, retail shopping, recreation and entertainment, and health care facility are presented on page number 150, 151, 152, 153, and 154 respectively.

terms of odds ratios estimates for walk access to each non-work amenity will be discussed in the following subsections.

6.2.3.1. Walk Access to Grocery Stores

Table 6.7 shows the odds ratios along with respective p-values estimates for walk access to grocery stores. The odds of accessing grocery stores through walking for younger age group (18 to 34 years) was significantly higher (2.412, p-value = 0.0518) compared to older age people in the reference group (75 years or above). White people have significantly lower odds (0.599, p-value = 0.0160) of having access to grocery stores using walk mode compared to non-white population. For employment explanatory variable, the odds of having access to grocery stores by walking for part time employed individuals was significantly higher (2.541, p-value = 0.0050) than the unemployed and students in the reference group.

People living in metro areas have 1.727 times higher odds of access to grocery stores via walk mode than their counterparts living in non-metro areas. Individuals with having two or more vehicles in their households have significantly lower odds (0.365, p-value = 0.0024) of access to grocery stores through walk compared to people with no vehicle in their households. The odds ratio estimated for physical disability explanatory variable significantly differ between people who are physically disable and individuals with no physical disability at less than 1% significance level (p-value = 0.0009). The odds of having access to grocery stores by walk for people with no physical disability was 2.069 times higher than the individuals having physical disability.

6.2.3.2. Walk Access to Personal Services

Table 6.7 also include the odds ratios along with respective p-values estimates for walk access to personal services. For this non-work amenity, the odds of having access through walk was significantly higher (2.584, p-value = 0.0197) for middle age group (35 to 54 years) compared to older age people (75 years or above) in the reference group. For walk access to personal services non-work amenity, the odds ratios estimated significantly differ for full time and part time employment levels considered in this study.

Table 6.7. Odds Ratios Estimates – Walk Access to Grocery Store, Personal Services, and Retail Shopping

Explanatory Variables	**Grocery Stores**		**Personal Services**		**Retail Shopping**	
	O.R	**p-value**	**O.R**	**p-value**	**O.R**	**p-value**
Age Group (75 Years or Above)						
Age Group (18 to 34 Years)	2.412	0.0518*	2.456	0.1452	2.204	0.2862
Age Group (35 to 54 Years)	1.990	0.1745	2.584	0.0197**	2.625	0.0092***
Age Group (55 to 74 Years)	1.472	0.3600	1.780	0.7919	1.689	0.6944
Race (Non-White)						
Race (White)	0.599	0.0160**	0.825	0.3598	0.644	0.0385**
Unemployed and Students						
Employed Full Time	1.940	0.3410	2.961	0.0852*	2.512	0.1429
Employed Part Time	2.541	0.0050***	3.349	0.0113**	2.842	0.0243**
Retired	1.676	0.9378	2.883	0.1318	2.330	0.3521
Area (Non-Metro)						
Area (Metro)	1.727	<.0001***	1.588	0.0009***	1.715	0.0002***
No Household Vehicle						
1 Household Vehicles	0.655	0.7542	0.556	0.9279	0.480	0.5092
2 or more Household Vehicles	0.365	0.0024***	0.295	0.0004***	0.326	0.0048***
No Driving License						
Have Driving License	2.106	0.1046	2.335	0.0669*	2.141	0.1157
Physically Disable						
No Physical Disability	2.069	0.0009***	1.554	0.0408**	1.670	0.0267**
Medicare/Medicaid (Covered)						
Medicare/Medicaid (Not Covered)	0.863	0.4620	0.776	0.2089	0.763	0.1973
Gender (Female)						
Gender (Male)	0.991	0.9467	1.219	0.1612	1.291	0.0816*

O.R denote odds ratio.

*, **, *** represent significance at 10%, 5%, and 1% levels, respectively.

The odds of having access to personal services using walk mode were 2.961 and 3.349 times higher for full time employed and part time employed individuals respectively compared to people who were unemployed and students in the reference group. People living in metro areas have significantly higher odds (1.588, p-value = 0.0009) of reaching personal services via walk than their counterparts who live in non-metro areas. People with two or more vehicles in their households have significantly far lower odds (0.295, p-value = 0.0004) of having access to personal services through walk compared to individuals with having no vehicle in their household. The other explanatory variable for which the odds significantly differ between observed and reference group was "driving license" at less than 10% significance level (p-value = 0.0669). Individuals with driving license have 2.335 times higher odds of accessing personal services by walk compared to their counterparts with no driving license. Similarly, the individuals with no physical disability have significantly higher odds (1.554, p-value = 0.0408) of access to personal services by walking than those who are physically disabled.

6.2.3.3. Walk Access to Retail Shopping

The odds ratios and p-values estimated as a result of developing logistic regression model to evaluate likelihood of walk access to retail shopping are also presented in Table 6.7. The people in the middle age group (35 to 54 years) have significantly higher odds (2.625, p-value = 0.0092) of access to retail shopping compared to older age people (75 years or above) in the reference group. The individuals with white race have significantly lower odds (0.644, p-value = 0.0385) of having access to retail shopping by walk mode compared to non-white population. The part time employed people have 2.842 times higher odds of reaching retail shopping locations than the unemployed and students at less than 5% significance level (p-value = 0.0243).

Similar to other non-work amenities, the odds of having access to retail shopping via walk mode was significantly higher (1.715, p-value = 0.0002) for metro area residents than the people living in non-metro areas. People with two or more vehicles in their household were having 0.326 times lower odds of access to retail shopping compared to those with no vehicle in their households at less than 1% significance level (p-value = 0.0048). Consistent with walk access to other non-work amenities, people who were not physically disable have significantly higher odds (1.670, p-value = 0.0267) of reaching retail shopping locations than physically disable individuals. In all of the logistic regression models developed, the odds ratio estimated for explanatory variable "gender" only significantly differ between male and female for retail shopping amenity. Males have 1.291 times higher odds of having access to retail shopping through walk compared to their counterpart females at less than 10% significance level (p-value = 0.0816). This finding was interesting as in general women need more access to retail shopping locations due to higher domestic responsibilities.

6.2.3.4. Walk Access to Recreation and Entertainment

Table 6.8 shows the odds ratios and corresponding p-values estimates as a result of logistic regression model developed to assess likelihood of walk access to recreation and entertainment facilities. The odds of having walk access to recreation and entertainment facilities was significantly higher (2.522, p-value = 0.0164) for middle age group people (35 to 54 years) compared to older age people in the reference group (75 years or above). The people who are retired have significantly lower odds (0.767, p-value = 0.0693) of access to recreation and entertainment using walk mode than the unemployed and students in the reference group.

People living in metro areas have 1.270 times higher odds of access to recreation and entertainment facilities by walk than their counterparts living in non-metro areas at less than 10%

significance level (p-value = 0.0956). The explanatory variable “physical disability” was significant at less than 1% significance level (p-value = 0.0001). The people who were not physically disable have 2.577 times higher odds of access to recreation and entertainment facilities compared the individuals having physical disability.

6.2.3.5. Walk Access to Health Care Facility

The odds ratios along with respective p-values estimates for likelihood of walk access to health care facility are also presented in Table 6.8. The individuals in the younger age group (18 to 34 years) have significantly higher odds (2.593, p-value = 0.0186) of access to health care facility using walk mode compared to older age people (75 years or above). For employment demographic variable, the part time employed individuals have significantly higher odds (1.988, p-value = 0.0608) of access to health care facility through walk than the unemployed and students.

Individuals with two or more vehicles in their households have significantly lower odds (0.267, p-value = 0.0014) of access to health care facility using walk mode than the people having no vehicle in their households. The people who were physically not disabled have 2.339 times higher odds of walk access to health care facility compared to their counterparts with physical disability at less than 1% significance level (p-value = 0.0010).

The next section will summarize the important findings related to equity analysis in terms of public transit, and walk access to non-work amenities. The section will also include some of the important implications for transportation agencies and researchers based on the equity analysis results in this chapter.

Table 6.8. Odds Ratios Estimates - Walk Access to Recreation and Entertainment, and Health Care Facility

Explanatory Variables	**Recreation and Entertainment**		**Health Care Facility**	
	O.R	**p-value**	**O.R**	**p-value**
Age Group (75 Years or Above)				
Age Group (18 to 34 Years)	2.205	0.2618	2.593	0.0186**
Age Group (35 to 54 Years)	2.522	0.0164**	1.760	0.5624
Age Group (55 to 74 Years)	1.735	0.8923	1.465	0.4359
Race (Non-White)				
Race (White)	0.850	0.4502	0.772	0.2425
Unemployed and Students				
Employed Full Time	1.113	0.4940	1.797	0.2176
Employed Part Time	1.219	0.1972	1.988	0.0608*
Retired	0.767	0.0693*	1.381	0.6319
Area (Non-Metro)				
Area (Metro)	1.270	0.0956*	1.018	0.9033
No Household Vehicle				
1 Household Vehicles	1.078	0.4619	0.408	0.3711
2 or more Household Vehicles	0.779	0.2967	0.267	0.0014***
No Driving License				
Have Driving License	1.605	0.3289	1.950	0.1769
Physically Disable				
No Physical Disability	2.577	0.0001***	2.339	0.0010***
Medicare/Medicaid (Covered)				
Medicare/Medicaid (Not Covered)	0.966	0.8658	0.816	0.3493
Gender (Female)				
Gender (Male)	1.252	0.1253	1.137	0.3993

O.R denote odds ratio.

*, **, *** represent significance at 10%, 5%, and 1% levels, respectively.

6.3. Summary of Findings and Implications

In this chapter, equity analysis results in terms of public transit and walk access to non-work amenities were presented. The non-work amenities considered in this study are: 1) grocery stores, 2) personal services, 3) retail shopping, 4) recreation and entertainment, and 5) healthcare facility. In the next subsections, the summary of equity analysis results and their relevant implications for transportation agencies and researchers will be discussed separately for public transit and walk access to non-work amenities.

6.3.1. Public Transit Access to Non-Work Amenities

In all of the five logistic regression models developed for assessing likelihood of public transit access to non-work amenities, younger people were having significantly higher odds of access compared to older age people. Older age people mostly rely upon public transportation services to perform activities due to their inability to drive and other financial and physical constraints. For employment explanatory variable, the odds of having access using public transit were significantly higher for unemployed and students compared to full time employed people for grocery stores, personal services, and healthcare facility amenities. The low access to amenities by full time employed people using public transit might be attributed to the fact that most of them possess their own vehicle and might not prefer to use public transit. In the case of recreation and entertainment category, the odds of having access by public transit was significantly higher for people who were retired compared to unemployed and students. This finding can be attributed to the fact that retired people usually have more free time for recreation and entertainment activities and mostly belong to older age group which rely more upon public transportation services.

In all the logistic regression models developed for public transit access to non-work amenities, the odds of having access were significantly higher for metro area residents compared to individuals who live in non-metro areas. In case of vehicle ownership, the individuals with two or more vehicles in their households were having significantly far lower odds of public transit access to each non-work amenity than the people with no vehicle in their households. The reason for this finding can be that people who have private vehicle(s) in their households may not use public transit to access these amenities. There could be two potential reasons for this: 1) people with vehicle(s) might be having sufficient public transit access to non-work amenities but they do not prefer to use public transit, and 2) people might tend to live in suburbs and areas away from public transit routes because they have the choice of using their own vehicle to access important non-work amenities. The other interesting and significant variable was “driving license”. The individuals with driving license have significantly higher odds of access to grocery stores, personal services, and retail shopping amenities than their counterparts with no driving license. The explanatory variable Medicare/Medicaid was significantly associated only with likelihood of public transit access to recreation and entertainment non-work amenity. The odds of having public transit access to recreation and entertainment facilities was significantly higher for people who were not covered under Medicare/Medicaid program than their counterparts with being covered under the program.

Recall that the equity analysis part of this study was based on the concept of Karel Martens’ theory of transportation justice. According to Karel Martens, the gains in accessibility due to transportation improvement projects should be highest for people with greatest constraints and fewest resources. More specifically, his theory was based on maximax criterion, which pursues to minimize the accessibility gap between the best off and the worst off members of a community while maximizing the average transportation accessibility in a region. The equity analysis results in terms of public transit access to non-work amenities in this study are regressive in nature for older age people, people who live in non-metro area, people without driving license, and people who are covered under the Medicare/Medicaid program. The results here indicate “double injustice” to these disadvantaged groups from the perspective of Martens transportation justice theory i.e. the disadvantaged groups with least resources and greatest constraints should have the highest accessibility to important activity locations. The results are progressive with regard to vehicle ownership, which is likely correlated with income. The results also did not show significant difference in terms of public transit access to non-work amenities based on race. The equity analysis results also appear to be more progressive for those who are not employed full time.

The people who are covered under Medicare/Medicaid program mostly belong to older age group, low income people, and people with disabilities. So, the older age people in particular are most disadvantaged in terms of public transit access to non-work amenities along with non-drivers, and people living in non-metro areas. A report by United Nations in 2015 stated that the older age (65 years or older) population is expected to reach 1.4 billion in urban areas globally by 2030 (United Nations, 2015). The elderly people should be given special attention by transportation planners and policy makers in their future accessibility improvement projects. The public transit agencies and policy makers should provide additional subsidies to the disadvantaged groups. They should also ensure to improve the efficiency of public transit systems in order to make sure that older age people, non-drivers, and people covered under Medicare/Medicaid program (low income people, and people with disabilities) should be having sufficient and easy access to important daily life activity locations using public transit. Based on the study results, more emphasis should be given by policy makers and public transit agencies to improve public transit systems in non-metro areas.

6.3.2. Walk Access to Non-Work Amenities

In case of walk access to non-work amenities, the odds of having access were significantly higher for younger and middle age group people compared to older age people. The reason might be due to the fact that younger and middle age people are able and more active to walk to these destinations, whereas older people are not so much. The explanatory variable "race/ethnicity" was significantly associated with likelihood of walk access to grocery stores and retail shopping. For grocery stores and retail shopping amenities, the odds of having access by walk for white populations were significantly lower than non-white population. This does not necessarily mean that non-white population have better walk access to these destinations compared to white people. White people might have better and easy access to these amenities, but they do not want to take pains (in terms of higher travel time and physical exertion) associated with walk mode and might use other motorized modes. In case of employment category, the odds of having access to grocery stores, retail shopping, and healthcare facility were significantly higher for part time employed people compared to unemployed and students. In case of recreation and entertainment amenity, the odds of walk access were significantly lower for retired people than unemployed and students. In case of walk access to personal services, the odds ratios estimated were significantly higher for full time and part time employed people compared to the unemployed and students in the reference group.

The metro area residents have significantly higher odds of walk access to all non-work amenities except healthcare facility (relationship was insignificant for healthcare facility) compared to their counterparts living in non-metro areas. This could be because of the fact that destinations are far apart in non-metro/rural areas and it is difficult to walk long distances. People with two or more vehicles in their households were having significantly lower odds of walk access to all non-work amenities with the exception of recreation and entertainment. Again, this finding can be attributed to the possibility that individuals who have two or more vehicles in their households does not prefer to access these destinations by walk, and instead use their own vehicle. While at the same time, these people might be living in neighborhoods that have better walk access to these non-work amenities. The other potential reason for this finding could be that these people may be more likely to live in suburban or rural auto-oriented areas where destinations are farther apart and it is more difficult to reach these places by walking. The explanatory variable "driving license" was only significantly associated with likelihood of walk access to personal services. The individuals with driving license have significantly higher odds of access to personal services compared to people who do not have driving license yet.

In contrast to public transit mode, the "physical disability" was significantly associated with likelihood of walk access to all non-work amenities. For all non-work amenities considered, the odds of having walk access were significantly higher for people who were not physically disable compared to individuals with physical disability. At the end, the explanatory variable "gender" was only significantly associated in the logistic regression model developed for retail shopping non-work amenity. The odds of having access to retail shopping using walk mode was significantly higher for male than female. This significant association of gender with walk access to retail shopping is interesting because females are usually more responsible or in frequent need for retail shopping due to their higher domestic responsibilities. Despite of more domestic needs, the finding here suggests that females have less access to their daily shopping needs by walk compared to men.

In terms of walk access to non-work amenities, the older age people are again disadvantaged and have less walk access to important amenities. Some of the studies conducted in the U.S., and Canada found that older people avoid walking due to falling (sometime because of icy sidewalks), perceived high risks of collision with traffic, and low awareness about walkability surroundings (Abou-Raya & ElMeguid, 2009) (Lord, Després, & Ramadier, 2011) (Lachapelle & Cloutier, 2017). The policy makers should emphasize on mitigating these constraints that mostly older age people face while walking in their neighborhoods in order to reach their desired destinations. Overall, the equity analysis results in terms of walk access to non-work amenities were inconsistent with Karel Martens theory of transportation justice and regressive in nature for older age people, unemployed and students, non-metro area residents, individuals without driving license, physically disable people, and females. The communities should be designed to emphasize more on improving the walkability conditions especially by taking into consideration these disadvantaged groups. The equity analysis results in terms of walk access to non-work amenities were progressive with regard to auto-ownership, which is related to income. The results were also progressive for non-white populations, which include African Americans and other minority population.

The location of important non-work amenities along with walkability conditions in non-metro areas should be reviewed by transportation planners in order to optimize walk access to these amenities. The future transportation projects should also make sure that walkability conditions should be favorable, and secure especially for people who face difficulty in walking or wheelchair users. Special mobility services should be provided to these physically disadvantaged groups of society in order to make sure that they have easy access to important life activity locations. For females, due to their higher domestic responsibilities, they are in more need of easy access to retail shopping than male population. Yet, the results in this study revealed that the odds of walk access to retail shopping was significantly lower for females than males. According to a study conducted by Sustrans (2013), the perception of insecurity is one of the main reason that affects the women’s decision to use cycle and walk modes for accessing activities, as they feel less safe and also there involve higher risk of traffic accidents (Sustrans, 2013). Improving security in walking neighborhoods and public spaces can help females feel protected while walking to access their daily needs (Lecompte & Bocarejo S, 2017).

CHAPTER 7. SUMMARY, CONCLUSIONS, AND LIMITATIONS

7.1. Summary of the Research

This dissertation was divided mainly into two parts: 1) impact of public transit, and walkability on community QOL and individual's OLS, and 2) an equity evaluation in terms of public transit and walk access to non-work amenities in the US. SEM methodology was used in first part of the dissertation to evaluate direct and indirect impact of public transit and walkability along with other important contributors such as physical built environment, geographic, and sociodemographic variables on QOL. There were three latent factors included in the SEM based on CFA results and they are: 1) physical built environment, 2) quality of transportation, and 3) support for transit funding. The physical built environment latent factor was formed from nine observed variables: 1) available jobs, 2) quality health care, 3) quality public schools, 4) cultural institutions, 5) shopping and entertainment options, 6) parks and recreational facilities, 7) overall cost of living, 8) public transit access to non-work amenities, and 9) walk access to non-work amenities. Quality of transportation latent factor comprised of five observed indicators which included quality of public transit services, quality of bikeability, quality of walkability, quality of roads condition, and traffic safety. The latent factor support for transit funding was made of four manifest variables. The variables were based on respondents' support for using 1) city, 2) county, 3) state, and 4) federal funds for public transit improvement in their communities.

The other important variables used in SEM related to public transit included perceived public transit importance for a community and public transit need/support for a community. The impact of another observed variable "ease of travel" on community QOL and individual's OLS was also evaluated in the model. The variable "ease of travel" was tested as a mobility indicator. The geographic variable "area type" was also included in the analysis in order to assess the impact of people living in metro vs non-metro areas on their QOL and life satisfaction. The other important set of variables that can impact individual's OLS irrespective of the transportation system available were sociodemographic characteristics. The sociodemographic variables included in the study were gender, age, race, income, employment, level of education, physical disability, and health. The observed endogenous variable "community QOL" was used as mediating variable between final dependent variable (individual's OLS) and exogamous variables (latent and observed).

In the second part of the dissertation, an equity analysis was performed by considering public transit and walk access to non-work amenities in the US. Five types of non-work amenities were considered in this study: 1) grocery stores, 2) personal services, 3) retail shopping, 4) recreation and entertainment, and 5) health care facility. Logistic regression modeling technique was used to evaluate equity. Separate logistic regression models were developed for likelihood of public transit and walk access to each non-work amenity considered in this study. The sociodemographic variables for which the equity analysis was performed included age, race, employment, area type (metro vs non-metro), number of vehicles in household, driving license, physical disability, individuals who are covered under Medicare/Medicaid program or not, and gender. Older age people, non-white population, unemployed and students, people living in non-metro area, people with no vehicle in their household, individuals with no driving license, physically disable people, individuals who are covered under Medicare/Medicaid program, and females were considered as disadvantaged groups in the equity evaluation.

7.2. Conclusions

7.2.1. Public Transit and Walkability Impact on QOL

It is concluded from the literature review that transportation has a significant impact on overall community QOL, and also life satisfaction at an individual level. Literature review confirmed that limited research was available on evaluating transportation impact on QOL. Some empirical studies evaluated the impact of explicit transportation components on QOL such as number of trips, satisfaction with travel, transportation pricing, but other important components related to walkability, public transit, and built environment are missing in a single study. The literature review also revealed that some researchers provided comprehensive theoretical frameworks that discussed about how different aspects of transportation, built environment, and sociodemographic characteristics of individuals can effect QOL, but empirical study is missing in this context.

By incorporating advance method of SEM, the results in this study revealed that improvement in physical built environment has significant direct effect on improving community QOL. The three indicators with highest direct effects on physical built environment latent factor identified were quality healthcare services, shopping and entertainment options, and available jobs. The latent factor "quality of transportation" also has high direct effect on community QOL. The top three observed variables with highest effects on quality of transportation found were quality of public transit services, quality of walkability, and quality of bikeability. It can be concluded that improvement in non-motorized transportation (walk, and bike), and public transit can improve QOL at a community level. The remaining latent factor "support for transit funding" has significant direct effect on individual's OLS. It is concluded from this finding that by providing more funding to public transit agencies would improve public transit systems operations and frequency, which can thereby help public transit users to access more efficient transit services resulting in improved satisfaction with their life.

The observed variable "ease of travel" has significant direct effect on both community QOL and individual's OLS. It can be concluded that by providing safe, efficient, and easily accessible travel options that can fulfill individual's daily travel needs will improve the residents QOL both at community and individual level. Perceived public transit importance by residents for a community has negative direct effect on community QOL. It can be concluded from this finding that people who are transit dependent (lower income people, people who cannot drive, and people with disabilities etc.,) have lower QOL in their community; QOL for transit dependent population can be improved by providing more efficient public transit systems. Public transit need/support has direct negative effect on individual's OLS. This finding also revealed that people who are in need of public transit services in their communities might be suffering with lower life satisfaction which can again be improved by providing more public transit services.

It is also concluded from the study results that people living in non-metro areas have marginally better community QOL compared to metro area residents. Regarding the effects of sociodemographic/personal characteristics on individual's OLS, the effects were significantly positive for age, income, and health; the results were significantly negative for level of education, and race/ethnicity variables. These results revealed that older age people, higher income people, individuals with better health conditions, white population, and people with lower level of education are more satisfied with their life as a whole. The surprisingly low life satisfaction associated with people who have higher level of education could be due to their higher ambitions and goals of life that are difficult to achieve sometimes.

7.2.2. Equity Analysis

Regarding accessibility and equity analysis, it is concluded from the literature review that accessibility is an important indicator in transportation equity evaluation because it adequately describes the relationship between people and different locations of interest. It is also concluded from the literature review that researchers focused on equity evaluation mainly in terms of accessibility to jobs locations. Some studies recently also considered accessibility to other amenities such as grocery stores, hospitals, and religious organizations as equity indicators in general (usually through automobile), but not explicitly through public transit or walking. Regarding the scale of studies, the literature review confirmed that no study had been conducted to evaluate social equity in terms of access to non-work amenities at national level in the US.

In terms of public transit access to non-work amenities, the logistic regression results revealed that age, area (metro vs non-metro), and number of vehicles in household were significantly associated with likelihood of accessing all five non-work amenities. The explanatory variable “driving license” was significantly associated with likelihood of accessing grocery stores, personal services, and retail shopping amenities using public transit. Medicare/Medicaid explanatory variable only have significant association in the logistic regression model developed for assessing public transit access to recreation and entertainment amenity. From the results of odds ratios estimate, it is concluded that equity in terms of public transit access to non-work amenities is regressive and inconsistent with the Karel Martens’ theory of transportation justice for the older age people, people without driving license, individuals who are covered under Medicare/Medicaid program (elderly, low income, people with disabilities), and non-metro area residents disadvantaged groups. The results are progressive with regard to people without their own vehicle and individuals who are not employed full time. The results also did not show significant difference in terms of public transit access to non-work amenities based on race.

The logistic regression models developed for assessing likelihood of walk access to non-work amenities revealed that age, and physical disability were significantly associated in all the five models developed. Race have significant association with likelihood of accessing grocery stores and retail shopping non-work amenities. The number of vehicles in household explanatory variable have significant association with likelihood of accessing all non-work amenities by walking except recreation and entertainment. Employment was significantly associated with likelihood of walk access to grocery stores, personal services, and retail shopping non-work amenities. Area (metro vs non-metro) explanatory variable have significant association with the likelihood of accessing all non-work amenities through walk with the exception of health care facility. The logistic regression results also revealed that driving license, and gender were significantly associated with likelihood of accessing personal services and retail shopping, respectively using walk mode. It is concluded from the odds ratios estimate that older age people, people without driving license, physically disable people, unemployed and students, people living in non-metro areas, and females face injustice in terms of walk access to non-work amenities. These groups are already disadvantaged in society because of their financial, and physical health constraints and should be having sufficient and easy walk access to their daily needs as suggested by Karel Martens. The equity analysis results in terms of walk access to non-work amenities were progressive for people without their own vehicle and non-white populations, which include African Americans and other minority population.

7.3. Limitations, and Future Research

SEM technique was used to evaluate direct and indirect impact of public transit and walkability along with other important built environment and sociodemographic indicators on community QOL and individual's OLS in first part of this dissertation. Despite SEM being an advance method and the factors evaluated in this study are novel to the literature, there are some limitations that need to be addressed in the future. First of all, the results in this study were based on an aggregate national level survey data and may not necessarily be applicable to the local communities. The researchers should explore the factors based on their own local communities and provide useful insights to transportation planners and policy makers. The formation of the latent factors can be changed in future research based on the type of data available and hypothesis set for the study. The researchers can also introduce new latent factors based on their own knowledge that could potentially influence QOL.

The second part of dissertation focused on equity analysis in terms of public transit and walk access to non-work amenities in the US. Even though this part of dissertation is the first study at national level, there are some limitations associated with it that can be improved in future research. The accessibility measure used in this study for equity analysis was measured on a binary scale with 0 (having no access to respective non-work amenity) and 1 (have access to respective non-work amenity). This measure is more generalized and does not contain much information such as travel time threshold, monetary cost in terms of public transit fares, and levels of access etc. Some survey respondents might have responded with the option that they can access respective non-work amenity, but practically they may not use public transit, or walk to reach their desired destination due to travel time, and financial constraints. The future research can incorporate these factors in terms of travel time threshold, and public transit fares etc. Another limitation with this accessibility measure is that it is self-reported. Some people who never use public transit may not know if they can access different amenities using public transit. Also accessibility can be measured at a Likert scale reflecting ease of access levels within certain travel time thresholds. The studies conducted at local level can measure accessibility indices using disaggregate data such as real time travel time data, and average number of daily trips etc. The accessibility measured at local level can be combined with census data to perform equity analysis.

The sociodemographic or explanatory variables categorized in this study are not standardized and are categorized based on the way variables were measured and data sample size. Future studies can use different categories for same variables based on their own dataset available. Future research can also introduce new variables for equity analysis purpose in terms of access to non-work amenities based on the study type and local environments.

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APPENDIX A. NATIONAL COMMUNITY LIVABILITY SURVEY CONDUCTED BY TTI AND NDSU

START HERE

Think about the 1,000s of communities in America…

1. In your opinion, how important is each factor to community livability? *Check one per row.*

	Not important	Slightly important	Moderately important	Important	Very important
Available jobs	○	○	○	○	○
Affordable transportation options	○	○	○	○	○
Cultural institutions	○	○	○	○	○
Quality healthcare	○	○	○	○	○
Affordable housing	○	○	○	○	○
Quality public schools	○	○	○	○	○
Overall cost of living	○	○	○	○	○
Shopping and entertainment options	○	○	○	○	○
Parks and recreation facilities	○	○	○	○	○
Weather	○	○	○	○	○
Clean environment	○	○	○	○	○
Low crime	○	○	○	○	○
Sense of community	○	○	○	○	○
Traffic Safety	○	○	○	○	○

2. How important is each aspect of transportation to community livability? *Check one per row.*

	Not important	Slightly important	Moderately important	Important	Very important
Public transit services	○	○	○	○	○
Bikeability	○	○	○	○	○
Low traffic congestion	○	○	○	○	○
Walkability / accessibility	○	○	○	○	○
Roads in good condition	○	○	○	○	○

3. What ZIP code do you live in? __ __ __ __ __

4. How long have you lived in the community where you live now?

- ○ Less than 1 year
- ○ 1 to 5 years
- ○ 6 to 10 years
- ○ 11 to 20 years
- ○ More than 20 years

5. How satisfied are you with the quality-of-life in your community?

Very dissatisfied	Dissatisfied	Neither satisfied nor dissatisfied	Satisfied	Very satisfied
○	○	○	○	○

CONTINUE ON BACK… ➘

Think about where you live now...

6. Rate the quality of each livability factor in your community right now: *Check one per row.*

	Very poor	Poor	Acceptable	Good	Very good
Available jobs	○	○	○	○	○
Affordable transportation options	○	○	○	○	○
Cultural institutions	○	○	○	○	○
Quality healthcare	○	○	○	○	○
Affordable housing	○	○	○	○	○
Quality public schools	○	○	○	○	○
Overall cost of living	○	○	○	○	○
Shopping and entertainment options	○	○	○	○	○
Parks and recreation facilities	○	○	○	○	○
Weather	○	○	○	○	○
Clean environment	○	○	○	○	○
Low crime	○	○	○	○	○
Sense of community	○	○	○	○	○
Traffic safety	○	○	○	○	○

7. Rate the quality of each aspect of transportation in your community right now: *Check one per row.*

	Very poor	Poor	Acceptable	Good	Very good
Public transit services	○	○	○	○	○
Bikeability	○	○	○	○	○
Low traffic congestion	○	○	○	○	○
Walkability / accessibility	○	○	○	○	○
Roads in good condition	○	○	○	○	○

People live on a wide variety of streets—from urban core downtowns streets to urban center streets to general urban streets to suburban streets to rural small town streets to natural/open-country streets.

8. Which of the following most closely describes the kind of street you live on?

- ○ **Urban core street** (downtown, high-rise/mid-rise housing units)
- ○ **Urban center street** (near downtown, multi-level housing units)
- ○ **General urban street** (single to multi-level buildings, townhomes/row houses/apartments/etc.)
- ○ **Suburban street** (mostly single-family houses or apartment buildings)
- ○ **Rural street** (small city/towns, typically single-family houses or small apartment buildings)
- ○ **Open-country/Natural area** (few houses, open-country mostly)

9. Which phrase best describes the way you define your community in terms of geographic size?

- ○ My community is **a part of my local neighborhood.**
- ○ My community is my **whole local neighborhood.**
- ○ My community is my **city.**
- ○ My community is my **county.**
- ○ My community is **all of the region I live in.**
- ○ Other: ______

CONTINUE ON PAGE 3 →

10. How much do you agree or disagree with the following statement?

"I can easily travel to places I need to go in my community using my current travel options."

Strongly disagree	Disagree	Neutral	Agree	Strongly agree
○	○	○	○	○

11. Think about your trips in a typical week...how many days do you use each mode?
Check one per row.

	Not available	0 days	1 day	2-4 days	5 or more days
Walk (including using a mobility assistive device)	○	○	○	○	○
Personal bicycle	○	○	○	○	○
Bike share	○	○	○	○	○
Drive myself (alone in car, truck, motorcycle, scooter)	○	○	○	○	○
Carpool (traveling with other riders in a private car)	○	○	○	○	○
Public transit (e.g., rail, bus, ferry)	○	○	○	○	○
Vanpool (traveling with other riders in a van)	○	○	○	○	○
Taxi-cab (e.g., Yellow Cab)	○	○	○	○	○
Ride-sourcing (e.g., Uber, Lyft)	○	○	○	○	○
Car-share (e.g., Car2Go, ZipCar)	○	○	○	○	○

12. Is public transit currently available to residents of your community?

○ Yes ○ No ○ Not sure

13a. Have you used public transit in your community?

○ Yes ○ No

14. Do you know someone else who has used public transit in your community?

○ Yes ○ No

13b. If transit were available, how likely are you to use public transit for some of your trips?

Not likely	Somewhat likely	Very likely
○	○	○

SKIP TO QUESTION #17
(TOP OF NEXT PAGE)

15. Which mode(s) of public transit are available in your community?
Check all that apply.

- ☐ **Rail** (e.g., light rail, commuter rail, subway, etc.)
- ☐ **Local bus** (e.g., fixed, flexible, deviated, etc.)
- ☐ **Paratransit for people with disabilities**
- ☐ **Commuter bus** (e.g., express, park-and-ride, etc.)
- ☐ **Demand responsive transit** (e.g., dial-a-ride, etc.)
- ☐ **Intercity bus** (e.g., Greyhound, Megabus, etc.)
- ☐ **Ferry**
- ☐ **Other mode(s):**

People use public transit to access a variety of services and amenities. We are interested in finding out if public transit can connect you with certain types of places.

16. If you chose to, could you ride public transit from near your residence to the following types of places? *Check one per row.*

Yes	No	*Not sure*	
○	○	○	**Grocery store or supermarket** (fresh fruit, vegetables, bread, meat)
○	○	○	**Personal services** (bank, hair/nail salon, laundromat)
○	○	○	**Other retail shopping** (clothes, pharmacy, household goods)
○	○	○	**Recreation and Entertainment** (parks, movies, museums, live theatre)
○	○	○	**Health care facility** (doctor's office, urgent care, hospital)

CONTINUE ON BACK...

17. If you are able, and chose to, could you walk from your residence to the following types of places? *Check one per row.*

Yes	No	Not sure	
○	○	○	**Grocery store or supermarket** (fresh fruit, vegetables, bread, meat)
○	○	○	**Personal services** (bank, hair/nail salon, laundromat)
○	○	○	**Other retail shopping** (clothes, pharmacy, household goods)
○	○	○	**Recreation and Entertainment** (parks, movies, museums, live theatre)
○	○	○	**Health care facility** (doctor's office, urgent care, hospital)

18. How much do you agree or disagree with the following statement?

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
"It is important for public transit to be available to my community's residents."	○	○	○	○	○

19. Why is it important to have public transit service in your community? *Check all that apply.*

- ☐ Because walk access to destinations is difficult in my community
- ☐ Because bike access to destinations is difficult in my community
- ☐ Transit is an option for seniors or people with disabilities
- ☐ Transit is an option for those who choose not to drive
- ☐ Transit is an option for saving on the cost of transportation
- ☐ Transit complements other travel modes, such as walking or biking
- ☐ Transit reduces energy consumption or protect air quality
- ☐ Transit eliminates the need to park or for destinations to provide parking
- ☐ Transit reduces traffic congestion
- ☐ *I do not think it is important to have transit service.*

20. How much do you agree with the following statements about funding transit? *Check one per row.*

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
I support using **city** funds for transit.	○	○	○	○	○
I support using **county** (or equivalent) funds for transit.	○	○	○	○	○
I support using **state** funds for transit.	○	○	○	○	○
I support using **federal** funds for transit.	○	○	○	○	○

21. Do you support more transit, less transit, or the same amount of transit in your community, given that public funds are needed to support part of the cost?

○ Less public transit ○ Same amount of public transit ○ More public transit

Most transit riders pay a fare to ride. The combined fares of all riders may or may not cover the entire cost of operating the service. In fact, most of the time transit services require some other sources of additional funds to pay for operations.

22. In general, how much of the total operating cost of transit should come from rider fares?

- ○ **All – 100%** (fares cover all costs)
- ○ **Most - >50%** (fares cover more than half of costs)
- ○ **Some - <50%** (fares cover less than half of costs)
- ○ **None – 0%** (no fare; other sources cover all costs)

23. Some transit riders pay a reduced fare.
Who should be eligible for reduced fare?
Check all that apply.

- ☐ Military veterans
- ☐ People with disabilities
- ☐ College/university students
- ☐ K-12 students
- ☐ Medicare or Medicaid cardholders
- ☐ Low-income individuals
- ☐ Other:

CONTINUE ON PAGE 5 →

We would like to understand how different situations would impact your choice to use or not use transit. We know from previous questions if you already use transit or not. So please answer the following question thinking about how each scenario may change your use of transit (or motivate you to begin using or stop using transit).

24. How would the following statements change your use of transit? *Check one per row.*

	Stop using transit	Use transit less often	No Change	Use transit more often	Begin using transit
Fuel prices increase to over $4.00 per gallon	○	○	○	○	○
Your car breaks down or is needed by someone else	○	○	○	○	○
Your household income decreases significantly	○	○	○	○	○
You are no longer able to drive for health reasons	○	○	○	○	○
You move to a more urban community with transit	○	○	○	○	○
You move to a more rural community with transit	○	○	○	○	○

Technology and Transportation in the Near Future

25. Assume you own a vehicle and smartphone...If you had to choose, which would you choose to give up permanently?

○ Vehicle (car/truck/motorcycle/scooter)
○ Smartphone (e.g., iPhone/Android)

In the future, you may not need to own a vehicle to have access to a vehicle when needed. For example, you may be able to join a subscription-based car-sharing service or use another mobility service of some type.

26. Which of the following statements most likely describes your future vehicle ownership?

○ *I do not own a vehicle now and I do not plan to get one in the future.*
○ I will no longer choose to own a vehicle in less than 1 year.
○ I will no longer choose to own a vehicle in 1 to 10 years.
○ I will no longer choose to own a vehicle in 11 to 20 years.
○ I will no longer choose to own a vehicle at some point beyond 20 years.
○ *I will always choose to own my own vehicle.*

Think about hourly or mileage based car-sharing services (e.g., Car2Go, CarShare, ZipCar) and assume they are available in your community now (if they are not already)...

27. How important is each factor in making car-sharing appealing and useful for you?
Check one per row.

	Not important	Slightly important	Moderately important	Important	Very important
Variety in type of vehicle (car, van, truck, scooter)	○	○	○	○	○
Wheelchair accessible vehicles	○	○	○	○	○
Convenient vehicle location	○	○	○	○	○
Simple reservation process (internet, phone app)	○	○	○	○	○
Low monthly or annual membership fee	○	○	○	○	○
Low cost per mile/hour of service	○	○	○	○	○
Low daily maximum rate (for multi-day rentals)	○	○	○	○	○

Self-driving vehicles, called autonomous vehicles, will exist in the near future.

28. How comfortable are you with the idea of an autonomous vehicle picking up and dropping you off for a personal business appointment?

Very uncomfortable	Uncomfortable	Neutral	Comfortable	Very comfortable
○	○	○	○	○

CONTINUE ON BACK... ↘

Please answer all questions. Responses are confidential.

29. All things considered, how satisfied are you with your life as a whole these days?

Completely dissatisfied ← → Completely satisfied

○ 0 ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ 6 ○ 7 ○ 8 ○ 9 ○ 10

30. In general, how would you rate your overall health? ○ Poor ○ Fair ○ Good

31. Are you? ○ Female ○ Male ○ Not listed: ____

32. What is your age?
- ○ 18 to 24 years
- ○ 25 to 34 years
- ○ 35 to 44 years
- ○ 45 to 54 years
- ○ 55 to 64 years
- ○ 65 to 74 years
- ○ 75 to 84 years
- ○ 85 or more years

33. What is the highest degree or level of school you have completed?
- ○ Some grade school (K-12)
- ○ High school graduate (diploma or GED)
- ○ Some college
- ○ Associate's degree
- ○ Bachelor's degree
- ○ Master's, professional, or doctorate degree

34. Are you of Hispanic, Latino, or Spanish origin? ○ Yes ○ No

35. What is your race? *Check all that apply.*
- ☐ White, Caucasian
- ☐ Black or African American
- ☐ American Indian or Alaska Native
- ☐ Native Hawaiian or Other Pacific Islander
- ☐ Asian
- ☐ Some Other Race: ____

36. Including yourself, how many people live in your household? ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ 6 or more

37. How many people in your household, including yourself and children, cannot drive? ○ 0 ○ 1 ○ 2 ○ 3 or more

38. Do you have a driver's license? ○ Yes ○ No

CONTINUE TOP OF NEXT COLUMN

39. How many working vehicles (cars, trucks, and motorcycles) are available in your household? ○ 0 ○ 1 ○ 2 ○ 3 or more

40. Which of the following best describes your current employment status? *Check all that apply.*
- ☐ Employed full-time
- ☐ Employed part-time
- ☐ Student
- ☐ Homemaker
- ☐ Retired
- ☐ Unable to work due to a disability
- ☐ Not employed, looking for work
- ☐ Other: ____

41. What is the combined annual income for all people living in your household?
- ○ Less than $15,000
- ○ $15,000 to $24,999
- ○ $25,000 to $34,999
- ○ $35,000 to $49,999
- ○ $50,000 to $74,999
- ○ $75,000 to $99,999
- ○ $100,000 to $249,999
- ○ $250,000 or more

42. Have you served on active duty in the U.S. Armed Forces, Reserves, or National Guard?
○ No ○ Yes, previously ○ Yes, currently (*Thank you for your service.*)

43. Are you currently covered by either of the following programs? *Check one per row.*

Yes	No	
○	○	**Medicare** (age 65+ or Social Security Disability)
○	○	**Medicaid** (low income or people with disabilities)

44. Do you have serious difficulty walking or climbing stairs? ○ Yes ○ No

45. Do you use a wheelchair or other mobility assistive device to travel outside your residence? ○ Yes ○ No

CONTINUE ON PAGE 7 →

46. Please share any final comments you have regarding community livability or public transit:

Returning a completed survey means you are eligible to receive one $3.00 online gift card code.

Please indicate how you prefer to receive your gift card code by providing an SMS text capable mobile phone number or email address.

SMS text capable mobile phone number: _(xxx) xxx - xxxx_

Email address: _name@online.com_

Please write clearly and double-check your spelling. We will not re-send undeliverable or returned messages.

You will receive your code in the next four weeks.

Are you a current or former rider of public transit?

If NO... you are finished. Return all pages using the provided envelope.

If YES... please take 3 more minutes to answer a few questions about your use of transit...

A Few Questions for Transit Riders

47. How often do you ride public transit?

- ○ 6 or 7 days per week
- ○ 4 or 5 days per week
- ○ 2 or 3 days per week
- ○ 1 day per week
- ○ 1 or 2 days per month
- ○ Less than once per month
- ○ *I no longer ride transit.*

48. How much do you agree or disagree with the following statement?

"Public transit is very important to my quality-of-life."

Strongly disagree	Disagree	Neutral	Agree	Strongly agree
○	○	○	○	○

49. How likely is it that you would recommend the public transit service you ride to a friend or colleague?

Not at all likely ... Extremely Likely

0	1	2	3	4	5	6	7	8	9	10
○	○	○	○	○	○	○	○	○	○	○

50. Why did you start riding public transit? *Check all that apply.*

- ☐ I wanted to be more physically active.
- ☐ I enjoyed the social interaction of riding transit.
- ☐ I decided to use transit for convenience.
- ☐ I no longer had access to a vehicle.
- ☐ I decided to use transit to save money.
- ☐ I decided to use transit to reduce my energy consumption or protect air quality.
- ☐ I did not want to drive in poor weather (rainy, snowy).
- ☐ I could no longer drive or had difficulties driving.
- ☐ I could not get a ride from others or did not want to.
- ☐ I have a disability that limits my ability to travel other ways.
- ☐ I wanted to avoid congestion.
- ☐ I wanted to make better use of my time while traveling.
- ☐ Other reason(s):

CONTINUE ON BACK... →

About Your Most Recent Trip on Transit

Please answer the following questions about the most recent trip you took on transit.

51. If public transit had not been available, which one travel option would you have used to make the trip?

Check only the one option you would have used.

- ○ Drove my vehicle
- ○ Asked friend/family for a ride
- ○ Used church or service organization
- ○ Walked
- ○ Biked
- ○ Used bike-share
- ○ Used taxi-cab
- ○ Used ride-sourcing (e.g., Uber, Lyft)
- ○ Used car-share (e.g., Car2Go, ZipCar)
- ○ Used another travel option: ______
- ○ *I have no other travel options.*

52. When was your most recent trip on transit?

- ○ Today
- ○ Another day this week
- ○ Last week
- ○ 2 to 4 weeks ago
- ○ More than 4 weeks ago
- ○ *Not sure*

53. Which mode(s) of public transit did you use on the trip? *Check all that apply.*

- ☐ **Rail** (e.g., light rail, commuter rail, subway, etc.)
- ☐ **Local bus** (e.g., fixed, flexible, deviated, etc.)
- ☐ **Paratransit for people with disabilities**
- ☐ **Commuter bus** (e.g., express, park-and-ride, etc.)
- ☐ **Demand responsive transit** (e.g., dial-a-ride, etc.)
- ☐ **Intercity bus** (e.g., Greyhound, Megabus, etc.)
- ☐ **Vanpool**
- ☐ **Ferry**
- ☐ **Other mode(s):** ______

54. What was the purpose for the trip?

Check all that apply.

- ☐ Work
- ☐ School, college, job training
- ☐ Medical appointments, health care, dental
- ☐ Family, personal business
- ☐ Social, recreational
- ☐ Shopping, errands
- ☐ Volunteering
- ☐ Other: ______

55. How much do you agree or disagree with the following statements? *Check one per row.*

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree	Does not apply
The vehicle arrived on-time.	○	○	○	○	○	○
The driver was helpful and friendly.	○	○	○	○	○	○
I felt safe riding transit.	○	○	○	○	○	○
The vehicle was clean.	○	○	○	○	○	○
The vehicle was comfortable.	○	○	○	○	○	○
The fare I paid was reasonable for my trip.	○	○	○	○	○	○

FINISHED!

RETURN ALL PAGES IN THE PROVIDED ENVELOPE.

APPENDIX B. SAS CODE FOR CONFIRMATORY FACTOR ANALYSIS

SAS code for CFA or measurement model

```
/*  Measurement Model or Confirmatory Factor Analysis */

proc calis data=survey plots=pathdiagram modification; /*The modification
option generates a list of potential variables/relationships to be removed
from the model */*fitindex on(only) = [chisq df probchi rmsea  LL_RMSEA
UL_RMSEA  cn srmsr bentlercfi agfi] noindextype; /* This limits the number of
fit indices listed in the output */

lineqs

/* These statements assign the observed indicator variables to their
respective latent variable */

            /* Physical Built Environment */
            COLrate      =     LCOLrateF1             F1 + E1,
            Jobsrate     =     LJobsrateF1            F1 + E2,
            Culturalra   =     LCulturalraF1          F1 + E3,
            Hcrate       =     LHcrateF1              F1 + E4,
            Schoolsrat   =     LSchoolsratF1          F1 + E5,
            Shoprate     =     LShoprateF1            F1 + E6,
            Parksrate    =     LParksrateF1           F1 + E7,
            TransitAcc   =     LTransitAccF1          F1 + E8,
            WalkAccess   =     LWalkAccessF1          F1 + E9,

             /* Quality of Transportation Aspects */
            Transitrat   =     LTransitratF2          F2 + E10,
            Bikerate     =     LBikerateF2            F2 + E11,
            Walkrate     =     LWalkrateF2            F2 + E12,
            Roadsrate    =     LRoadsrateF2           F2 + E13,
            Trafsafera   =     LTrafsaferaF1          F2 + E14,

        /* Transit Cost Share */
            Fundcity     =     LFundcityF3            F3 + E15,
            Fundcnty     =     LFundcntyF3            F3 + E16,
            Fundstate    =     LFundstateF3           F3 + E17,
            Fundfed      =     LFundfedF3             F3 + E18;

 variance
 /* These statements assign a variance of 1 to the latent variables, and
assign a name to the other variances that are to be estimated by the model.
You're not required to name the variances for each variable, however, it's
much easier to read the output as SAS will generate those that aren't
specified with a generic label */

         F1=1,
         F2=1,
         F3=1,
         Easytravel= VarEasyTravel,
         ComQOL=VarComQOL,
         LifeSat=VarLifeSat,
         Male=VarMale,
```

```
        Age=VarAge,
        White=VarWhite,
        Income=VarIncome,
        Employment=VarEmployment,
        Disability=VarDisability,
        Educ=VarEduc,
        Health=VarHealth,
        Area_Type=VarArea_Type,
        Transamt=VarTransamt,
        TransIMP=VarTransIMP,
        E1 - E18= VARE1 - VARE18;
  cov
  /* Similar to the variance statement, covariance allows you to specify a
value, or label the covariance, between two variables.  If a value is not
specified, the model will estimate the covariance value.  Unlike SEM, in CFA,
all non-indicator variables are allowed to covary */

           F1 F2=CF1F2,
           F1 F3=CF1F3,
           F2 F3=CF2F3,
           F1 Easytravel=CF1Easytravel,
           F1 ComQOL = CF1ComQOL,
           F1 LifeSat = CF1LifeSat,
           F1 Age=CF1Age,
           F1 Disability=CF1Disability,
           F1 Educ=CF1Educ,
           F1 Employment=CF1Employment,
           F1 Health=CF1Health,
           F1 Income=CF1Income,
           F1 Male= CF1Male,
           F1 White=CF1White,
           F1 Area_Type=CF1Area_Type,
           F2 Easytravel=CF2Easytravel,
           F2 ComQOL = CF2ComQOL,
           F2 LifeSat = CF2LifeSat,
           F2 Age=CF2Age,
           F2 Disability=CF2Disability,
           F2 Educ=CF2Educ,
           F2 Employment=CF2Employment,
           F2 Health=CF2Health,
           F2 Income=CF2Income,
           F2 Male= CF2Male,
           F2 White=CF2White,
           F2 Area_Type=CF2Area_Type,
           F3 Easytravel=CF3Easytravel,
           F3 ComQOL = CF3ComQOL,
           F3 LifeSat = CF3LifeSat,
           F3 Age=CF3Age,
           F3 Disability=CF3Disability,
           F3 Educ=CF3Educ,
           F3 Employment=CF3Employment,
           F3 Health=CF3Health,
           F3 Income=CF3Income,
           F3 Male= CF3Male,
           F3 White=CF3White,
           F3 Area_Type=CF3Area_Type,
           comqol Easytravel=CComqolEasytravel,
```

```
Comqol LifeSat=CComQOLLifeSat,
Comqol Health=CComqolHealth,
Comqol Male=CComqolMale,
Comqol Age=CComqolAge,
Comqol Disability=CComqolDisab,
Comqol White=CComqolWhite,
Comqol Income=CComqolIncome,
Comqol Employment=CComqolEmpl,
Comqol Educ=CComqolEduc,
Comqol Area_Type=CComqolArea_Type,
LifeSat Easytravel=CLifeSatEasytravel,
LifeSat Health=CLifeSatHealth,
LifeSat Male=CLifeSatMale,
LifeSat Age=CLifeSatAge,
LifeSat Disability=CLifeSatDisab,
LifeSat White=CLifeSatWhite,
LifeSat Income=CLifeSatIncome,
LifeSat Employment=CLifeSatEmpl,
LifeSat Educ=CLifeSatEduc,
LifeSat Area_Type=CLifeSatArea_Type,
Health Easytravel=CHealthEasytravel,
Health Male=CHealthMale,
Health Age=CHealthAge,
Health Disability=CHealthDisab,
Health White=CHealthWhite,
Health Income=CHealthIncome,
Health Employment=CHealthEmpl,
Health Educ=CHealthEduc,
Health Area_Type=CHealthArea_Type,
Male Easytravel=CMaleEasytravel,
Male Age=CMaleAge,
Male Disability=CMaleDisab,
Male White=CMaleWhite,
Male Income=CMaleIncome,
Male Employment=CMaleEmpl,
Male Educ=CMaleEduc,
Male Area_Type=CMaleArea_Type,
Age Easytravel=CAgeEasytravel,
Age Disability=CAgeDisab,
Age White=CAgeWhite,
Age Income=CAgeIncome,
Age Employment=CAgeEmpl,
Age Educ=CAgeEduc,
Age Area_Type=CAgeArea_Type,
Disability Easytravel=CDisabilityEasytravel,
Disability White=CDisabilityWhite,
Disability Income=CDisabilityIncome,
Disability Employment=CDisabilityEmpl,
Disability Educ=CDisabilityEduc,
Disability Area_Type=CDisabilityArea_Type,
White Easytravel=CWhiteEasytravel,
White Income=CWhiteIncome,
White Employment=CWhiteEmpl,
White Educ=CWhiteEduc,
White Area_Type=CWhiteArea_Type,
Income Easytravel=CIncomeEasytravel,
Income Employment=CIncomeEmpl,
```

```
          Income Educ=CIncomeEduc,
          Income Area_Type=CIncomeArea_Type,
          Employment Easytravel=CEmploymentEasytravel,
          Employment Educ=CEmplEduc,
          Employment Area_Type=CEmplArea_Type,
          Educ Easytravel=CEducEasytravel,
          Educ Area_Type=CEducArea_Type,
          Area_Type Easytravel=CArea_TypeEasytravel,
          Transamt Male=CTransamtMale,
          Transamt Age=CTransamtAge,
          Transamt White=CTransamtWhite,
          Transamt Income=CTransamtIncome,
          Transamt Employment=CTransamtEmploy,
          Transamt Disability=CTransamtDisab,
          Transamt Educ=CTransamtEduc,
          Transamt Health=CTransamtHealth,
          Transamt Area_Type=CTransamtArea_Type,
          Transamt ComQOL=CTransamtComQOL,
          Transamt LifeSat=CTransamtLifeSat,
          F1 Transamt=CF1Transamt,
          F2 Transamt=CF2Transamt,
          F3 Transamt=CF3Transamt,
          TransIMP Male=CTransIMPMale,
          TransIMP Age=CTransIMPAge,
          TransIMP White=CTransIMPWhite,
          TransIMP Income=CTransIMPIncome,
          TransIMP Employment=CTransIMPEmploy,
          TransIMP Disability=CTransIMPDisab,
          TransIMP Educ=CTransIMPEduc,
          TransIMP Health=CTransIMPHealth,
          TransIMP Area_Type=CTransIMPArea_Type,
          TransIMP ComQOL=CTransIMPComQOL,
          TransIMP LifeSat=CTransIMPLifeSat,
          F1 TransIMP=CF1TransIMP,
          F2 TransIMP=CF2TransIMP,
          F3 TransIMP=CF3TransIMP,

       /* Additional Covariance Parameters based on LM results */

          E8 E10= CE8E10,
          E8 E9= CE8E9,
          E16 E17= CE16E17,
          E17 E18= CE17E18;
 /* The var statment specifies all of the variables in the model */

 var

  Comqol LifeSat Colrate Jobsrate Culturalra Hcrate Schoolsrat Shoprate
Parksrate WalkAccess TransitAcc Transitrat  Trafsafera Bikerate Walkrate
Roadsrate Fundcity Fundcnty Fundstate Fundfed Easytravel Transamt TransIMP
Health Male Age Disability White Income Employment Educ Area_Type ;

 title 'CFA Results for All Participants';
 title2 'Initial Model';
  run;
```

APPENDIX C. SAS CODE FOR SEM

SAS code for SEM

```
***** Proposed SEM Model *****;

proc calis data=survey plots=pathdiagram modification; /*The modification
option generates a list of potential variables/relationships to be removed
from the model */* fitindex on(only) = [chisq df probchi rmsea  LL_RMSEA
UL_RMSEA  cn srmsr bentlercfi agfi] noindextype; /* This limits the number of
fit indices listed in the output */

lineqs

  /* These statements assign the observed indicator variables to their
respective latent variable */

            /* Livability */
            COLrate          =   LCOLrateF1           F1 + E1,
            Jobsrate         =   LJobsrateF1          F1 + E2,
            Culturalra       =   LCulturalraF1        F1 + E3,
            Hcrate           =   LHcrateF1            F1 + E4,
            Schoolsrat       =   LSchoolsratF1        F1 + E5,
            Shoprate         =                        F1 + E6,
            Parksrate        =   LParksrateF1         F1 + E7,
            TransitAcc       =   LTransitAccF1        F1 + E8,
            WalkAccess       =   LWalkAccessF1        F1 + E9,

            /* Quality of Transportation Aspects */
            Transitrat       =   LTransitratF2        F2 + E10,
            Bikerate         =                        F2 + E11,
            Walkrate         =   LWalkrateF2          F2 + E12,
            Roadsrate        =   LRoadsrateF2         F2 + E13,
            Trafsafera       =   LTrafsaferaF2        F2 + E14,

        /* Transit Cost Share */
            Fundcity         =   LFundcityF3          F3 + E15,
            Fundcnty         =                        F3 + E16,
            Fundstate        =   LFundstateF3         F3 + E17,
            Fundfed          =   LFundfedF3           F3 + E18,

            /* Paths */

ComQOL = PComQOLF1 F1 + PComQOLEasyTravel EasyTravel + PComQOLF2 F2 +
PComQOLF3 F3 + PComQOLTransamt Transamt + PComQOLTransIMP TransIMP +
PComQOLArea_Type Area_Type + D1,

LifeSat = PLifeSatComQOL ComQOL + PLifeSatHealth Health + PLifeSatMale Male +
PLifeSatAge Age + PLifeSatDisability Disability + PLifeSatWhite White +
PLifeSatIncome Income + PLifeSatEmployment Employment + PLifeSatEduc Educ +
PLifeSatArea_Type Area_Type + PLifeSatEasyTravel EasyTravel + PLifeSatF1 F1 +
PLifeSatF2 F2 + PLifeSatF3 F3 + PLifeSatTransamt Transamt + PLifeSatTransIMP
TransIMP + D2;
```

```
variance

     F1-F3=VARF1-VARF3,
     E1-E18 = VARE1-VARE18,
     D1-D2=VARD1-VARD2,
     Male=VarMale,
     Age=VarAge,
     White=VarWhite,
     Income=VarIncome,
     Employment=VarEmployment,
     Disability=VarDisability,
     Educ=VarEduc,
     Health=VarHealth,
     Area_Type=VarArea_Type,
     Transamt=VarTransamt,
     TransIMP=VarTransIMP,
     Easytravel= VarEasyTravel;

  cov

  /* Similar to the variance statement, covariance allows you to specify a
value, or label the covariance, between two variables. */

     F1 F2=CF1F2,
     F1 F3=CF1F3,
     F2 F3=CF2F3,
     F1 Age=CF1Age,
     F1 Disability=CF1Disability,
     F1 Educ=CF1Educ,
     F1 Employment=CF1Employment,
     F1 Health=CF1Health,
     F1 Income=CF1Income,
     F1 Male= CF1Male,
     F1 White=CF1White,
     F1 Area_Type=CF1Area_Type,
     F2 Age=CF2Age,
     F2 Disability=CF2Disability,
     F2 Educ=CF2Educ,
     F2 Employment=CF2Employment,
     F2 Health=CF2Health,
     F2 Income=CF2Income,
     F2 Male= CF2Male,
     F2 White=CF2White,
     F2 Area_Type=CF2Area_Type,
     F3 Age=CF3Age,
     F3 Disability=CF3Disability,
     F3 Educ=CF3Educ,
     F3 Employment=CF3Employment,
     F3 Health=CF3Health,
     F3 Income=CF3Income,
     F3 Male= CF3Male,
     F3 White=CF3White,
     F3 Area_Type=CF3Area_Type,
     Health Male=CHealthMale,
     Health Age=CHealthAge,
     Health Disability=CHealthDisab,
```

```
Health White=CHealthWhite,
Health Income=CHealthIncome,
Health Employment=CHealthEmpl,
Health Educ=CHealthEduc,
Health Area_Type=CHealthArea_Type,
Male Age=CMaleAge,
Male Disability=CMaleDisab,
Male White=CMaleWhite,
Male Income=CMaleIncome,
Male Employment=CMaleEmpl,
Male Educ=CMaleEduc,
Male Area_Type=CMaleArea_Type,
Age Disability=CAgeDisab,
Age White=CAgeWhite,
Age Income=CAgeIncome,
Age Employment=CAgeEmpl,
Age Educ=CAgeEduc,
Age Area_Type=CAgeArea_Type,
Disability White=CDisabilityWhite,
Disability Income=CDisabilityIncome,
Disability Employment=CDisabilityEmpl,
Disability Educ=CDisabilityEduc,
Disability Area_Type=CDisabilityArea_Type,
White Income=CWhiteIncome,
White Employment=CWhiteEmpl,
White Educ=CWhiteEduc,
White Area_Type=CWhiteArea_Type,
Income Employment=CIncomeEmpl,
Income Educ=CIncomeEduc,
Income Area_Type=CIncomeArea_Type,
Employment Educ=CEmplEduc,
Employment Area_Type=CEmplArea_Type,
Educ Area_Type=CEducArea_Type,
Easytravel Male=CEasyMale,
Easytravel Age=CEasyAge,
Easytravel White=CEasyWhite,
Easytravel Income=CEasyIncome,
Easytravel Employment=CEasyEmploy,
Easytravel Disability=CEasyDisab,
Easytravel Educ=CEasyEduc,
Easytravel Health=CEasyHealth,
Easytravel Area_Type=CEasyArea_Type,
F1 Easytravel=CF1Easytravel,
F2 Easytravel=CF2Easytravel,
F3 Easytravel=CF3Easytravel,
Transamt Male=CTransamtMale,
Transamt Age=CTransamtAge,
Transamt White=CTransamtWhite,
Transamt Income=CTransamtIncome,
Transamt Employment=CTransamtEmploy,
Transamt Disability=CTransamtDisab,
Transamt Educ=CTransamtEduc,
Transamt Health=CTransamtHealth,
Transamt Area_Type=CTransamtArea_Type,
F1 Transamt=CF1Transamt,
F2 Transamt=CF2Transamt,
F3 Transamt=CF3Transamt,
```

```
      TransIMP Male=CTransIMPMale,
      TransIMP Age=CTransIMPAge,
      TransIMP White=CTransIMPWhite,
      TransIMP Income=CTransIMPIncome,
      TransIMP Employment=CTransIMPEmploy,
      TransIMP Disability=CTransIMPDisab,
      TransIMP Educ=CTransIMPEduc,
      TransIMP Health=CTransIMPHealth,
      TransIMP Area_Type=CTransIMPArea_Type,
      F1 TransIMP=CF1TransIMP,
      F2 TransIMP=CF2TransIMP,
      F3 TransIMP=CF3TransIMP,
      E8 E10= CE8E11,
      E8 E9= CE8E9,
      E16 E17= CE16E17,
      E17 E18= CE17E18;

 /* The var statment specifies all of the variables in the model */

 var

Comqol LifeSat Colrate Jobsrate Culturalra Hcrate Schoolsrat Shoprate
Parksrate Weatherrat TransitAcc WalkAccess Transitrat Trafsafera Bikerate
Walkrate Roadsrate Fundcity Fundcnty Fundstate Fundfed Easytravel Transamt
TransIMP Health Male Age Disability White Income Employment Educ Area_Type ;

 title 'SEM Results for All Participants';
  run;
```

APPENDIX D. SEM RESULTS

Table D.1. SEM Fit Indices

Fit Summary		
Modeling Info	Number of Observations	742
	Number of Variables	33
	Number of Moments	561
	Number of Parameters	198
	Number of Active Constraints	0
	Baseline Model Function Value	12.6904
	Baseline Model Chi-Square	9403.6033
	Baseline Model Chi-Square DF	528
	Pr > Baseline Model Chi-Square	<.0001
Absolute Index	Fit Function	1.9171
	Chi-Square	1420.5749
	Chi-Square DF	363
	Pr > Chi-Square	<.0001
	Z-Test of Wilson & Hilferty	23.2993
	Hoelter Critical N	214
	Root Mean Square Residual (RMR)	0.1023
	Standardized RMR (SRMR)	0.0621
	Goodness of Fit Index (GFI)	0.8797
Parsimony Index	Adjusted GFI (AGFI)	0.8140
	Parsimonious GFI	0.6048
	RMSEA Estimate	0.0627
	RMSEA Lower 90% Confidence Limit	0.0593
	RMSEA Upper 90% Confidence Limit	0.0662
	Probability of Close Fit	<.0001
	ECVI Estimate	2.4772
	ECVI Lower 90% Confidence Limit	2.3231

Table D.1. SEM Fit Indices (continued)

	Fit Summary	
	ECVI Upper 90% Confidence Limit	2.6420
	Akaike Information Criterion	1816.5749
	Bozdogan CAIC	2927.2260
	Schwarz Bayesian Criterion	2729.2260
	McDonald Centrality	0.4903
Incremental Index	Bentler Comparative Fit Index	0.8808
	Bentler-Bonett NFI	0.8489
	Bentler-Bonett Non-normed Index	0.8267
	Bollen Normed Index Rho1	0.7803
	Bollen Non-normed Index Delta2	0.8830
	James et al. Parsimonious NFI	0.5836

Table D.2. Unstandardized Effects in Linear Equations

Variable	Predictor	Parameter	Estimate	Standard Error	t Value	Pr > |t|
COLRATE	F1	LCOLrateF1	0.48270	0.04352	11.0926	<.0001
JOBSRATE	F1	LJobsrateF1	0.84196	0.04679	17.9937	<.0001
CULTURALRA	F1	LCulturalraF1	0.83693	0.04761	17.5790	<.0001
HCRATE	F1	LHcrateF1	0.86539	0.04803	18.0180	<.0001
SCHOOLSRAT	F1	LSchoolsratF1	0.63344	0.04571	13.8568	<.0001
SHOPRATE	F1		1.00000			
PARKSRATE	F1	LParksrateF1	0.82666	0.04653	17.7653	<.0001
TRANSITACC	F1	LTransitAccF1	0.51017	0.09448	5.3996	<.0001
WALKACCESS	F1	LWalkAccessF1	0.64214	0.09137	7.0276	<.0001
TRANSITRAT	F2	LTransitratF2	0.86127	0.06107	14.1033	<.0001
BIKERATE	F2		1.00000			
WALKRATE	F2	LWalkrateF2	0.98154	0.05791	16.9499	<.0001
ROADSRATE	F2	LRoadsrateF2	0.59645	0.05315	11.2227	<.0001
TRAFSAFERA	F2	LTrafsaferaF2	0.49008	0.04478	10.9450	<.0001
FUNDCITY	F3	LFundcityF3	0.95837	0.02694	35.5706	<.0001
FUNDCNTY	F3		1.00000			
FUNDSTATE	F3	LFundstateF3	0.90544	0.02592	34.9254	<.0001
FUNDFED	F3	LFundfedF3	0.85836	0.03206	26.7698	<.0001
COMQOL	F1	PComQOLF1	0.59688	0.07311	8.1645	<.0001
COMQOL	EASYTRAVEL	PComQOLEasyTravel	0.08763	0.03453	2.5378	0.0112
COMQOL	F2	PComQOLF2	0.16409	0.07521	2.1816	0.0291
COMQOL	F3	PComQOLF3	-0.03351	0.04040	-0.8294	0.4069
COMQOL	TRANSAMT	PComQOLTransamt	0.03892	0.06105	0.6375	0.5238
COMQOL	TRANSIMP	PComQOLTransIMP	-0.08432	0.03474	-2.4271	0.0152
COMQOL	AREA_TYPE	PComQOLArea_Type	0.05839	0.02813	2.0758	0.0379
LIFESAT	COMQOL	PLifeSatComQOL	0.59292	0.08096	7.3240	<.0001
LIFESAT	HEALTH	PLifeSatHealth	1.11263	0.15131	7.3533	<.0001
LIFESAT	MALE	PLifeSatMale	-0.20138	0.12468	-1.6152	0.1063
LIFESAT	AGE	PLifeSatAge	0.38796	0.08227	4.7155	<.0001

Table D.2. Unstandardized Effects in Linear Equations (continued)

Variable	Predictor	Parameter	Estimate	Standard Error	t Value	Pr > |t|
LIFESAT	DISABILITY	PLifeSatDisability	-0.24768	0.19119	-1.2954	0.1952
LIFESAT	WHITE	PLifeSatWhite	-0.53959	0.21714	-2.4850	0.0130
LIFESAT	INCOME	PLifeSatIncome	0.21111	0.07162	2.9478	0.0032
LIFESAT	EMPLOYMENT	PLifeSatEmployment	-0.04413	0.09216	-0.4789	0.6320
LIFESAT	EDUC	PLifeSatEduc	-0.18008	0.06988	-2.5769	0.0100
LIFESAT	AREA_TYPE	PLifeSatArea_Type	0.04938	0.05984	0.8252	0.4093
LIFESAT	EASYTRAVEL	PLifeSatEasyTravel	0.34633	0.07129	4.8582	<.0001
LIFESAT	F1	PLifeSatF1	0.12627	0.17716	0.7128	0.4760
LIFESAT	F2	PLifeSatF2	-0.18478	0.16648	-1.1099	0.2671
LIFESAT	F3	PLifeSatF3	0.20861	0.08282	2.5189	0.0118
LIFESAT	TRANSAMT	PLifeSatTransamt	-0.40165	0.12537	-3.2036	0.0014
LIFESAT	TRANSIMP	PLifeSatTransIMP	0.03555	0.07143	0.4977	0.6187

Table D.3. Standardized Effects in Linear Equations

Variable	Predictor	Parameter	Estimate	Standard Error	t Value	Pr > |t|
COLRATE	F1	LCOLrateF1	0.42705	0.03255	13.1195	<.0001
JOBSRATE	F1	LJobsrateF1	0.67616	0.02278	29.6834	<.0001
CULTURALRA	F1	LCulturalraF1	0.66161	0.02346	28.2051	<.0001
HCRATE	F1	LHcrateF1	0.67701	0.02274	29.7729	<.0001
SCHOOLSRAT	F1	LSchoolsratF1	0.52875	0.02906	18.1958	<.0001
SHOPRATE	F1		0.75921	0.01873	40.5367	<.0001
PARKSRATE	F1	LParksrateF1	0.66815	0.02315	28.8571	<.0001
TRANSITACC	F1	LTransitAccF1	0.20373	0.03640	5.5978	<.0001
WALKACCESS	F1	LWalkAccessF1	0.27325	0.03644	7.4981	<.0001
TRANSITRAT	F2	LTransitratF2	0.56826	0.02850	19.9359	<.0001
BIKERATE	F2		0.73620	0.02267	32.4675	<.0001
WALKRATE	F2	LWalkrateF2	0.71594	0.02347	30.5090	<.0001
ROADSRATE	F2	LRoadsrateF2	0.45989	0.03316	13.8694	<.0001
TRAFSAFERA	F2	LTrafsaferaF2	0.44826	0.03352	13.3712	<.0001
FUNDCITY	F3	LFundcityF3	0.88781	0.01078	82.3645	<.0001
FUNDCNTY	F3		0.93306	0.00907	102.9	<.0001
FUNDSTATE	F3	LFundstateF3	0.83754	0.01359	61.6198	<.0001
FUNDFED	F3	LFundfedF3	0.76104	0.01720	44.2418	<.0001
COMQOL	F1	PComQOLF1	0.51698	0.05859	8.8240	<.0001
COMQOL	EASYTRAVEL	PComQOLEasyTravel	0.08457	0.03328	2.5412	0.0110
COMQOL	F2	PComQOLF2	0.13236	0.06026	2.1966	0.0280
COMQOL	F3	PComQOLF3	-0.03775	0.04550	-0.8296	0.4067
COMQOL	TRANSAMT	PComQOLTransamt	0.02425	0.03804	0.6376	0.5238
COMQOL	TRANSIMP	PComQOLTransIMP	-0.09672	0.03982	-2.4292	0.0151
COMQOL	AREA_TYPE	PComQOLArea_Type	0.07257	0.03494	2.0772	0.0378
LIFESAT	COMQOL	PLifeSatComQOL	0.29732	0.03984	7.4634	<.0001
LIFESAT	HEALTH	PLifeSatHealth	0.25182	0.03364	7.4858	<.0001
LIFESAT	MALE	PLifeSatMale	-0.05054	0.03127	-1.6162	0.1061
LIFESAT	AGE	PLifeSatAge	0.16013	0.03377	4.7422	<.0001

Table D.3. Standardized Effects in Linear Equations (continued)

Variable	Predictor	Parameter	Estimate	Standard Error	t Value	Pr > |t|
LIFESAT	DISABILITY	PLifeSatDisability	-0.04438	0.03424	-1.2960	0.1950
LIFESAT	WHITE	PLifeSatWhite	-0.07888	0.03170	-2.4887	0.0128
LIFESAT	INCOME	PLifeSatIncome	0.11235	0.03803	2.9547	0.0031
LIFESAT	EMPLOYMENT	PLifeSatEmployment	-0.01660	0.03466	-0.4789	0.6320
LIFESAT	EDUC	PLifeSatEduc	-0.09413	0.03647	-2.5811	0.0098
LIFESAT	AREA_TYPE	PLifeSatArea_Type	0.03078	0.03729	0.8253	0.4092
LIFESAT	EASYTRAVEL	PLifeSatEasyTravel	0.16760	0.03425	4.8933	<.0001
LIFESAT	F1	PLifeSatF1	0.05484	0.07690	0.7131	0.4758
LIFESAT	F2	PLifeSatF2	-0.07474	0.06722	-1.1119	0.2662
LIFESAT	F3	PLifeSatF3	0.11783	0.04665	2.5260	0.0115
LIFESAT	TRANSAMT	PLifeSatTransamt	-0.12552	0.03908	-3.2120	0.0013
LIFESAT	TRANSIMP	PLifeSatTransIMP	0.02045	0.04109	0.4977	0.6187

APPENDIX E. SAS CODE FOR LOGISTIC REGRESSION MODELS

```
/*****         Logistic Regression for Equity Analysis    *******/

**********   Transit Accessibility to Non-work Amenities  ********;

Proc Logistic data = survey;
Class Age Race Employment Area HhVeh (ref = '0') License (ref = '0')
Disability Medi_ins Male (ref= '0');
model GrocTran (event='1') = Age Race Employment Area HhVeh License
Disability Medi_ins Male;
run;

Proc Logistic data = survey;
Class Age Race Employment Area HhVeh (ref = '0') License (ref = '0')
Disability Medi_ins Male (ref= '0');
model PerserTran (event='1') = Age Race Employment Area HhVeh License
Disability Medi_ins Male;
run;

Proc Logistic data = survey;
Class Age Race Employment Area HhVeh (ref = '0') License (ref = '0')
Disability Medi_ins Male (ref= '0');
model RetailTran (event='1') = Age Race Employment Area HhVeh License
Disability Medi_ins Male;
run;

Proc Logistic data = survey;
Class Age Race Employment Area HhVeh (ref = '0') License (ref = '0')
Disability Medi_ins Male (ref= '0');
model RecTran (event='1') = Age Race Employment Area HhVeh License Disability
Medi_ins Male;
run;

Proc Logistic data = survey;
Class Age Race Employment Area HhVeh (ref = '0') License (ref = '0')
Disability Medi_ins Male (ref= '0');
model HCTran (event='1') = Age Race Employment Area HhVeh License Disability
Medi_ins Male;
run;

/***********   Walk Accessibility to Non-Work Amenities   **********/

Proc Logistic data = survey;
Class Age Race Employment Area HhVeh (ref = '0') License (ref = '0')
Disability Medi_ins Male (ref= '0');
model GrocWalk (event='1') = Age Race Employment Area HhVeh License
Disability Medi_ins Male;
run;

Proc Logistic data = survey;
Class Age Race Employment Area HhVeh (ref = '0') License (ref = '0')
Disability Medi_ins Male (ref= '0');
```

```
model PerserWalk (event='1') = Age Race Employment Area HhVeh License
Disability Medi_ins Male;
run;

Proc Logistic data = survey;
Class Age Race Employment Area HhVeh (ref = '0') License (ref = '0')
Disability Medi_ins Male (ref= '0');
model RetailWalk (event='1') = Age Race Employment Area HhVeh License
Disability Medi_ins Male;
run;

Proc Logistic data = survey;
Class Age Race Employment Area HhVeh (ref = '0') License (ref = '0')
Disability Medi_ins Male (ref= '0');
model RecWalk (event='1') = Age Race Employment Area HhVeh License Disability
Medi_ins Male;
run;

Proc Logistic data = survey;
Class Age Race Employment Area HhVeh (ref = '0') License (ref = '0')
Disability Medi_ins Male (ref= '0');
model HCWalk (event='1') = Age Race Employment Area HhVeh License Disability
Medi_ins Male;
run;
```

APPENDIX F. LOGISTIC REGRESSION MODELS RESULTS – PUBLIC TRANSIT ACCESS TO NON-WORK AMENITIES

Table F.1. Logistic Regression Results (Public Transit Access to Grocery Store)

Explanatory Variables	Odds Ratio	95% CI	S.E	p-value
Age Group (75 Years or Above)				
Age Group (18 to 34 Years)	3.241	(1.500 – 7.001)	0.2176	0.0083***
Age Group (35 to 54 Years)	2.184	(1.144 – 4.172)	0.1585	0.2573
Age Group (55 to 74 Years)	1.568	(0.944 – 2.604)	0.1221	0.2131
Race (Non-White)				
Race (White)	0.734	(0.477 – 1.129)	0.1100	0.1596
Employment (Unemployed and Students)				
Employment (Employed Full Time)	0.790	(0.423 – 1.475)	0.1535	0.0719*
Employment (Employed Part Time)	1.124	(0.594 – 2.125)	0.1555	0.6227
Employment (Retired)	1.323	(0.714 – 2.451)	0.1586	0.1305
Area (Non-Metro)				
Area (Metro)	1.918	(1.427 – 2.577)	0.0754	<.0001***
Household Vehicles (No Vehicle)				
Household Vehicles (1 Vehicle)	0.351	(0.134 – 0.919)	0.1811	0.3287
Household Vehicles (2 or more Vehicles)	0.210	(0.080 – 0.554)	0.1853	0.0002***
Driving License (No Driving License)				
Driving License (Have Driving License)	2.214	(0.890 – 5.507)	0.2325	0.0873*
Physical Disability (Physically Disable)				
Physical Disability (No Disability)	0.794	(0.506 – 1.244)	0.1146	0.3138
Medicare/Medicaid (Covered)				
Medicare/Medicaid (Not Covered)	1.280	(0.837 – 1.957)	0.1084	0.2550
Gender (Female)				
Gender (Male)	1.240	(0.917 – 1.676)	0.0770	0.1632

CI denote confidence interval. Explanatory variables in bold represent reference group.

Table F.2. Logistic Regression Results (Public Transit Access to Personal Services)

Explanatory Variables	Odds Ratio	95% CI	S.E	p-value
Age Group (75 Years or Above)				
Age Group (18 to 34 Years)	2.698	(1.228 – 5.927)	0.2209	0.0520*
Age Group (35 to 54 Years)	2.164	(1.115 – 4.200)	0.1610	0.1952
Age Group (55 to 74 Years)	1.630	(0.965 – 2.755)	0.1244	0.5489
Race (Non-White)				
Race (White)	0.768	(0.496 – 1.190)	0.1116	0.2376
Employment (Unemployed and Students)				
Employment (Employed Full Time)	0.722	(0.385 – 1.354)	0.1558	0.0943*
Employment (Employed Part Time)	0.980	(0.516 – 1.862)	0.1577	0.7734
Employment (Retired)	1.088	(0.585 – 2.023)	0.1613	0.3531
Area (Non-Metro)				
Area (Metro)	2.056	(1.522 – 2.776)	0.0767	<.0001***
Household Vehicles (No Vehicle)				
Household Vehicles (1 Vehicle)	0.591	(0.231 – 1.511)	0.1783	0.9354
Household Vehicles (2 or more Vehicles)	0.334	(0.130 – 0.862)	0.1821	0.0023***
Driving License (No Driving License)				
Driving License (Have Driving License)	2.272	(0.896 – 5.760)	0.2373	0.0837*
Physical Disability (Physically Disable)				
Physical Disability (No Disability)	0.915	(0.577 – 1.451)	0.1176	0.7050
Medicare/Medicaid (Covered)				
Medicare/Medicaid (Not Covered)	1.233	(0.800 – 1.901)	0.1104	0.3419
Gender (Female)				
Gender (Male)	1.072	(0.788 – 1.458)	0.0785	0.6577

Table F.3. Logistic Regression Results (Public Transit Access to Retail Shopping)

Explanatory Variables	Odds Ratio	95% CI	S.E	p-value
Age Group (75 Years or Above)				
Age Group (18 to 34 Years)	2.828	(1.303 – 6.137)	0.2196	0.0140**
Age Group (35 to 54 Years)	1.910	(0.997 – 3.659)	0.1597	0.3557
Age Group (55 to 74 Years)	1.367	(0.821 – 2.274)	0.1234	0.1288
Race (Non-White)				
Race (White)	0.763	(0.493 – 1.181)	0.1115	0.2250
Employment (Unemployed and Students)				
Employment (Employed Full Time)	0.783	(0.413 – 1.481)	0.1550	0.1301
Employment (Employed Part Time)	1.003	(0.522 – 1.929)	0.1584	0.9303
Employment (Retired)	1.221	(0.648 – 2.300)	0.1616	0.1931
Area (Non-Metro)				
Area (Metro)	2.199	(1.633 – 2.963)	0.0760	<.0001***
Household Vehicles (No Vehicle)				
Household Vehicles (1 Vehicle)	0.308	(0.115 – 0.826)	0.1851	0.2827
Household Vehicles (2 or more Vehicles)	0.172	(0.064 – 0.467)	0.1896	<.0001***
Driving License (No Driving License)				
Driving License (Have Driving License)	2.499	(0.969 – 6.445)	0.2416	0.0580*
Physical Disability (Physically Disable)				
Physical Disability (No Disability)	1.047	(0.659 – 1.663)	0.1182	0.8471
Medicare/Medicaid (Covered)				
Medicare/Medicaid (Not Covered)	1.247	(0.811 – 1.918)	0.1099	0.3149
Gender (Female)				
Gender (Male)	1.093	(0.806 – 1.484)	0.0779	0.5665

Table F.4. Logistic Regression Results (Public Transit Access to Recreation and Entertainment)

Explanatory Variables	**Odds Ratio**	**95% CI**	**S.E**	**p-value**
Age Group (75 Years or Above)				
Age Group (18 to 34 Years)	3.744	(1.621 – 8.649)	0.2279	0.0104**
Age Group (35 to 54 Years)	2.672	(1.303 – 5.480)	0.1685	0.1443
Age Group (55 to 74 Years)	1.904	(1.066 – 3.399)	0.1315	0.4801
Race (Non-White)				
Race (White)	0.762	(0.482 – 1.203)	0.1165	0.2432
Employment (Unemployed and Students)				
Employment (Employed Full Time)	1.094	(0.553 – 2.165)	0.1623	0.3499
Employment (Employed Part Time)	1.355	(0.670 – 2.740)	0.1691	0.7140
Employment (Retired)	1.773	(0.894 – 3.518)	0.1732	0.0558*
Area (Non-Metro)				
Area (Metro)	2.475	(1.805 – 3.394)	0.0805	<.0001***
Household Vehicles (No Vehicle)				
Household Vehicles (1 Vehicle)	0.681	(0.255 – 1.815)	0.1863	0.6644
Household Vehicles (2 or more Vehicles)	0.364	(0.135 – 0.980)	0.1911	0.0042***
Driving License (No Driving License)				
Driving License (Have Driving License)	2.103	(0.773 – 5.719)	0.2553	0.1454
Physical Disability (Physically Disable)				
Physical Disability (No Disability)	1.001	(0.607 – 1.652)	0.1277	0.9961
Medicare/Medicaid (Covered)				
Medicare/Medicaid (Not Covered)	1.484	(0.940 – 2.342)	0.1164	0.0899*
Gender (Female)				
Gender (Male)	1.190	(0.861 – 1.644)	0.0825	0.2920

Table F.5. Logistic Regression Results (Public Transit Access to Health Care Facility)

Explanatory Variables	Odds Ratio	95% CI	S.E	p-value
Age Group (75 Years or Above)				
Age Group (18 to 34 Years)	3.829	(1.762 – 8.321)	0.2172	0.0053***
Age Group (35 to 54 Years)	2.538	(1.317 – 4.891)	0.1589	0.2219
Age Group (55 to 74 Years)	1.966	(1.170 – 3.304)	0.1223	0.6143
Race (Non-White)				
Race (White)	0.780	(0.507 – 1.200)	0.1100	0.2584
Employment (Unemployed and Students)				
Employment (Employed Full Time)	0.723	(0.390 – 1.341)	0.1524	0.0904*
Employment (Employed Part Time)	0.940	(0.500 – 1.764)	0.1550	0.9810
Employment (Retired)	1.130	(0.615 – 2.078)	0.1577	0.2325
Area (Non-Metro)				
Area (Metro)	1.896	(1.411 – 2.549)	0.0754	<.0001***
Household Vehicles (No Vehicle)				
Household Vehicles (1 Vehicle)	0.361	(0.138 – 0.945)	0.1814	0.2834
Household Vehicles (2 or more Vehicles)	0.234	(0.089 – 0.617)	0.1851	0.0007***
Driving License (No Driving License)				
Driving License (Have Driving License)	2.077	(0.837 – 5.157)	0.2320	0.1151
Physical Disability (Physically Disable)				
Physical Disability (No Disability)	0.845	(0.538 – 1.327)	0.1151	0.4647
Medicare/Medicaid (Covered)				
Medicare/Medicaid (Not Covered)	1.114	(0.731 – 1.698)	0.1076	0.6162
Gender (Female)				
Gender (Male)	1.001	(0.740 – 1.354)	0.0771	0.9974

APPENDIX G. LOGISTIC REGRESSION MODELS RESULTS – WALK ACCESS TO NON-WORK AMENITIES

Table G.1. Logistic Regression Results (Walk Access to Grocery Store)

Explanatory Variables	Odds Ratio	95% CI	S.E	p-value
Age Group (75 Years or Above)				
Age Group (18 to 34 Years)	2.412	(1.195 – 4.869)	0.2014	0.0518*
Age Group (35 to 54 Years)	1.990	(1.106 – 3.580)	0.1468	0.1745
Age Group (55 to 74 Years)	1.472	(0.933 – 2.323)	0.1117	0.3600
Race (Non-White)				
Race (White)	0.599	(0.395 – 0.909)	0.1062	0.0160**
Employment (Unemployed and Students)				
Employment (Employed Full Time)	1.940	(1.072 – 3.511)	0.1416	0.3410
Employment (Employed Part Time)	2.541	(1.386 – 4.658)	0.1441	0.0050***
Employment (Retired)	1.676	(0.934 – 3.009)	0.1449	0.9378
Area (Non-Metro)				
Area (Metro)	1.727	(1.315 – 2.268)	0.0695	<.0001***
Household Vehicles (No Vehicle)				
Household Vehicles (1 Vehicle)	0.655	(0.265 – 1.619)	0.1708	0.7542
Household Vehicles (2 or more Vehicles)	0.365	(0.146 – 0.911)	0.1747	0.0024***
Driving License (No Driving License)				
Driving License (Have Driving License)	2.106	(0.857 – 5.176)	0.2294	0.1046
Physical Disability (Physically Disable)				
Physical Disability (No Disability)	2.069	(1.348 – 3.175)	0.1093	0.0009***
Medicare/Medicaid (Covered)				
Medicare/Medicaid (Not Covered)	0.863	(0.582 – 1.279)	0.1005	0.4620
Gender (Female)				
Gender (Male)	0.991	(0.751 – 1.307)	0.0707	0.9467

Table G.2. Logistic Regression Results (Walk Access to Personal Services)

Explanatory Variables	Odds Ratio	95% CI	S.E	p-value
Age Group (75 Years or Above)				
Age Group (18 to 34 Years)	2.456	(1.216 – 4.964)	0.2008	0.1452
Age Group (35 to 54 Years)	2.584	(1.431 – 4.665)	0.1472	0.0197**
Age Group (55 to 74 Years)	1.780	(1.127 – 2.812)	0.1119	0.7919
Race (Non-White)				
Race (White)	0.825	(0.546 – 1.246)	0.1053	0.3598
Employment (Unemployed and Students)				
Employment (Employed Full Time)	2.961	(1.587 – 5.525)	0.1436	0.0852*
Employment (Employed Part Time)	3.349	(1.771 – 6.334)	0.1462	0.0113**
Employment (Retired)	2.883	(1.560 – 5.328)	0.1464	0.1318
Area (Non-Metro)				
Area (Metro)	1.588	(1.209 – 2.086)	0.0695	0.0009***
Household Vehicles (No Vehicle)				
Household Vehicles (1 Vehicle)	0.556	(0.224 – 1.379)	0.1707	0.9279
Household Vehicles (2 or more Vehicles)	0.295	(0.118 – 0.740)	0.1757	0.0004***
Driving License (No Driving License)				
Driving License (Have Driving License)	2.335	(0.943 – 5.782)	0.2314	0.0669*
Physical Disability (Physically Disable)				
Physical Disability (No Disability)	1.554	(1.019 – 2.371)	0.1078	0.0408**
Medicare/Medicaid (Covered)				
Medicare/Medicaid (Not Covered)	0.776	(0.523 – 1.152)	0.1008	0.2089
Gender (Female)				
Gender (Male)	1.219	(0.924 – 1.610)	0.0708	0.1612

Table G.3. Logistic Regression Results (Walk Access to Retail Shopping)

Explanatory Variables	Odds Ratio	95% CI	S.E	p-value
Age Group (75 Years or Above)				
Age Group (18 to 34 Years)	2.204	(1.057 – 4.597)	0.2068	0.2862
Age Group (35 to 54 Years)	2.625	(1.410 – 4.886)	0.1518	0.0092***
Age Group (55 to 74 Years)	1.689	(1.036 – 2.751)	0.1170	0.6944
Race (Non-White)				
Race (White)	0.644	(0.425 – 0.977)	0.1063	0.0385**
Employment (Unemployed and Students)				
Employment (Employed Full Time)	2.512	(1.310 – 4.817)	0.1489	0.1429
Employment (Employed Part Time)	2.842	(1.462 – 5.527)	0.1517	0.0243**
Employment (Retired)	2.330	(1.223 – 4.439)	0.1538	0.3521
Area (Non-Metro)				
Area (Metro)	1.715	(1.294 – 2.274)	0.0719	0.0002***
Household Vehicles (No Vehicle)				
Household Vehicles (1 Vehicle)	0.480	(0.191 – 1.210)	0.1744	0.5092
Household Vehicles (2 or more Vehicles)	0.326	(0.128 – 0.828)	0.1784	0.0048***
Driving License (No Driving License)				
Driving License (Have Driving License)	2.141	(0.829 – 5.529)	0.2420	0.1157
Physical Disability (Physically Disable)				
Physical Disability (No Disability)	1.670	(1.061 – 2.628)	0.1157	0.0267**
Medicare/Medicaid (Covered)				
Medicare/Medicaid (Not Covered)	0.763	(0.507 – 1.151)	0.1047	0.1973
Gender (Female)				
Gender (Male)	1.291	(0.968 – 1.722)	0.0734	0.0816*

Table G.4. Logistic Regression Results (Walk Access to Recreation and Entertainment)

Explanatory Variables	Odds Ratio	95% CI	S.E	p-value
Age Group (75 Years or Above)				
Age Group (18 to 34 Years)	2.205	(1.053 – 4.613)	0.1996	0.2618
Age Group (35 to 54 Years)	2.522	(1.330 – 4.780)	0.1494	0.0164**
Age Group (55 to 74 Years)	1.735	(1.028 – 2.926)	0.1163	0.8923
Race (Non-White)				
Race (White)	0.850	(0.557 – 1.296)	0.1077	0.4502
Employment (Unemployed and Students)				
Employment (Employed Full Time)	1.113	(0.616 – 2.012)	0.1419	0.4940
Employment (Employed Part Time)	1.219	(0.664 – 2.238)	0.1461	0.1972
Employment (Retired)	0.767	(0.423 – 1.391)	0.1516	0.0693*
Area (Non-Metro)				
Area (Metro)	1.270	(0.959 – 1.684)	0.0718	0.0956*
Household Vehicles (No Vehicle)				
Household Vehicles (1 Vehicle)	1.078	(0.412 – 2.821)	0.1808	0.4619
Household Vehicles (2 or more Vehicles)	0.779	(0.296 – 2.051)	0.1832	0.2967
Driving License (No Driving License)				
Driving License (Have Driving License)	1.605	(0.621 – 4.149)	0.2423	0.3289
Physical Disability (Physically Disable)				
Physical Disability (No Disability)	2.577	(1.584 – 4.191)	0.1241	0.0001***
Medicare/Medicaid (Covered)				
Medicare/Medicaid (Not Covered)	0.966	(0.645 – (1.446)	0.1030	0.8658
Gender (Female)				
Gender (Male)	1.252	(0.939 – 1.667)	0.0732	0.1253

Table G.5. Logistic Regression Results (Walk Access to Health Care Facility)

Explanatory Variables	Odds Ratio	95% CI	S.E	p-value
Age Group (75 Years or Above)				
Age Group (18 to 34 Years)	2.593	(1.233 – 5.454)	0.2031	0.0186**
Age Group (35 to 54 Years)	1.760	(0.920 – 3.366)	0.1558	0.5624
Age Group (55 to 74 Years)	1.465	(0.875 – 2.454)	0.1194	0.4359
Race (Non-White)				
Race (White)	0.772	(0.501 – 1.191)	0.1105	0.2425
Employment (Unemployed and Students)				
Employment (Employed Full Time)	1.797	(0.935 – 3.455)	0.1518	0.2176
Employment (Employed Part Time)	1.988	(1.021 – 3.869)	0.1536	0.0608*
Employment (Retired)	1.381	(0.721 – 2.646)	0.1588	0.6319
Area (Non-Metro)				
Area (Metro)	1.018	(0.758 – 1.368)	0.0752	0.9033
Household Vehicles (No Vehicle)				
Household Vehicles (1 Vehicle)	0.408	(0.160 – 1.038)	0.1770	0.3711
Household Vehicles (2 or more Vehicles)	0.267	(0.104 – 0.687)	0.1814	0.0014***
Driving License (No Driving License)				
Driving License (Have Driving License)	1.950	(0.740 – 5.138)	0.2472	0.1769
Physical Disability (Physically Disable)				
Physical Disability (No Disability)	2.339	(1.412 – 3.875)	0.1287	0.0010***
Medicare/Medicaid (Covered)				
Medicare/Medicaid (Not Covered)	0.816	(0.534 – 1.248)	0.1083	0.3493
Gender (Female)				
Gender (Male)	1.137	(0.844 – 1.532)	0.0761	0.3993