

Article

Public Transit and Walk Access to Non-Work Amenities in the United States—A Social Equity Perspective

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Abstract

The primary goal of Transportation systems is to provide transportation accessibility to opportunities. Equitable access to essential destinations encompassing social, recreational, educational, and civic opportunities needs to be more consistent across different social groups. This study evaluates the disparities in social justice using social equity as a measure of transit access and walk access to non-work amenities. These non-work amenities include grocery stores, personal services, retail outlets, recreational venues, entertainment centers, and healthcare facilities in the U.S. Logistic regression models are developed using the 2017 National Community Livability Survey data. The results indicate regressive public transit access for socially disadvantaged groups, including older citizens, non-drivers, Medicare/Medicaid beneficiaries, and non-metropolitan residents. Walk access inequities similarly affect older individuals, non-drivers, the physically disabled, the unemployed, students, women, and non-metropolitan residents. This research emphasizes the importance of addressing transit and walk-access inequities to non-work amenities within transportation systems. By acknowledging the disparities in transportation equity, decision-makers and communities can foster more inclusive and equitable access to essential destinations, thereby promoting social cohesion and overall community well-being.

Keywords: social equity; public transit; walking; accessibility; non-work amenities; logistic regression



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1. Introduction

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, races, etc. [1]. McCahill and Ebeling (2015) presented a transportation equity framework that outlined four key dimensions of equity, including: (1) accessibility, (2) affordability, (3) health and safety, and (4) procedural equity [2]. In a broader context, accessibility measures the ease of reaching important destinations, such as shopping, work, school, and various services from a given location within a specified travel cost or time limit. Affordability refers to the financial cost transportation users must bear regarding out-of-pocket travel costs, as opposed to considerations of travel time or distance covered. Health and safety dimensions cover the potential effects of transportation on the well-being

and safety of diverse social classes within a community. The procedural equity dimension refers to the procedure of how transportation projects are executed and delivered. This includes the participation of people from different social groups and the contribution of feedback to relevant agencies.

Within the transportation system, accessibility has been recognized as the primary motivation for travel, and it is regarded as the most valuable equity indicator tool. This is because it effectively captures the relationship between individuals and various geographical locations [3,4]. Sundquist et al. (2017) categorize accessibility into two general types: employment accessibility, i.e., ease of reaching job locations from home, and non-work accessibility, i.e., ease of reaching parks, grocery stores, schools, and other such destinations from a given origin point [5]. It is evident from the past literature that accessibility to essential life activities plays a vital role in a person's quality of life and life satisfaction [6,7]. Therefore, it is important to investigate social justice regarding people's ability to access destinations that are important for their everyday life activities. Cities are crucial for the enrichment of life and the economic well-being of people. Still, many urban policies have done little to achieve their goals or have had counterproductive and unintended consequences [8]. Developing smart cities with a combination of ecological wisdom is essential for sustainable urban development, which will potentially offer a productive synthesis in urban planning practice [9].

An effective public transit system should enhance access to employment and essential services, given the recognition that private automobiles are not universally accessible modes of travel for everyone [10]. Improvements in the quality of public transit services and the ability of people to reach their desired destinations are vitally important for people who rely on public transit. This is particularly significant for those who either cannot drive or cannot afford a personal vehicle, resulting in restricted accessibility to carry out their daily activities, especially in areas with limited or no public transit services [11].

Walkability is defined as the level to which the built environment motivates walking by providing pedestrians with a safe, convenient, comfortable, and attractive travel corridor [12]. Walking, combined with other modes such as public transit or driving, plays a crucial role in providing access, particularly for people with disabilities, children, older adults, and low-income people. This underscores the significance of assessing equity in the transportation system by considering access to services via walking as an important indicator [13]. This study investigates social equity by examining people's ability to access non-work-related amenities in the United States using public transit or walking.

While prior research has recognized the importance of accessibility and examined specific aspects of equity within transportation, a gap exists in understanding social equity regarding people's ability to access non-work-related amenities via public transit or walking modes nationwide. To address this research gap, this study evaluated social equity in the context of access to non-work amenities across the United States. Understanding these equity disparities could be significant for advancing social justice in transportation. By examining accessibility to non-work destinations at a national scale, this study provides valuable insights towards developing interventions and policies to promote equitable access to essential services and improve the well-being and quality of life for marginalized populations.

2. Literature Review

2.1. Accessibility Broad Definition

Accessibility in transportation refers to the level of opportunities for interaction [14]. It is defined broadly 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" [15]. Poor

accessibility to transportation modes limits access to recreation, work, health services, study, and social interaction, impacting economic development and social inclusion [16,17].

Unlike conventional mobility measures such as travel time or level of service, accessibility accounts for the connection between land use and transportation [18]. It has been incorporated into transportation equity to consider spatial and social factors in social welfare assessments [19]. Equity indicators in transportation studies are typically selected based on community transportation priorities, encompassing access to employment, health-care resources, grocery stores, reduced travel times, and improved walkability [1]. Curl (2018) demonstrated differences between objective and perceived self-reported measures of access to different destinations in terms of journey times [20]. The author used data from Greater Nottingham, UK, as a demonstrative case study, utilizing a national-level accessibility indicators dataset. They compared this dataset with self-reported travel times for various destinations via public transport, walking, and car. The author concluded that both social and spatial variation in accessibility measures should be considered for equity analysis.

2.2. Karel Martens' Theory of Transportation Justice

Martens criticized the traditional approach to equity analysis in transportation, which centered on travel demand. He describes this approach as rooted in the idea of equality based on people's travel demands, leading to mobility-oriented transportation planning, such as increasing speed and reducing congestion. Martens argued that this approach exacerbates existing transportation inequalities for low-income groups and non-drivers, ultimately causing more hardships [21–24].

Martens introduced a transportation justice theory centered on travel needs, accessibility, and people, in contrast to the traditional approach focusing on mobility, travel demand, and system performance. Martens focuses on the Rawlsian theory of justice to determine the 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 a minimum floor constraint, (3) maximizing the average level of access with a range constraint, and (4) maximizing the lowest access level [25]. Martens finds the third principle (also called the Maximax criterion) 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 [18,23].

Martens introduced four principles of justice applied to transportation planning: (1) people experiencing insufficient accessibility in the 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 [24].

2.3. Non-Work Accessibility and Equity

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, finding disparities favoring white neighborhoods [26]. Scott and Horner (2008) conducted a detailed study using accessibility measures and a variety of destination types in Louisville, showing that four out of five underprivileged socioeconomic groups did not experience accessibility disadvantages in reaching important destinations [27]. Grengs (2015) estimated non-work accessibility indicators and evaluated social equity in non-work accessibility in Detroit, highlighting advantages for underprivi-

leged groups regarding physical accessibility to specific amenities but disadvantages in reaching supermarkets and shopping due to low vehicle ownership [28]. Ahern and Hine (2015) examined healthcare access for older people in rural Ireland, revealing challenges in accessing healthcare services due to a lack of coordination between health service providers and transportation operators [29]. Dharmadhikari and Lee (2015) analyzed public transit accessibility to grocery stores for students in Fargo, North Dakota, showing moderate accessibility within a 10 min walk to bus stops [30]. Kim et al. (2018) studied healthcare accessibility in Seoul, Korea, finding high inequity in accessibility distribution to private healthcare facilities [31]. Aitken et al. (2018) assessed accessibility to public transit stops and the walking environment in Santiago de Chile, identifying areas with inadequate equity indicators and failing to meet minimum equity standards [32].

Giuffrida et al. (2022) presented a simplified framework for considering equity in public transit network evaluation and design. For equity analysis purposes, the authors considered zonal-level socio-demographic characteristics and public transit accessibility to main opportunities, e.g., educational facilities, health services, industrial sites, railway stops, offices, etc. The framework was demonstrated through its application to a case study of Molfetta, Italy. The study results indicated improvement in equity of public transit accessibility to different opportunities in the main urban area, but some peripheral areas still lack accessibility. The authors suggested introducing demand-responsive public transit services in low-demand peripheral areas [33]. Bereitschaft (2023) conducted a study to find out whether socially vulnerable populations have equitable access to public transit and walkable-access neighborhoods within America's largest metropolitan areas. The study results indicated equitable access to walkable and public transit-accessible neighborhoods for socially vulnerable populations. The study results also showed concerningly higher levels of personal crimes, lower public transit accessibility, and poorer-performing schools for socially vulnerable populations living in more walkable neighborhoods [34]. Chen (2023) examined the spatial equity of public service facilities by considering both the supply of public service facilities and demand, utilizing the node centrality optimization method. Using the central city of Shanghai as a case study, the authors considered the characteristics of population distribution in residential locations, the structure of pedestrian pathways, and the layout of existing public service facilities for spatial equity analysis. Based on the study results, the authors concluded that spatial equity in access to public service facilities can be enhanced by optimizing the public service facilities layout, spatial patterns in residential locations, and pedestrian pathways [35]. Cai et al. (2024) evaluated the equity of public charging services in central Shanghai. The study results revealed that 81% of households access only 10% of services, and two-thirds of subdistricts face supply–demand conflicts [36]. Khan et al. (2025) evaluated how street network attributes affect pedestrian accessibility around transit stations. The findings from the study revealed that network configuration plays the most significant role in explaining accessibility, offering insights for optimizing transit station locations [37].

Khattak et al. (2023) examined the spatial equity regarding walking access to parks/green spaces using the methods of the Lorenz curve and the Gini coefficient. The accessibility metrics were estimated using a modified gravity model for the case study of Islamabad, Pakistan. The study results indicated inequalities in terms of walking access to parks/green spaces in Islamabad [38]. Wan et al. (2024) evaluated the relationship between transit-oriented development (TOD) and social equity in rail transit station areas using XGBoost and SHAP machine learning techniques. Using Dalian, China, as a case study, the results revealed that economic factors, particularly commuter population densities, significantly influence social equity outcomes [39]. Zheng et al. (2020) evaluated spatial equity regarding access to public green spaces in Zhengzhou, China using kernel density

two-step floating catchment area (KD2SFCA) method. The authors considered walking, bicycling, public transport, and private cars as modes of access to public green spaces. The study results indicated that spatial equity was highest for district public green spaces, community public green spaces were second, and municipal public green spaces were the lowest [40]. Shafiq et al. (2024) analyzed transport disadvantages in the Porto Metropolitan Area by integrating geographic and statistical methods to identify population groups with limited public transport access. The study findings indicated that suburban and rural areas face poor coverage and low service frequencies [41].

While previous studies have examined transportation equity and accessibility to employment and non-work destinations, there is a gap in the comprehensive national-scale analysis of accessibility to non-work amenities using public transit and walking modes. Existing studies have focused on specific metropolitan areas and regions. By conducting a nationwide analysis, this study addresses this research gap and offers a comprehensive understanding of social equity in access to non-work amenities across the United States.

3. Data and Methods

3.1. Data

The data utilized in this study is derived from the National Community Livability Survey (NCLS), conducted in 2017 from April to December in the United States. The Texas A&M Transportation Institute and the Upper Great Plains Transportation Institute (UGPTI) at North Dakota State University jointly administered the survey. The survey aimed to evaluate the role of public transit and non-motorized transportation in community quality of life (QOL) and overall life satisfaction (OLS) of individuals and to analyze the livability of a community as a whole [42]. A stratified random sampling technique was employed to ensure an adequate proportional distribution of the survey to the U.S. adult non-institutionalized population. The survey sample was stratified based on nine Census Divisions, four U.S. regions, by sex, and by age to ensure adequate participation of respondents across the U.S. from each major geographic area. The surveys were sent to 25,000 adults across 50 U.S. states. A total of 994 completed responses were received, with an overall 4% response rate. Information was collected from respondents about the livability of a community (both general and local), public transit, non-motorized transportation, accessibility to non-work amenities by public transit and walk, individual's OLS, community QOL, future transportation and technology, and sociodemographic indicators. Portions of survey data used in this study are described below.

The non-work accessibility indicators and respondents' sociodemographic characteristics are included in this study for analysis purposes. To understand the non-work accessibility indicators, the survey included two questions: one to understand the respondent's ability to access non-work amenities through public transit and another to understand the respondent's ability to access non-work amenities by walking. The non-work amenity options included in the survey questions were: (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) healthcare facility (hospital, doctor's office, and urgent care). Accessibility to non-work amenities through public transit and walking was measured as an indicator variable 0 (cannot access the corresponding non-work amenity) and 1 (can access the respective non-work amenity). Table 1 shows the frequency and respective percentage of respondents who can access non-work amenities by using public transit (if public transit is available in their community) or walking. It can be observed that less than half of the respondents mentioned that they could access non-work amenities using public transit mode and walking.

Table 1. Accessibility and sociodemographic variables.

Variables	Frequency	Percentage
Accessibility Indicators		
Public transit access to non-work amenities (Yes)		
Grocery store or supermarket	348	35%
Personal services	328	33%
Other retail shopping	348	35%
Recreation and entertainment	288	29%
Healthcare facility	348	35%
Walk access to non-work amenities (Yes)		
Grocery store or supermarket	447	45%
Personal services	417	42%
Other retail shopping	338	34%
Recreation and entertainment	348	35%
Healthcare facility	288	29%
Sociodemographic Indicators		
Age		
18–34 years	80	8%
35–54 years	249	25%
55–74 years	517	52%
75 years or above	149	15%
Race		
White	865	87%
Non-white	129	13%
Employment		
Unemployed and students	179	18%
Employed full-time	348	35%
Employed part-time	109	11%
retired	358	36%
Area Type		
Metro	417	42%
Non-metro	577	58%
Number of vehicles in the Household		
No household vehicle	40	4%
One vehicle in the household	278	28%
Two or more vehicles in the household	676	68%
Driving License		
No driving license	50	5%
Have a driving license	944	95%
Physical Disability		
Physically disabled	169	17%
no physical disability	825	83%
Medicare/Medicaid (Covered)		
Medicare/Medicaid (covered)	417	42%
Medicare/Medicaid (not covered)	577	58%
Gender		
Male	407	41%
Female	587	59%

The sociodemographic characteristics of the respondents considered in this study were age, race, employment, type of area living (metro and non-metro), number of vehicles in the household, driving license, physical disability, Medicare/Medicaid, and gender. The frequency and percentage of the survey sample for each sociodemographic category are given in Table 1.

3.2. Methods

3.2.1. Transportation Equity Categories

Equity in transportation has been categorized into three different types, including: (1) horizontal equity, (2) vertical equity for income and social class, and (3) vertical equity for mobility needs and ability [43].

Horizontal Equity

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

Vertical Equity with Respect to Income and Social Class

Vertical equity for income and social class is specifically related to transportation benefits and cost 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 to recompense for overall system inequities [25]. In other words, in transportation equity assessment, progressive equity refers to situations where socially disadvantaged groups experience comparatively better accessibility outcomes, while regressive equity arises when they face poorer accessibility to opportunities compared to socially advantaged 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 are often referred to as public transit-dependent populations.

Vertical Equity with Respect to Mobility Need and Ability

Vertical equity for mobility needs and ability specifically relates to the distribution of transportation impacts among individuals with varying mobility needs and abilities; for instance, a person with physical disabilities or who cannot drive. In this category, an equitable transportation system should support services and facilities that accommodate all users, particularly those with special needs.

Following the vertical equity concepts, past research recommended vertical equity for the transportation sector, where transportation benefits could be provided more favorably to disadvantaged groups of the community [18,23,44,45]. This study investigates the second and third types of equity categories, i.e., vertical equity with respect to social class, income, mobility need, and physical ability regarding people's ability to access non-work amenities through public transit and walking in the US.

3.2.2. Equity Evaluation Methods

In transportation literature, different techniques have been used for equity analysis depending on the scope of the study, equity indicators, and the 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, and quality of walking, are the Gini coefficient, Lorenz curve, Atkinson index, Theil index, and independent sample *t*-test [32,46–48].

Martinelli & Medellin (2007) used an 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 [46]. Bereitschaft (2017) used an 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 those with low SV [48]. Similarly, Hamre (2017) applied logistic regression for social equity evaluation by considering employer-based public transit subsidies as a performance measure [49]. This study used the logistic regression modeling technique to evaluate social equity regarding people's ability to access non-work amenities through public transit and walking.

3.2.3. Modeling Strategy for Equity Analysis

The response/dependent variable in the logistic regression models is people's ability to access respective non-work amenities through public transit or walking. The study used binary logistic regression models for equity evaluation because the considered response variable was dichotomous, i.e., 0 (cannot access respective non-work amenity through public transit or walking) and 1 (can access respective non-work amenity through public transit or walking). Demographic variables, including age, race, employment, area type (metro vs. non-metro), number of vehicles in the household, driver's license, physical disability, individuals who are or are not covered under Medicare/Medicaid program, and gender, are used as explanatory variables in each model. For example, in the first logistic regression model developed, the response variable will be "public transit access to grocery stores" with sociodemographic indicators as explanatory variables. Similarly, separate binary logistics regression models will be developed for each amenity considered in this study.

The odds ratios will be established by developing each model to investigate the likelihood of access to respective non-work amenities by each demographic/socioeconomic group. The odds of socially disadvantaged groups' ability to access non-work amenities compared to respective socially advantaged groups will be determined. The socially disadvantaged groups considered in this study include older adults, minority populations, unemployed individuals, students, people residing in non-metro areas, those without a vehicle in their household, individuals without a driving license, physically disabled individuals, those covered under the Medicare/Medicaid program, and females. Past research suggests that women's daily travel patterns differ from men's. Due to their caretaking and household responsibilities, women are more likely to travel to non-work amenities than men, such as shops, childcare facilities, health centers, etc. Women are also more reliant on public transit than men, especially those in lower-income families [50,51]. The odds of women's ability to access non-work amenities compared to men will also be investigated in this study. The study considered people who are covered under the Medicare/Medicaid program as disadvantaged because these people mainly belong to low-income, physically disabled, and older age groups. McCahill and Ebeling (2015) considered rural populations under transportation-specific disadvantaged groups in their transportation equity framework [2]. The study will also compare access to non-work amenities across urban/metro and rural/non-metro areas.

The generalized form of the logistic regression model incorporated in this study is given as:

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

where

$$Y = \begin{cases} 1, & \text{Access to respective non-work amenity} \\ 0, & \text{Otherwise} \end{cases} \quad (2)$$

Y is the binary response variable, β_0 is the intercept to be calculated, and β_i and X_i represent an estimated vector of parameters and a vector of independent variables,

respectively. The maximum likelihood estimation technique is used in Equation (3) to estimate the parameters. The odds in logistic regression are calculated as follows:

$$Odds = \frac{Pr(Y = 1)}{1 - Pr(Y = 1)} \quad (3)$$

The *odds* ratios were used to investigate the likelihood of access to respective non-work amenities by each demographic/socioeconomic group. The odds of access to non-work amenities for socially disadvantaged groups compared to their respective socially advantaged groups were determined. The study will also compare access to non-work amenities across urban/metro and rural/non-metro areas.

4. Results and Discussion

This section discusses the equity analysis results regarding public transit and walk access to non-work amenities as an equity indicator. The odds of reaching the respective non-work amenity through public transit and walking for disadvantaged groups are compared to those for other groups for equity analysis. Furthermore, accessibility is evaluated as the perceived potential to walk or use public transport, rather than the actual use of these modes, and the findings should be interpreted accordingly.

4.1. Public Transit Access to Non-Work Amenities

Table 2 shows the odds ratios and their respective *p*-value estimates for the likelihood of accessing non-work amenities using public transit for the five models, each representing access to specific amenities. Binary logistic regression models were developed separately for each non-work amenity category. The variables in bold represent the reference group or disadvantaged group. The *p*-value indicates the statistical significance of the estimated odds ratios. The rest of this section discusses the results shown in Table 2 in more detail.

4.1.1. Public Transit Access for Seniors Compared to Other Age Groups

The model used seniors (>75 years) as the base case for comparison to other age groups. All the odds ratios for young adults (18–34 years) were statistically significant and significantly higher than those of seniors (see Figure 1). Young adults had higher odds of accessing all the non-work amenities, ranging from 2.698 times for retail shopping to 3.829 times for healthcare facilities. For middle-aged adults (35 to 54 years) and older adults (55 to 74 years), the results were statistically insignificant. Young adults, perhaps, are still starting their lives and probably have less access to personal autos compared to middle-aged and older adults. This explains why their results were statistically significant. Seniors, on the other hand, may not have access to personal autos mainly due to their physical abilities and may need some form of public transport to access non-work amenities. The results of this study help identify inequities in access to public transport and could be used by policymakers to design public transportation that caters to seniors.

Table 2. Public transit access to non-work amenities—Odds ratios estimates.

Explanatory Variables	Grocery Stores		Personal Services		Retail Shopping		Recreation and Entertainment		Healthcare Facility	
	O.R	<i>p</i> -Value	O.R	<i>p</i> -Value	O.R	<i>p</i> -Value	O.R	<i>p</i> -Value	O.R	<i>p</i> -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 **	3.744	0.0104 **	3.829	0.0053 ***
Age Group (35 to 54 Years)	2.184	0.2573	2.164	0.1952	1.910	0.3557	2.672	0.1443	2.538	0.2219
Age Group (55 to 74 Years)	1.568	0.2131	1.630	0.5489	1.367	0.1288	1.904	0.4801	1.966	0.6143
Race (Non-White)										
Race (White)	0.734	0.1596	0.768	0.2376	0.763	0.2250	0.762	0.2432	0.780	0.2584
Unemployed and Students										
Employed Full Time	0.790	0.0719 *	0.722	0.0943 *	0.783	0.1301	1.094	0.3499	0.723	0.0904 *
Employed Part Time	1.124	0.6227	0.980	0.7734	1.003	0.9303	1.355	0.7140	0.940	0.9810
Retired	1.323	0.1305	1.088	0.3531	1.221	0.1931	1.773	0.0558 *	1.130	0.2325
Area (Non-Metro)										
Area (Metro)	1.918	<0.0001 ***	2.056	<0.0001 ***	2.199	<0.0001 ***	2.475	<0.0001 ***	1.896	<0.0001 ***
No Household Vehicle										
One Household Vehicle	0.351	0.3287	0.591	0.9354	0.308	0.2827	0.681	0.6644	0.361	0.2834
Two or more Household Vehicles	0.210	0.0002 ***	0.334	0.0023 ***	0.172	<0.0001 ***	0.364	0.0042 ***	0.234	0.0007 ***
No Driving License										
Have Driving License	2.214	0.0873 *	2.272	0.0837 *	2.499	0.0580 *	2.103	0.1454	2.077	0.1151
Physically Disable										
No Physical Disability	0.794	0.3138	0.915	0.7050	1.047	0.8471	1.001	0.9961	0.845	0.4647
Medicare/Medicaid (Covered)										
Medicare/Medicaid (Not Covered)	1.280	0.2550	1.233	0.3419	1.247	0.3149	1.484	0.0899 *	1.114	0.6162
Gender (Female)										
Gender (Male)	1.240	0.1632	1.072	0.6577	1.093	0.5665	1.190	0.2920	1.001	0.9974

*, **, *** represent significance at 10%, 5%, and 1% levels, respectively. O.R. denotes the odds ratio.

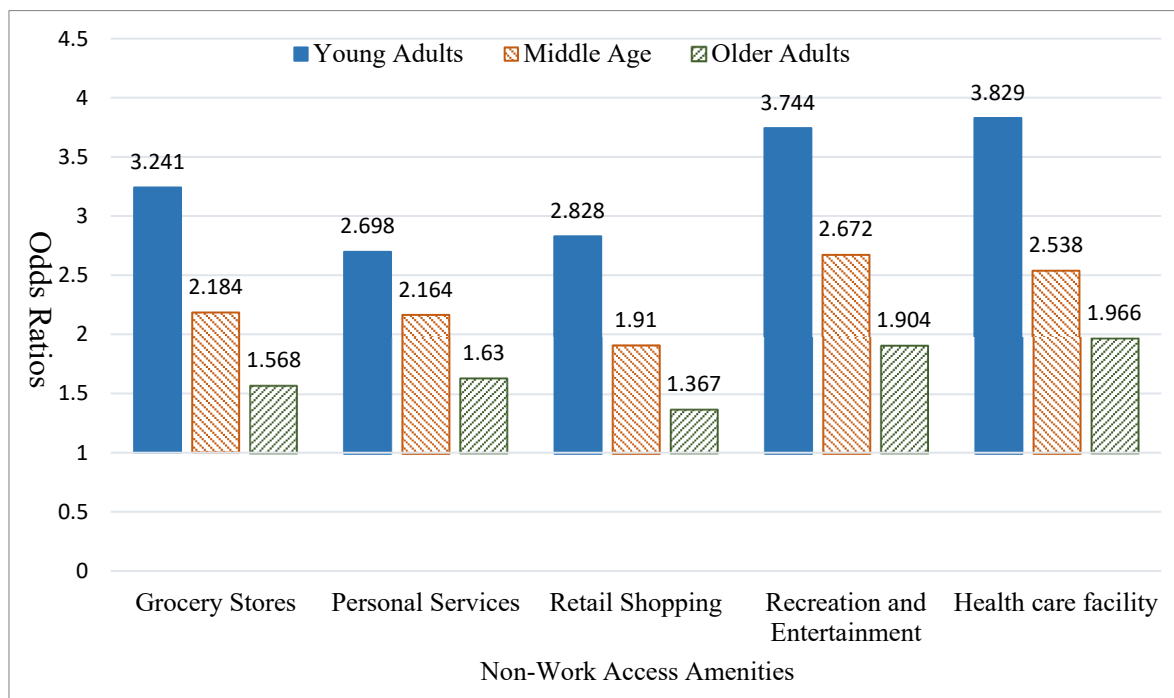


Figure 1. Odd Ratios for Seniors compared to other age groups for Public Transit Access to Non-Work Amenities (All patterned columns are insignificant).

4.1.2. Race-Based Public Transit Access to Non-Work Amenities

The results for public transit access to non-work amenities were compared for non-white and white respondents. The results for this explanatory variable were statistically insignificant for all the non-work categories. The Odds Ratios were lower for the white respondents. The odds ratio indicated that white respondents were less likely to access public transport than their non-white counterparts for non-work amenities. However, it is important to interpret this result cautiously, as it does not necessarily imply that white respondents have inherently lower access to public transport infrastructure. It could suggest that they may have alternative transportation options or different preferences regarding modes of transportation. The findings are in agreement with the previous studies that emphasized the importance of public transportation for minority and low-income populations [16,52] and consistent with the findings at the Metropolitan Statistical Area (MSA) level [53].

4.1.3. Employment-Based Public Transit Access to Non-Work Amenities

Full-time employed respondents had lower access to public transit services compared to the unemployed/students. The results were significant for all the non-work amenities except for retail shopping, recreation, and entertainment (see Figure 2). The results may indicate that full-time employed respondents potentially had higher access to personal autos. For part-time employees, the results were statistically insignificant. Interestingly, the odds of access to recreation and entertainment were both statistically significant and higher for the retired employment category when compared to the unemployed/students. This finding can be attributed to the fact that retired individuals typically have more leisure time to engage in recreational and entertainment activities and often belong to the older age group that relies more heavily on public transportation services.

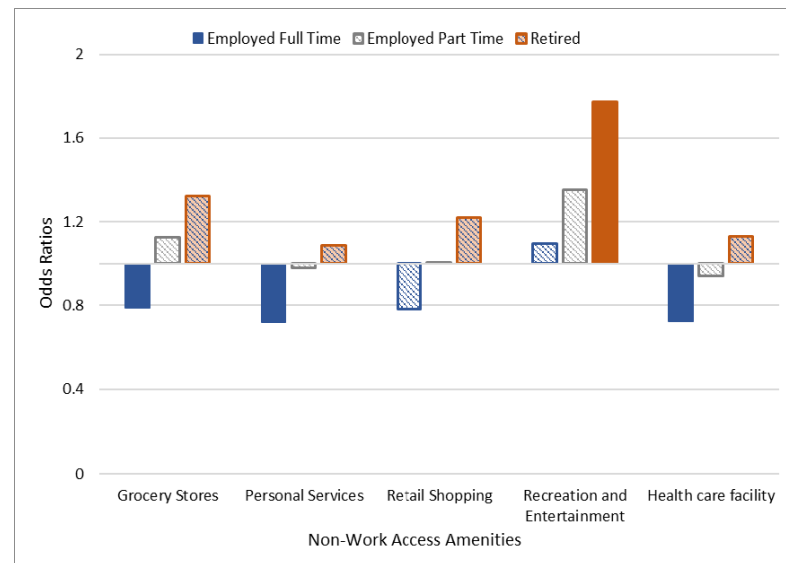


Figure 2. Odds Ratios for the unemployed and students as reference group compared to other employment categories for Public Transit Access to Non-Work Amenities.

4.1.4. Public Transit Access for Metro and Non-Metro Area Residents

In all the logistic regression models developed, the odds of access were significantly higher for metro area residents than those in non-metro areas (see Figure 3). This finding shows a significant disparity in the urban–rural divide regarding public transportation availability and accessibility in the US. Several factors contribute to this disparity. Metro areas are typically denser in population compared to rural areas. This leads to more extensive public transit networks, a greater service frequency, and enables the development and maintenance of comprehensive transit systems. Secondly, metro areas typically have a higher demand for public transit due to congestion, which leads to higher investments and funding support for transit options. On the other hand, non-metro areas face challenges both financially and politically in providing efficient and cost-effective public transit solutions due to their lower densities and limited financial resources. Based on the study results, policymakers and public transit agencies should place greater emphasis on improving public transit services in non-metro areas.

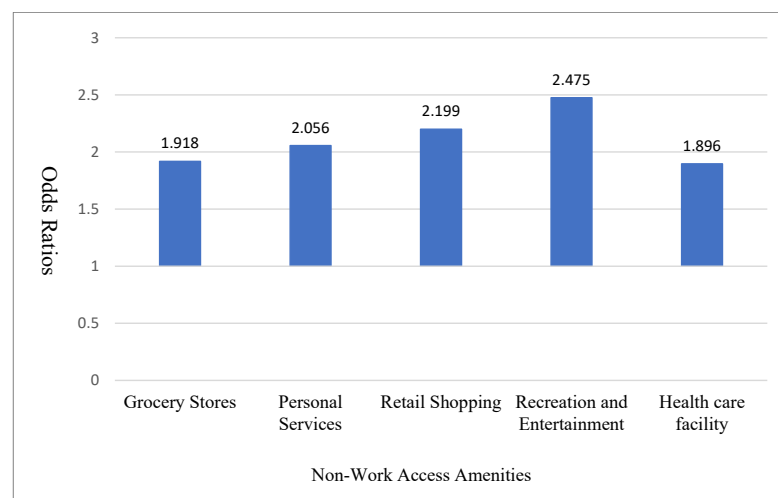


Figure 3. Odds Ratios for Metro Area Residents Compared to Non-metro Area Residents for Public Transit Access to Non-work Amenities.

4.1.5. Public Transit Access Based on the Number of Vehicles in the Household

The odds ratios estimated for respondents with no household vehicle as the reference group to respondents with household vehicle(s) are shown in Figure 4. Individuals with no vehicles in their households had significantly higher odds of public transit access to each non-work amenity than those with two or more vehicles. This result suggests that individuals without household vehicles depend more on transit as their primary mode of transportation to access essential non-work amenities. There are several potential reasons for this. Firstly, individuals without vehicles may have financial constraints, lack driving licenses, or make conscious choices to use public transportation for environmental or lifestyle reasons. The results underscore the importance of considering vehicle ownership when making transportation planning decisions and including this in the equity evaluation of transportation system improvements.

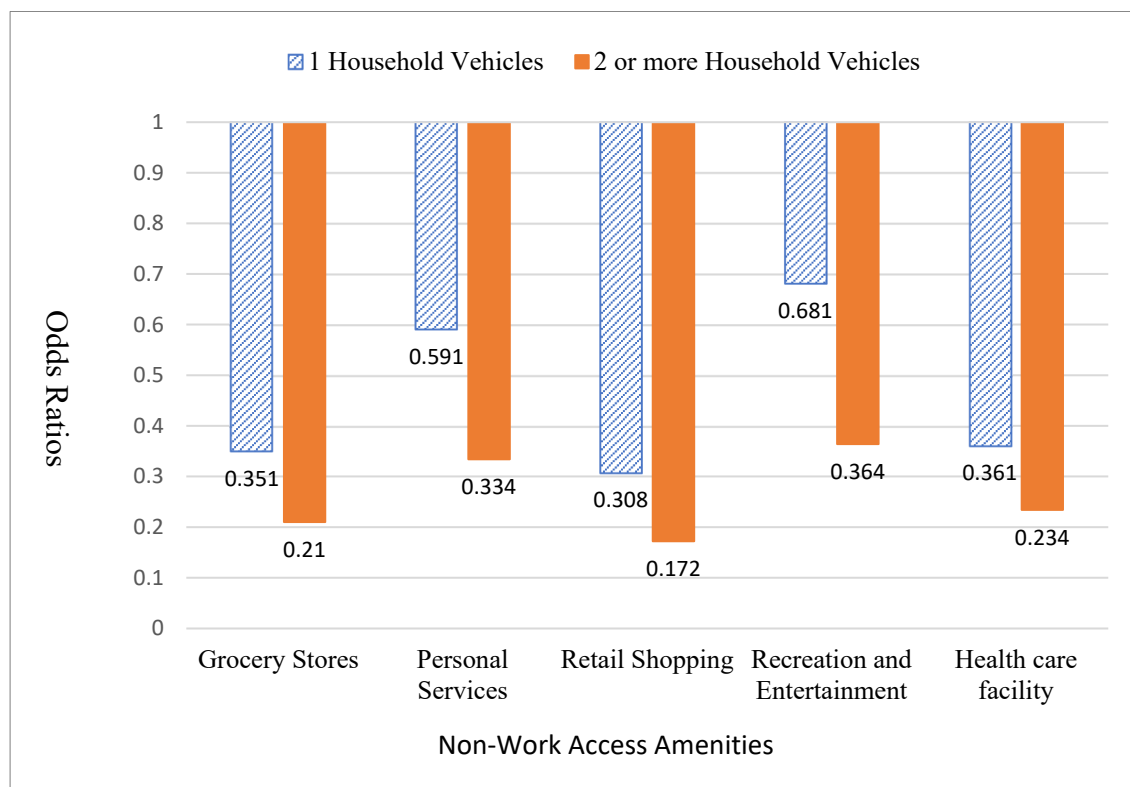


Figure 4. Odds Ratios for Respondents with no Household Vehicle to Respondents with Household Vehicle(s) for Public Transit Access to Non-work Amenities.

4.1.6. Public Transit Access for Respondents with/or Without a Driving License

The other interesting and significant variable was “driving license”. The individuals with driving licenses have significantly higher odds of public transit access to grocery stores, personal services, and retail shopping amenities than their counterparts with no driving licenses, as shown in Figure 5. The variable driving license was used as a proxy for the respondent’s ability to drive. There is a limitation with this assumption, as some respondents may drive without a license, and others with a driving license may not feel comfortable driving to access these amenities. The results suggest that while having a driving license generally gives individuals higher private vehicle access to non-work, it does not necessarily imply a lower reliance on public transit. Instead, individuals with a driving license may utilize public transit as an alternative mode of transportation, potentially due to factors such as traffic congestion, parking challenges, or personal preferences. The result raises important policy considerations regarding the integration of public transit

and private vehicle use. It emphasizes the need to develop transportation strategies that provide adequate connections between modes of transportation. Additionally, with the emergence of ride-sharing services such as Uber and Lyft, individuals with driving licenses may choose these convenient options instead of driving themselves to access non-work amenities. These services can also complement public transit by providing flexible, on-demand connections where transit coverage is limited. The findings highlight that equitable access to transportation is shaped by multiple factors, including the availability of alternative modes like ridesharing, and should be considered when addressing disparities in public transit access.

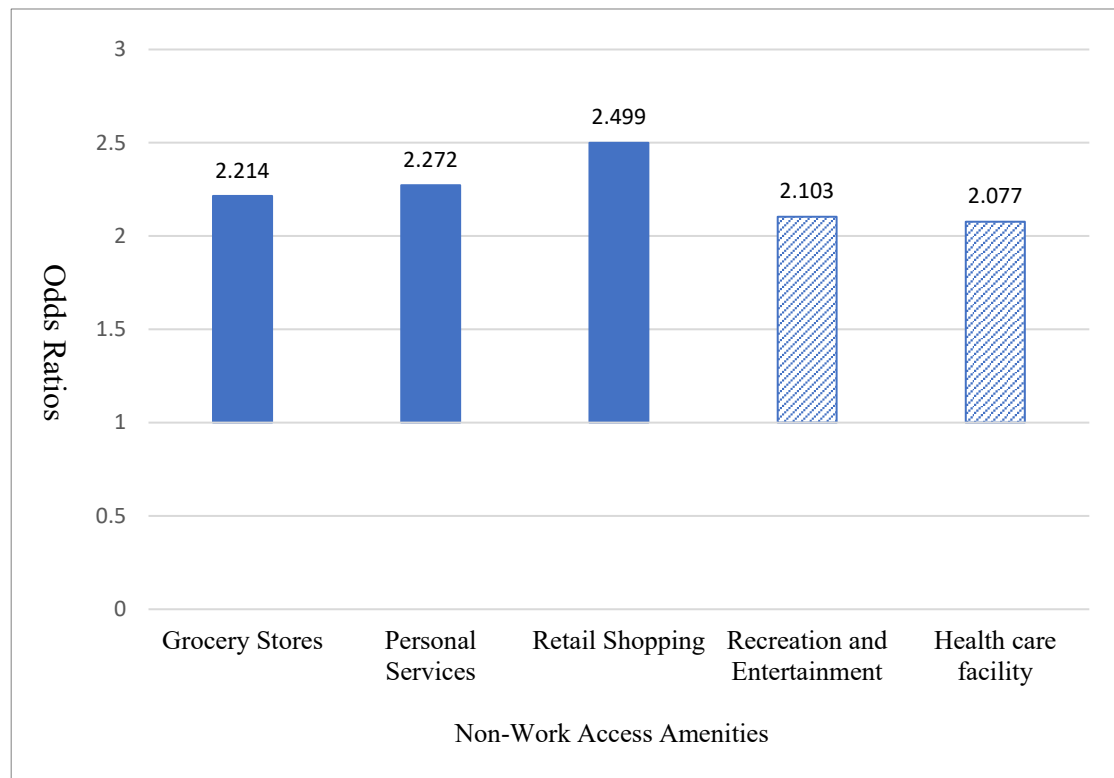


Figure 5. Odds Ratios for Respondents with no Driving License to Respondents with Driving License for Public Transit Access to Non-work Amenities.

4.1.7. Public Transit Access for Respondents Covered Under Medicare/Medicaid or Not

Medicare/Medicaid was significantly associated only with the likelihood of public transit access to recreation and entertainment amenities. The results show that individuals who are not covered under the Medicare/Medicaid program had significantly higher odds of accessing public transit for recreation and entertainment facilities compared to their counterparts, as shown in Figure 6. The individuals covered under the Medicare/Medicaid program mostly belong to the older age group, lower incomes, and people with disabilities. This finding aligns with the broader equity challenges faced by older individuals, non-drivers, and residents of non-metropolitan areas regarding public transit access to non-work amenities. A report by the United Nations 2015 stated that the older age (65 years or older) population is expected to reach 1.4 billion in urban areas globally by 2030 [48]. By addressing the unique mobility challenges older individuals face, such as limited driving abilities and reliance on public transportation, policymakers can enhance their overall quality of life and livability.

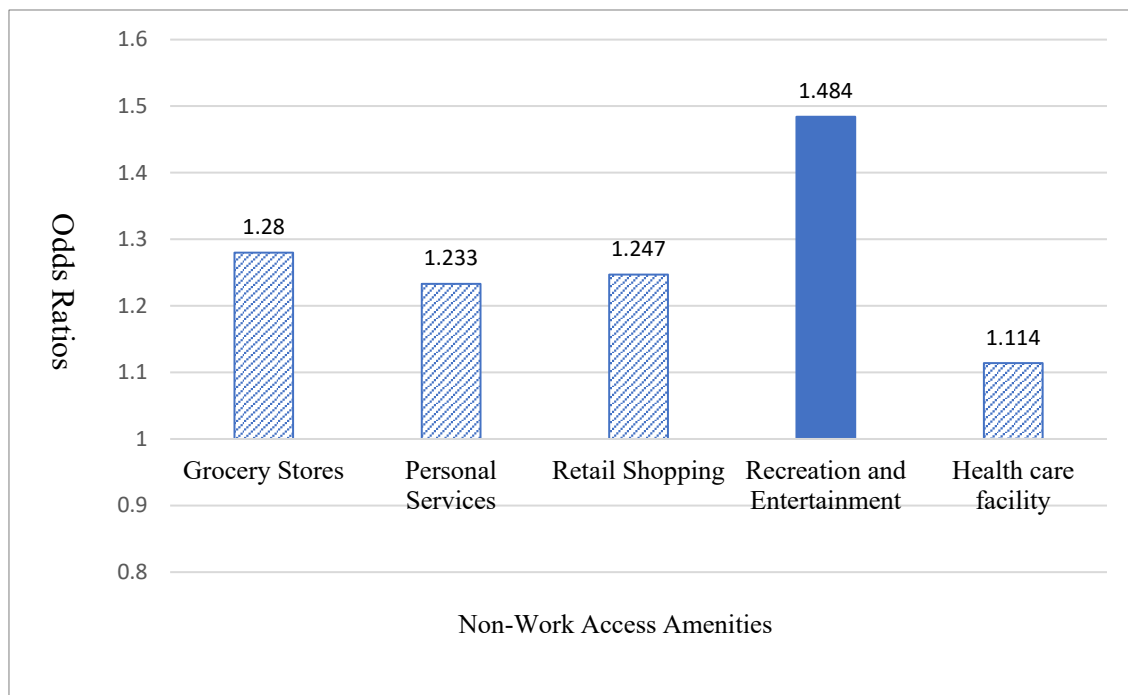


Figure 6. Odds Ratios for Respondents Covered/Not Covered under Medicare/Medicaid for Public Transit Access to Non-work Amenities.

Regarding public transit access to hospital facilities, it is noteworthy that the variable did not show a significant association, raising significant access concerns for individuals covered under the Medicare/Medicaid programs. Limited access to hospitals via public transit, which is often their primary means of transport, can profoundly impact the overall livability and well-being of these vulnerable populations. It reinforces the need for targeted efforts by transportation planners and policymakers to address the accessibility gaps and ensure that essential healthcare services are easily accessible to those who rely on public transit. Policies that enhance public transit connectivity to hospitals, provide inclusive transportation options, and implement targeted interventions can help mitigate healthcare access disparities, fostering more equitable and inclusive societies.

4.1.8. Gender-Based Public Transit Access to Non-Work Amenities

Past research suggests that women's daily travel patterns are different from men's. Women are more likely to be traveling to non-work amenities than men, such as shops, childcare facilities, health centers, etc., due to their caretaking and household responsibilities. Additionally, women from lower-income families are more reliant on public transit for their transportation needs [49,50]. The results showed statistically insignificant differences, with men having marginally higher odds of public transit access. While statistical insignificance suggests that gender-based disparities in public transit access were not observed in this study, it is essential to consider the broader equity perspective.

4.2. Walk Access to Non-Work Amenities

Table 3 shows the logistic regression models' results for walking access to non-work amenities. Separate binary logistic regression models were developed for assessing walk access to each non-work amenity category. The variables in bold represent the reference group. The rest of this section discusses the model results in more detail, as shown in Table 3.

Table 3. Walk access to non-work amenities—Odds ratios estimates.

Explanatory Variables	Grocery Stores		Personal Services		Retail Shopping		Recreation and Entertainment		Healthcare Facility	
	O.R	<i>p</i> -Value	O.R	<i>p</i> -Value	O.R	<i>p</i> -Value	O.R	<i>p</i> -Value	O.R	<i>p</i> -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	2.205	0.2618	2.593	0.0186 **
Age Group (35 to 54 Years)	1.990	0.1745	2.584	0.0197 **	2.625	0.0092 ***	2.522	0.0164 **	1.760	0.5624
Age Group (55 to 74 Years)	1.472	0.3600	1.780	0.7919	1.689	0.6944	1.735	0.8923	1.465	0.4359
Race (Non-White)										
Race (White)	0.599	0.0160 **	0.825	0.3598	0.644	0.0385 **	0.850	0.4502	0.772	0.2425
Unemployed and Students										
Employed Full Time	1.940	0.3410	2.961	0.0852 *	2.512	0.1429	1.113	0.4940	1.797	0.2176
Employed Part Time	2.541	0.0050 ***	3.349	0.0113 **	2.842	0.0243 **	1.219	0.1972	1.988	0.0608 *
Retired	1.676	0.9378	2.883	0.1318	2.330	0.3521	0.767	0.0693 *	1.381	0.6319
Area (Non-Metro)										
Area (Metro)	1.727	<0.0001 ***	1.588	0.0009 ***	1.715	0.0002 ***	1.270	0.0956 *	1.018	0.9033
No Household Vehicle										
One Household Vehicle	0.655	0.7542	0.556	0.9279	0.480	0.5092	1.078	0.4619	0.408	0.3711
Two or more Household Vehicles	0.365	0.0024 ***	0.295	0.0004 ***	0.326	0.0048 ***	0.779	0.2967	0.267	0.0014 ***
No Driving License										
Have Driving License	2.106	0.1046	2.335	0.0669 *	2.141	0.1157	1.605	0.3289	1.950	0.1769
Physically Disable										
No Physical Disability	2.069	0.0009 ***	1.554	0.0408 **	1.670	0.0267 **	2.577	0.0001 ***	2.339	0.0010 ***
Medicare/Medicaid (Covered)										
Medicare/Medicaid (Not Covered)	0.863	0.4620	0.776	0.2089	0.763	0.1973	0.966	0.8658	0.816	0.3493
Gender (Female)										
Gender (Male)	0.991	0.9467	1.219	0.1612	1.291	0.0816 *	1.252	0.1253	1.137	0.3993

*, **, *** represent significance at 10%, 5%, and 1% levels, respectively. O.R. denotes the odds ratio.

4.2.1. Walk Access for Seniors Compared to Other Age Groups

The results indicate that seniors aged 75 years and older face significant challenges regarding their walking access to non-work amenities compared to younger and middle-aged individuals, as shown in Figure 7. These results align with previous studies conducted in the U.S. and Canada, which identified various factors that inhibit older people from walking due to falls, perceived risks of collision with traffic, and low awareness about the walkability of their surroundings [54–56]. From an equity perspective, addressing the barriers older individuals face in accessing non-work amenities while walking is crucial. Policymakers should prioritize measures to enhance the walkability of neighborhoods and mitigate the specific constraints experienced by older age groups. This could involve implementing safety measures to address concerns related to falling or traffic collisions.

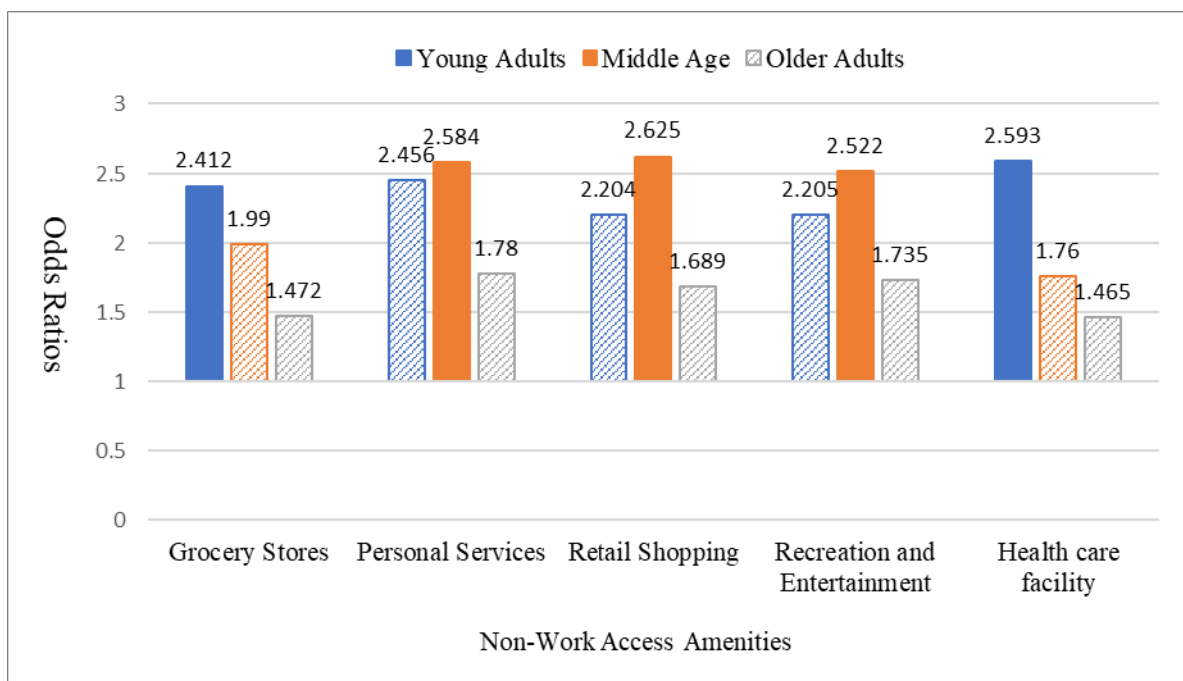


Figure 7. Odds Ratios for Seniors compared to other age groups for Walk Access to Non-Work Amenities.

4.2.2. Race-Based Walk Access to Non-Work Amenities

The explanatory variable “race/ethnicity” was significantly associated with the likelihood of walk access to grocery stores and retail shopping (see Figure 8). For grocery stores and retail shopping amenities, the odds of having access by walking for white populations were significantly lower than for non-white populations. This does not necessarily mean that the non-white population has better walk access to these destinations than white people. White people might have better and easier access to these amenities. Still, they do not want to take the pains (in terms of higher travel time and physical exertion) associated with the walk mode and might use other motorized modes.

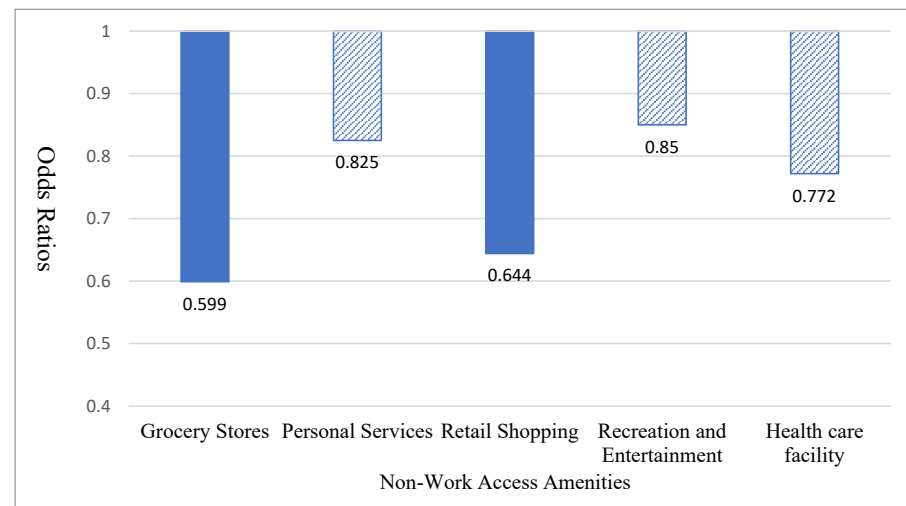


Figure 8. Odds Ratios for White Respondents to Non-white for Walk Access to Non-work Amenities.

4.2.3. Employment-Based Walk Access to Non-Work Amenities

The odds ratios were estimated with unemployed/students as the reference group to other employment categories, as shown in Figure 9. Part-time and fully employed individuals had significantly higher odds of having walking access to grocery stores, retail shopping, and healthcare facilities than unemployed individuals and students. This indicates that actively employed individuals have better walk access to non-work amenities. On the contrary, unemployed individuals and students may face walking access challenges, which could impact their transportation equity compared to other groups. Retired individuals had significantly lower odds than unemployed individuals and students for access to non-work amenities. This suggests that retired individuals may face challenges accessing recreational facilities while walking. Factors such as physical limitations or residing in areas with limited availability of recreational amenities could contribute to this disparity. It highlights the need for specific interventions to improve walk access for retired individuals, enabling them to engage in recreational activities and maintain a high quality of life.

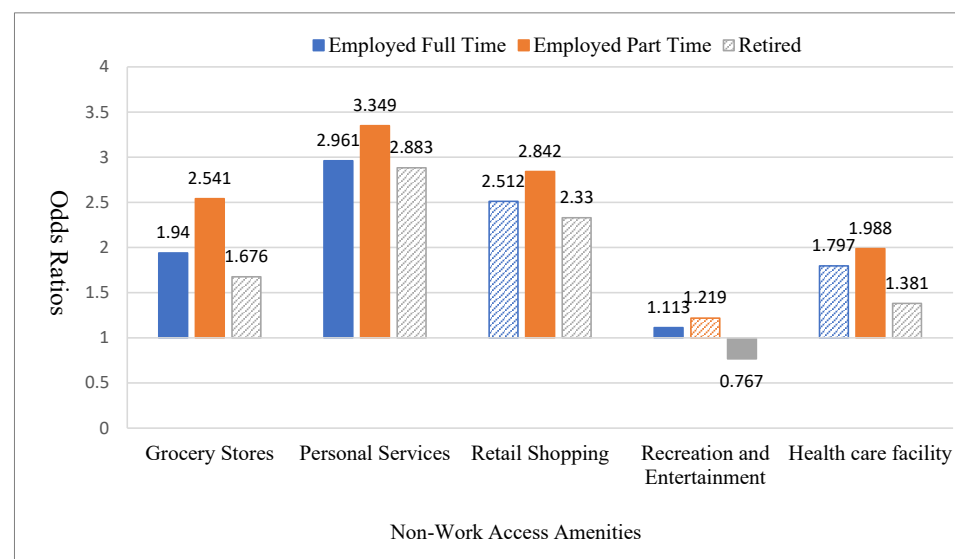


Figure 9. Odds Ratios for the unemployed and students as the reference group compared to other employment categories for Walk Access to Non-Work Amenities.

4.2.4. Walk Access for Metro and Non-Metro Area Residents

The results indicate that metro area residents have significantly higher odds of walking access to all non-work amenities (except healthcare facilities, where the odds are higher but not significant) than individuals residing in non-metro areas (see Figure 10). This result suggests there may be challenges in walk access for non-metro area residents due to longer distances between destinations and potentially less developed pedestrian infrastructure in rural areas. Transportation planners should review the distribution of critical non-work amenities in non-metro areas and assess the walkability conditions to ensure that residents in these regions have equitable access to essential services and amenities. The results are expected as urban environments typically offer greater walkability due to the proximity of amenities, infrastructure, and population density. Addressing these disparities requires careful consideration of the unique characteristics and challenges of non-metro areas, including the need for improved walkability infrastructure and the strategic placement of amenities to enhance accessibility for residents in these regions.

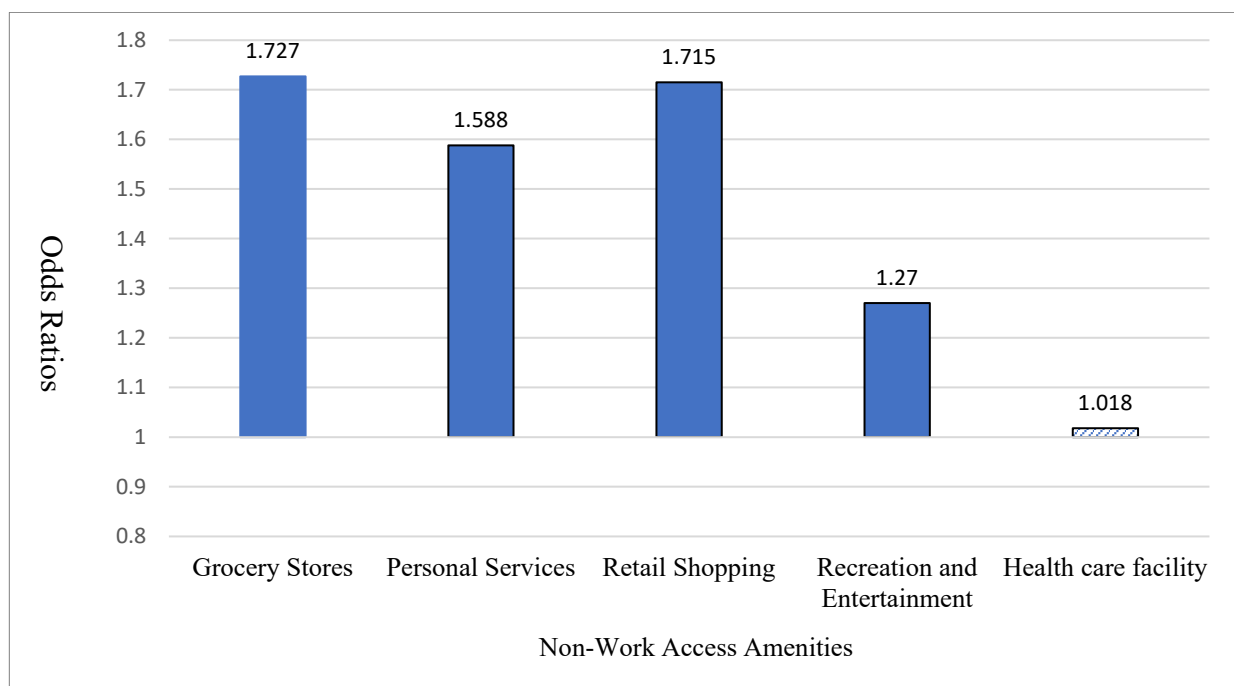


Figure 10. Odds Ratios for Non-metro Area Residents compared to Metro Area Residents for Walk Access to Non-work Amenities.

4.2.5. Walk Access for Respondents Based on the Number of Vehicles in the Household

The odds ratio estimates for walking access to non-work amenities for respondents with no household vehicle to respondents having a vehicle(s) in their household are presented in Figure 11. The results show that individuals with two or more vehicles in their households had significantly lower odds of walking access to all non-work amenities except for recreation and entertainment. This finding suggests that individuals with multiple household vehicles may prefer to use their vehicles rather than walk to access these amenities and rely less on walking. Additionally, people with two or more household vehicles are more likely to reside in suburban or rural areas where destinations are spread out and not easily accessible by walking. These areas may be designed with a stronger focus on automobile transportation, making walking less practical or feasible. On the other hand, individuals without household vehicles may reside in neighborhoods that offer better walk access to non-work amenities. This could indicate that these areas are more pedestrian-friendly with shorter distances between destinations. Efforts should be made to

improve walkability in auto-oriented areas by enhancing pedestrian infrastructure, creating safe and inviting walking environments, and reducing the distances between residential areas and essential amenities.

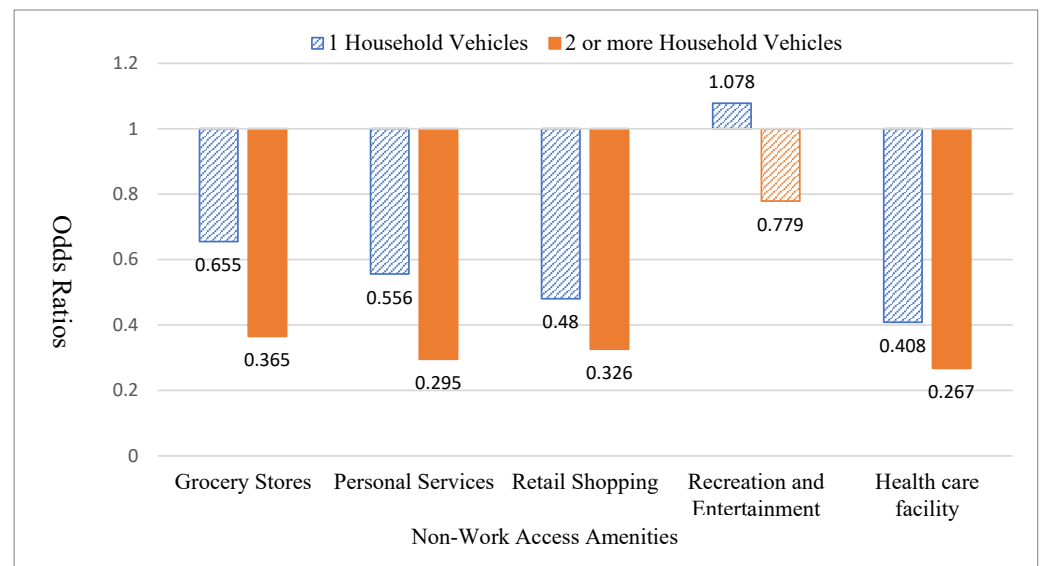


Figure 11. Odds Ratios for Respondents with no Household Vehicle compared to Respondents with Household Vehicles for Walk Access to Non-work Amenities.

4.2.6. Walk Access for Respondents with a Driving License or Not

The explanatory variable “driving license” was found to have a significant association with walk access to personal services, as shown in Figure 12. Individuals with a driving license showed higher odds of accessing personal services by walking compared to those without a driving license. This highlights the potential disparity in transportation equity, as individuals with driving licenses have greater mobility options and more choices to use walking to access personal services.

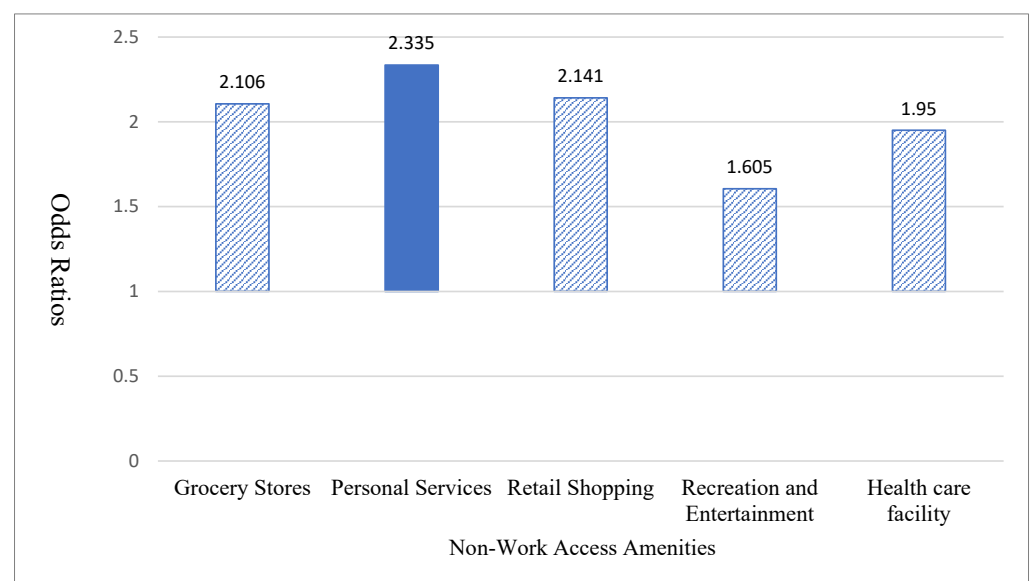


Figure 12. Odds Ratios for Respondents with no Driving License compared to Respondents with Driving License for walking access to Non-Work Amenities.

4.2.7. Walk Access for Physically Disabled Respondents

In contrast to public transit mode, the “physical disability” variable was significantly associated with the likelihood of walking access to all non-work amenities. The results show that individuals without physical disabilities have significantly higher odds of walking access to non-work amenities compared to those with physical disabilities (see Figure 13). This finding reveals a disparity in walk equity, indicating that the physically disabled may encounter additional challenges and barriers when walking and accessing essential amenities. To address this inequity, transportation planners must account for favorable and secure walkability conditions, particularly for individuals with mobility limitations or wheelchair users. This could include infrastructure like wheelchair-accessible sidewalks, crosswalks, and ramps, ensuring they are designed to accommodate the needs of individuals with physical disabilities. In addition, transportation policy planning should include specialized mobility services tailored to the needs of physically disadvantaged groups so that they have equitable access to essential locations for their daily activities.

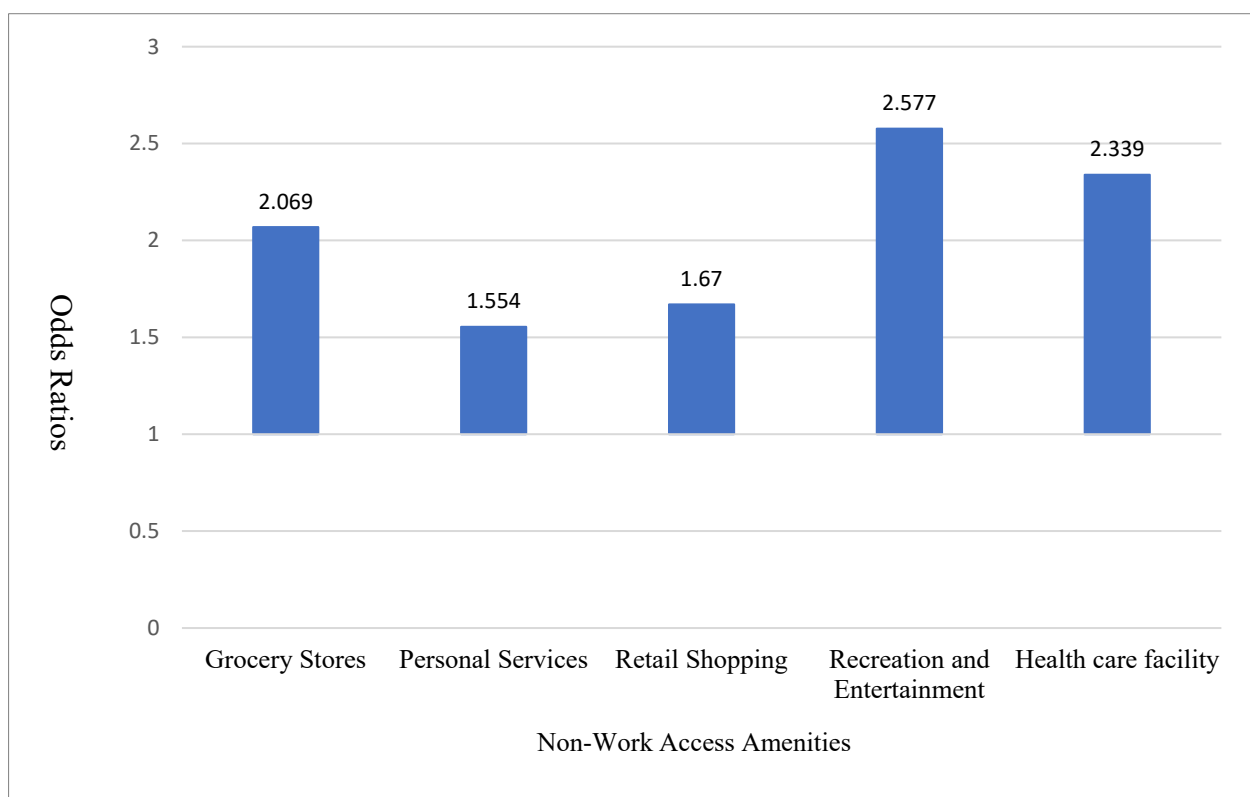


Figure 13. Odds Ratios for Physically Disabled Respondents Compared to Respondents with no Physical Disability for Walk Access to Non-work Amenities.

4.2.8. Gender-Based Walk Access to Non-Work Amenities

The results show that gender was only significantly associated with walking access to retail shopping among the non-work amenities. Interestingly, the odds of having walk access to retail shopping were significantly higher for males compared to females, as shown in Figure 14. Studies have shown that factors such as safety and security concerns influence women’s travel patterns and mode choices. Perceptions of insecurity and a higher risk of traffic accidents can deter women from using walking and cycling modes to access activities [57]. Additionally, indicators like homelessness, crime rates, and sidewalk cleanliness can negatively affect women’s walkability index [58]. Improving security in walking neighborhoods and public spaces can help females feel protected while walking to access their daily needs [51].

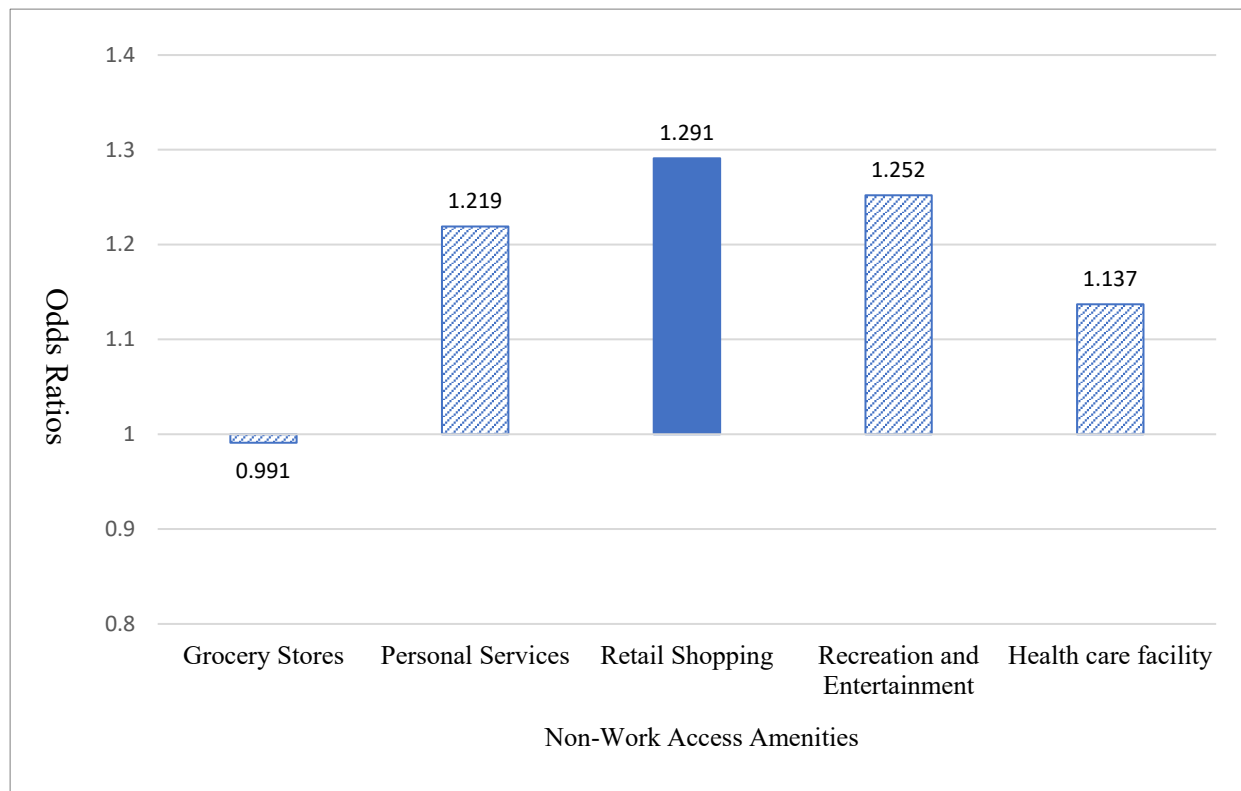


Figure 14. Odds Ratios for Male Respondents Compared to Female Respondents for Walk Access to Non-work Amenities.

5. Conclusions

This study evaluated social equity by using access to public transit for non-work amenities as the measure of equity, using data from the entire U.S. The results highlight significant disparities in social equity regarding public transit and walk access to non-work amenities. Social equity in terms of public transit access to non-work amenities is regressive for older-aged people, people without driving licenses, individuals who are covered under the Medicare/Medicaid program (elderly, low income, people with disabilities), and non-metro area residents are among the disadvantaged groups. To address these challenges, ensuring sufficient and convenient walking access is crucial, keeping in mind their financial constraints and physical health. Enhancing walking environments through improved infrastructure and heightened safety can promote equitable access for these groups.

In terms of walk access to non-work amenities, the results show that older age people, people without driving licenses, physically disabled people, unemployed and students, people living in non-metro areas, and females face inequities. Considering their financial and physical health challenges, these groups should have sufficient and convenient walking access to their daily needs. Creating safer and more accessible walking environments, improving infrastructure, and addressing safety concerns can help promote equity in walk access. Although race did not show significant differences in public transit access, non-white populations were found to have more equitable walk access to non-work amenities. Recognizing and building upon these positive findings is important to ensure equity for all communities, regardless of their racial background.

This study has some limitations, including the use of self-reported perceived accessibility measures, which may not always align with the practical usage of transit and walking for non-work amenities. The underrepresentation of specific population groups, such as minorities and younger adults, in the survey sample also limits the generalizability of the

findings. Future studies should incorporate objective accessibility measures and cover both social and spatial domains in equity analysis. Standardizing the categorization of explanatory variables and exploring additional variables specific to the study context can further enhance equity analysis. Future research should use larger and more representative datasets to enhance the robustness and generalizability of transport equity assessments across diverse populations in the United States. Future studies should also adopt an integrated framework that jointly evaluates public transport and walking accessibility to more comprehensively assess transport equity. Overall, this research highlights the need for transportation policies and interventions that prioritize equity and address the specific needs of disadvantaged groups. By adopting inclusive and accessible transportation systems, cities can work towards creating more equitable and livable communities for all individuals.

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