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Evaluating Sustainable & Equitable Financing For Pedestrian Infrastructure Maintenance And How The Quality Of Pedestrian Infrastructure Affects The Choice To Walk

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EVALUATING SUSTAINABLE & EQUITABLE FINANCING FOR PEDESTRIAN INFRASTRUCTURE MAINTENANCE AND HOW THE QUALITY OF PEDESTRIAN INFRASTRUCTURE AFFECTS THE CHOICE TO WALK

by

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THESIS

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ABSTRACT

In many communities, pedestrian infrastructure is discontinuous, inaccessible to those with physical disabilities, and poorly maintained. Understanding how we can fix these problems and how they might affect people's walking will be a step towards creating safe and accessible infrastructure for pedestrians and our transportation network as a whole. One challenge is finding a sustainable and equitable source of funding since many municipal governments across the country require adjacent property to maintain and repair sidewalks adjacent to their property. These policies are difficult to enforce, may place a relatively high cost on lower-income households, and may be at least partly responsible for the poor condition of many sidewalks. We also know very little about how the quality and design of pedestrian infrastructure affects the decision to walk. Therefore, in the first part of this research, we evaluated three alternative options for financing the maintenance of public sidewalks in Albuquerque, New Mexico: increasing the gross receipts tax (GRT), the gasoline excise tax, or the property tax. We concluded that any of the alternatives would perform better than policies that require adjacent property owners to maintain public sidewalks. They are generally less regressive, cost less on average, and would allow municipalities to manage sidewalk assets more effectively. In the second part of this research, we conducted a household travel survey to collect data on walking frequency and attributes related to sidewalk quality and the quality of the walking environment in Albuquerque, New Mexico. We used summary statistics and statistical modeling to identify sidewalk and related infrastructure attributes associated with more walking. Our study results were limited by a smaller than anticipated sample size; however, we found that a lack of marked crosswalks where residential streets cross higher volume roads was significantly associated with less walking. We did not find any other significant infrastructure effects, something we mainly attribute to our small sample size. Having sidewalks and maintaining them well were reported to be most important for encouraging walking.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

Chapter 1: Introduction

Sidewalks are an important part of a multimodal transportation system. They enable walking in high traffic environments where walking in the street would be impractical or dangerous and may encourage walking in other locations by providing a safer and more comfortable walking environment. Walking is an important mode of transportation for several reasons: it requires almost no out of pocket expense, has minimal environmental impact (Frank and Pivo n.d.; Frumkin 2002), active transportation such as walking improves public health (Frank et al. 2006; Frumkin 2002; Mueller et al. 2015; Warburton et al. 2006), it requires relatively inexpensive infrastructure, it can be used by people who are too young to drive or by those who cannot drive due to certain disabilities or other circumstances, and it may encourage greater social interaction. However, the majority of the population in the United States does not walk (Agrawal and Schimek 2007). Results from the National Household Travel Survey in 2017 found that only about 10% of all trips and 4% of work trips were made by walking.

Despite these and other benefits, there appears to be a wide gap between the provision and quality of pedestrian infrastructure such as sidewalks and that for motorized travel (Evans-Cowley 2006a; Perez and Zipf 2010; Truong and Meyer 2015). In many cities across the United States, sidewalks are in poor condition (Evans-Cowley 2006b; Shoup 2010b) with many being discontinuous, inaccessible to those with physical disabilities, and poorly maintained (Evans-Cowley 2006b; New Jersey DOT 2006; Rannila and Mitchell 2016; Shoup 2010a). This is particularly true in Albuquerque, New Mexico, according to a recent ADA transition study completed for the city, which estimated over $200 million in necessary sidewalk improvements (City of Albuquerque 2017). A similar study for Los Angeles, California estimates sidewalk repair costs are approximately $1.2 billion (Shoup 2010b). With poor sidewalk conditions being a common problem and repair costs very high, there are two issues we want to focus on: sustainable and equitable financing for sidewalk maintenance and evaluating how the quality of pedestrian infrastructure affects the choice to walk.

While there are many reasons for the varying provision and quality of pedestrian infrastructure within and among different communities, one nearly universal challenge is an adequate, sustainable, and equitable source of funding for pedestrian infrastructure maintenance and reconstruction (Evans-Cowley 2006b; Hicks 2014; Legarza 2000; New Jersey DOT 2006; Shoup 2010a). Municipal governments across the country maintain and repair their streets and roadways; however, most require residents to maintain and repair public sidewalks adjacent to their property (Evans-Cowley 2006b; Hicks 2014; New Jersey DOT 2006; Shoup 2010a). For example, a survey of 82 cities in 45 states by the Los Angeles Bureau of Street Services conducted in 2008 found that 71 cities required adjacent property owners to pay at least some portion of the cost of sidewalk repairs while only 11 cities assumed full responsibility for maintaining sidewalks (Shoup 2010a).

Placing the responsibility for maintaining public sidewalks and financing their repair costs on adjacent property owners may contribute to the challenge that most cities have with maintaining their sidewalks in a state of good repair. Several studies have documented that property owner compliance with requirements to maintain public sidewalks adjacent to their property is generally lacking, and that many cities are reluctant or incapable of enforcing these policies (Evans-Cowley 2006b; Hicks 2014; Legarza 2000; Rannila and Mitchell 2016). Property owners may not be aware of what sidewalk conditions require repair (Legarza 2000) and may not know that they are responsible for sidewalk maintenance (Hicks 2014). It is also important to consider how this ordinance affects lower-income households. With prior studies finding evidence of poorer sidewalk conditions in lower-income and minority communities (Bostock 2001; Kelly et al. 2007a; Neckerman et al. 2009; Zhu and Lee 2008) and the potential for sidewalk repair costs reaching hundreds to thousands of dollars (Carrillo et al. 2012; Gunn et al. 2014; Legarza 2000), it may be difficult for lower-income households to afford repair costs. Therefore, in the second chapter of this study, we ask: 1) if the current policy of placing the responsibility of sidewalk repairs on the adjacent property owner is a fair policy?; 2) if there are other funding alternatives available?; and 3) how these alternatives distribute costs among different neighborhoods and income groups.

Given the extent of sidewalk maintenance problems, it is also important to understand which maintenance problems and design attributes most affect walking. Little research has been done on how the quality and condition of sidewalks and pedestrian infrastructure affect a person's decision to walk. Prior research has mainly focused on how large-scale features of the built environment such as density and land use affect a person's decision to walk (Ewing and Cervero 2010; Frank and Pivo n.d.; Handy et al. 2002). As a result, we know comparatively little about how the design of sidewalks and quality of the overall pedestrian environment affect the decision to walk. Therefore, for the third chapter of this study, we evaluate if the quality of pedestrian infrastructure affects the choice to walk and which attributes are most important.

To evaluate sustainable and equitable financing for sidewalk maintenance, we collected an inventory of sidewalk defects in Albuquerque, New Mexico and determined the repair cost. We then evaluated three alternatives for financing sidewalk repairs which included incrementing the gross receipts tax, property tax, and gasoline tax. This allowed us to evaluate the equity of the current policy and determine if there is a more equitable and sustainable funding alternative. To evaluate how the quality of pedestrian infrastructure affects the choice to walk, we conducted a household travel survey in Albuquerque, New Mexico and asked respondents from different neighborhoods about their perceptions of the quality of certain pedestrian infrastructure attributes. We then developed linear regression models to evaluate possible associations between pedestrian infrastructure attributes and walking frequency.

Through investigating sustainable and equitable financing for sidewalk repairs, as well as the effects on a person's decision to walk, this research can help municipalities and transportation planners prioritize the repairs that are needed and identify ways of improving the pedestrian environment. The information from these studies may additionally help planners know which design features to include in the pedestrian environment in order to potentially encourage more walking under constrained municipal budgets and also to help create more safe and accessible transportation systems for pedestrians.

Chapter 2: Sustainable and Equitable Financing for Pedestrian Infrastructure Maintenance

1. INTRODUCTION

In many cities across the country, including Albuquerque, New Mexico, adjacent property owners are responsible for maintaining and repairing sidewalks adjacent to their property (City of Albuquerque 2017; Evans-Cowley 2006b; Harper 2017b; Hicks 2014; New Jersey DOT 2006; Shoup 2010a). Not only is this policy difficult to enforce (Evans-Cowley 2006b; Hicks 2014; Legarza 2000; Rannila and Mitchell 2016), but some homeowners may be unaware they are responsible (Hicks 2014), and not all homeowners may be able to afford the repair costs.

So why do so many municipalities require property owners to maintain public sidewalks adjacent to their property when evidence suggests that such policies are ineffective? The answer is unclear, but history provides a few clues. It may be a policy held over from early British common law that required property owners to maintain a public right of way through their property (New Jersey DOT 2006); however, this does not explain the differing treatment of roadways. While some municipalities, especially in the 18^{th} and 19^{th} centuries, built public sidewalks, it may also have been common for property owners to finance the construction of public streets and sidewalks adjacent to their property in order to increase their property values (Ehrenfeucht and Loukaitou-Sideris 2007). In some places, public sidewalks were privately owned, and, therefore, requiring the owners to maintain them may seem logical (Rannila and Mitchell 2016). Requirements to clear snow and ice (and other debris) from public sidewalks may have also lead to broader maintenance requirements ("An ordinance to cause the removal of obstructions on the sidewalks caused by snow or ice" 1857; Messier 2017). The inability of municipalities to gain public support for levying new taxes to pay for sidewalk maintenance has also been raised as a possible explanation (Hicks 2014; Shoup 2010a). What is absent from the literature are arguments and evidence supporting the superiority or benefits of adjacent property owner maintenance policies over other public asset management models – and curiously, little discussion of why the roadways adjacent to sidewalks are not similarly maintained by adjacent property owners.

In this study we evaluate several alternative options for financing the maintenance of public sidewalks in Albuquerque, New Mexico. We consider increments to three broad-based taxes that many municipalities, including Albuquerque, already levy to pay for public infrastructure, including streets. Each alternative can raise the same amount of needed revenue, but who pays and when, and who performs the maintenance differs. Raising revenue through broad-based taxes would generally avoid the costs and difficulty associated with enforcing the current policy (and similar policies in most other cities) and eliminate the prospect of homeowners facing unexpected and potentially large sidewalk repair costs. We suspect that placing the municipality in charge of maintaining sidewalks would also be more cost-effective as maintenance needs could be tracked and prioritized, preventative maintenance might be a possibility, repairs could be combined with other street maintenance projects, and economies of scale in repair work could lower marginal costs. Another important consideration, and the focus of our study, is the distributional impact of each sidewalk financing alternative, including the current policy.

There are other ways to pay for sidewalks that we do not consider in our study. For example, tax increment finance districts, special assessment districts, and various federal grant funding programs. Tax increment finance districts and special assessment districts are generally used to reimburse developers or the government, respectively, for building new infrastructure, including sidewalks and roadways among other things. These are generally not used for routine infrastructure maintenance, although they could be appropriate for dealing with a large maintenance backlog. There are several federal programs to which municipalities may apply for sidewalk construction funding, but they are generally not meant, and often explicitly prohibit, funding maintenance activities. For example, federal Surface Transportation Block Grant (STBG) funding set aside for Transportation Alternatives (TA) and the Community Development Block Grant (CBDG) are two programs that provide funding which can be used for building new sidewalks or improving their accessibility; however, maintenance and repair activities are ineligible. In our study, we focused on broad-based taxes that are commonly used to finance the day-to-day operation of a municipality, which we argue should include maintaining public sidewalks.

Each policy we considered had two potential, important, distributional impacts. First, to the extent that the current policy is insufficient at maintaining sidewalks in a state of good repair, which local evidence strongly suggests (City of Albuquerque 2017; Harper 2017a), there is the possibility that some communities have more well-maintained sidewalks than others. Prior studies have found some evidence of poorer sidewalk conditions in lower income and minority communities (Bostock 2001; Kelly et al. 2007a; Neckerman et al. 2009; Zhu and Lee 2008), and an audit conducted by the City of Albuquerque (Harper 2017a) suggested that sidewalk conditions are worse in Albuquerque's lower-income communities. Furthermore, even if sidewalk conditions were similar across the city, lower-income households may be more dependent on walking for transportation which would also raise equity concerns regarding poor sidewalk maintenance. Additionally, the financial burden placed on households of different income levels should also be considered for each alternative and the current policy.

The cost of replacing a concrete sidewalk in one neighborhood is generally the same as another (although differing widths may cause some variation); however, the ability of households to pay may vary greatly. The current policy is likely regressive since all households face similar costs but have differing income levels (i.e., lower income households would have to pay a larger share of their income). Furthermore, if low-income communities have greater deferred maintenance needs, then enforcement of the current policy would be even more regressive. Each of the alternatives that we considered in this study would spread the costs of sidewalk maintenance out differently and possibly more fairly. The revenue generated by each alternative is also likely to vary over time, therefore we also discuss the long-term sustainability of each alternative since raising taxes or levying new taxes is often a difficult task to accomplish.

2. METHODOLOGY

The research consisted of three main tasks. In the first step, we surveyed Albuquerque's sidewalks to create an inventory of maintenance needs by neighborhood. We then used that inventory to estimate current maintenance costs and evaluate disparities in current sidewalk states of repair. In the final step, we used neighborhood maintenance costs to evaluate the equity of several alternative sidewalk financing methods and compared them to Albuquerque's current policy.

2.1. Sidewalk Inventory

When we began this project, Albuquerque, like many municipalities, had no data describing existing sidewalk maintenance needs or even where sidewalks exist and their basic attributes; therefore, our first task was collecting data on common maintenance problems. Since Albuquerque is a large city, it was not feasible to inventory every sidewalk and every problem. Therefore, we used a sampling scheme to collect small snapshots of common sidewalk defects across the city and then used that data to estimate sidewalk conditions for all areas of the city.

The sidewalk inventory collected data on two common types of sidewalk defects that reflect maintenance needs: vertical discontinuities (e.g., a slab raised above another that creates a tripping hazard or barrier to a wheelchair) and degraded walking surfaces (e.g., cracks, holes, spalling). We used existing federal ADA guidelines to determine the severity of these conditions that warrant a maintenance action (FHWA, 2004). We did not inventory sidewalk features that are out of compliance with other aspects of ADA standards such as maximum cross slopes, grades, transition zones, presence of curb ramps, physical obstructions, etc. since these are generally the responsibility of the municipality to fix and not related to maintenance.

We randomly selected 50 out of a total of 249 neighborhoods in Albuquerque from which to sample sidewalks. We chose neighborhoods as our unit of analysis, as sidewalk design and state of repair are likely to be more similar within neighborhoods than between them. Streets within neighborhoods were typically built around the same time, and now maintenance generally occurs at the neighborhood level. Neighborhoods were identified from a Geographic Information System (GIS) data file of neighborhood association boundaries maintained by the City of Albuquerque. Each neighborhood was assigned a random number, and then the 50 neighborhoods with the lowest numbers were chosen. Within each of the neighborhoods we sampled, we randomly chose five intersections where we evaluated the first 200 feet of each sidewalk extending outwards from the intersection. The intersections were chosen in each neighborhood by first randomly selecting five street segments using the same random number process that was used for selecting neighborhoods. Since most street segments make two intersections with other streets (one at each end of the segment unless the street is a cul-de-sac or dead end) we also randomly chose one of the two intersections for each selected street segment. Streets and intersections were selected from a GIS data file of Albuquerque street centerlines maintained by the City of Albuquerque. The sidewalk survey was completed between August 2017 and September 2017. Data was recorded in the field using paper forms and checklists and then entered in an ArcGIS geodatabase.

Before we conducted our field survey, we selected three neighborhoods to test our sampling methods by comparing defect rates within and between neighborhoods. We chose three neighborhoods to maximize diversity in terms of neighborhood age, urban form and geographic location. The three neighborhoods which we labeled “UNM/Central”, “Westside” and “Northeast” represented an older, urban neighborhood, near downtown Albuquerque and the University of New Mexico; an older, more suburban, subdivision on the city's west side; and a new, suburban, subdivision in Albuquerque's northeast heights area, respectively (see Figure 1).

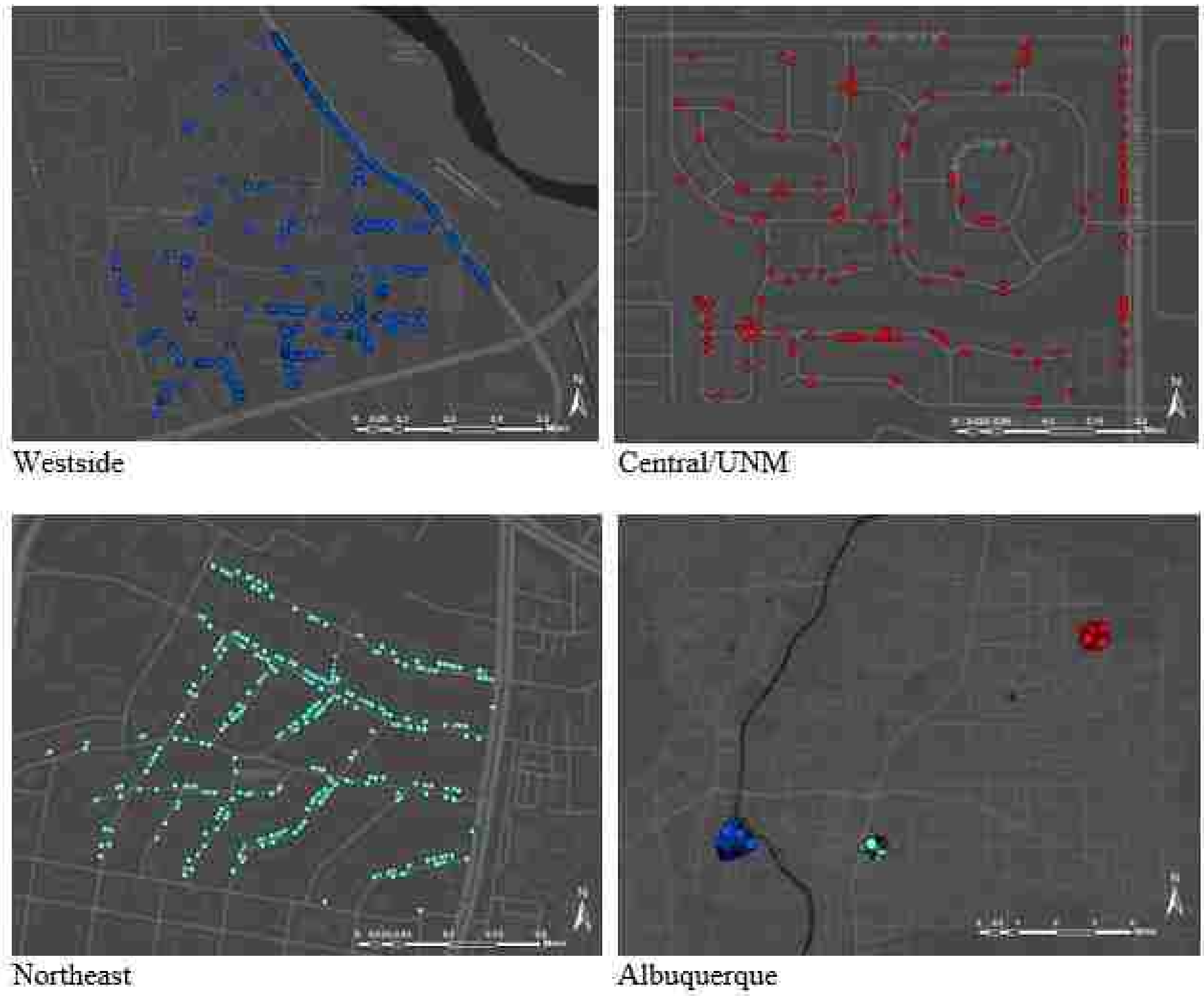


Figure 1. Sampling Test Neighborhoods (each dot represents a defect).

For each of the three test neighborhoods, we surveyed every street for defects and recorded the results in a GIS as shown in Figure 1. We then compared defect rates between each neighborhood, finding that they varied from a high of 65 defects per mile in Central/UNM to a low of 24 defects per mile in Northeast (see Figure 2). We also compared defect rates within each neighborhood with estimates derived from different sized samples. We randomly sampled 5, 7 and 10 intersections (surveying sidewalks extending out 200ft in each direction of each intersection) in each neighborhood. While increased sampling increased the precision of the defect rate estimates, due to limited time and resources, accurate results with similar precision could be obtained by sampling just 5 intersections per neighborhood (see Figure 2). Based on these results we proceeded with sampling 5 randomly selected intersections in each of the 50 randomly selected neighborhoods.

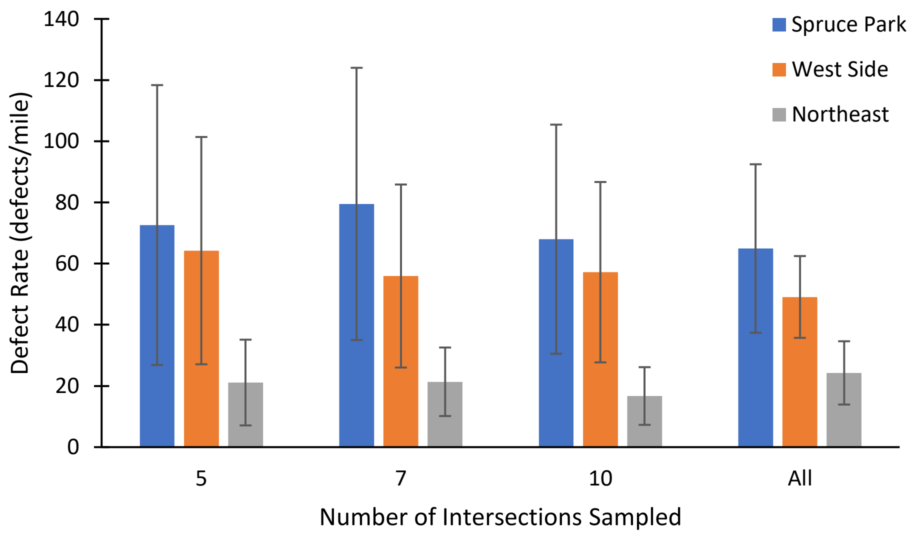
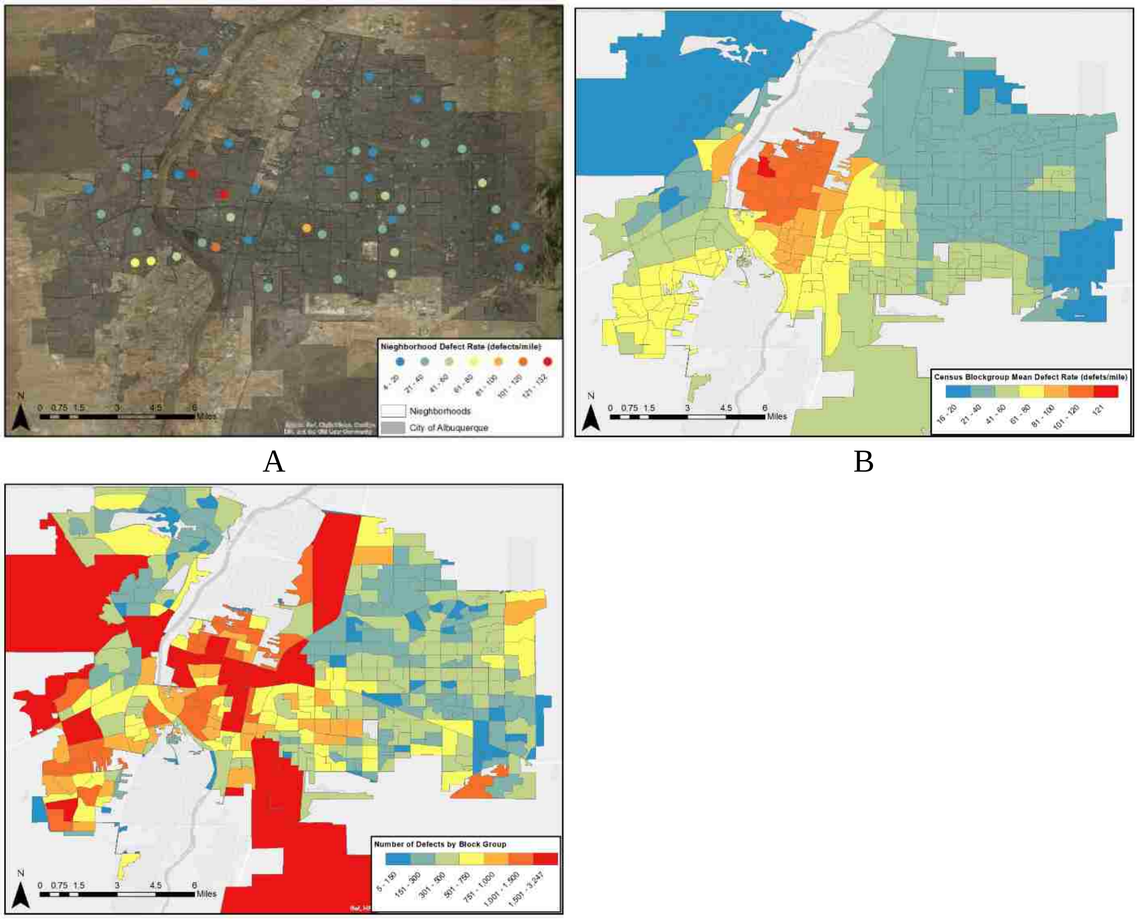


Figure 2. Defect rates from three test neighborhoods.

The results of our field data collection are shown in Figure 3a. Generally, defect rates were higher in the center of the city and lower in the northwest and northeast parts of the city. Defect rates were also higher in the southern third of the city. The defect rates generally correspond to the age of the neighborhoods with central area being the oldest, followed by areas to the southwest and southeast. The northeast and northwest are where many newer subdivisions have recently been built.

Defect rates from the field survey were then used to estimate defect rates for all areas of the city (Figure 3b). We used inverse distance weighting to estimate a defect rate raster covering the entire extent of the city. The raster was then used to estimate the average defect rate within each U.S. Census block group (Figure 3c). We aggregated the defect rates to block groups so that we could match defect rates with corresponding block group level household and income data from the U.S. Census Bureau's American Community Survey (ACS) that was used in our tax and equity analysis discussed below. Spatial autocorrelation was tested to determine if the number of neighborhood defects were similar to other nearby neighborhoods. The spatial autocorrelation test for defect rates between neighborhoods resulted in a p-value of 0 and a Moran's I index of 0.538 which indicates that there is, in fact, spatial autocorrelation between neighborhoods. The spatial autocorrelation test for the number of defects between neighborhoods resulted in a p-value of 0 and a Moran's I index of 0.219 which also indicates spatial autocorrelation between neighborhoods.



A B

C

Figure 3. Defect rates from field survey of 50 neighborhoods (A), Interpolated defect rates aggregated to census block groups (B), and Number of defects by census block group (C).

2.2. Estimating Maintenance Costs

To estimate maintenance costs, we first estimated the miles of sidewalk in each census block group within the city so that we could estimate the total number of defects. Albuquerque did not have a GIS data file on sidewalk infrastructure when we began this project, so we estimated the length of sidewalks as twice the length of each roadway in each census block group. Roadways were identified from the city's GIS data set of street centerlines. We excluded interstate highways and highway frontage roadways from our analysis as these roadway types generally do not have sidewalks along them. We then estimated the total number of defects in each census block group by multiplying each block group's estimated sidewalk length by its estimated defect rate.

We then estimated the cost to repair defects in each block group by first determining an average defect repair cost using unit construction cost data from the city of Albuquerque. We assumed that each defect would require replacing one 4 by 6-foot section concrete sidewalk, which is a rough estimate of the average size of a sidewalk slab. Furthermore, we assumed that the concrete slab is 4 inches thick and is not reinforced and that the adjacent curb and gutter would not need to be replaced. Sidewalk repair costs also included demolition of the existing sidewalk, construction mobilization, and traffic control. Finally, we multiplied the cost of replacing a sidewalk slab ($138.23 per slab) by the number of defects in each block group to estimate the cost of repairing sidewalks in each block group and the entire city. The total cost was estimated to be $26,800,000.

2.3. Equity and Sustainability Analysis

We evaluated three new methods for raising funds to cover the sidewalk maintenance cost estimated above. These included raising the City of Albuquerque's gross receipts tax (GRT, which is similar to a sales tax but also applies to many services), property tax, and New Mexico's gasoline excise tax, a portion of which is currently returned to municipalities. We also evaluated the current policy of charging adjacent property owners. We did not consider income taxes because most municipalities do not collect them. Each of these financing methods can raise the required revenue to clear the city's backlog of sidewalk maintenance but how their costs are distributed across neighborhoods and socioeconomic groups is likely to differ. Some taxes may be fairer than others. We considered progressive taxes (where lower-income households pay a tax that is a smaller share of their income than higher income households) to be more fair than regressive taxes (where lower-income households pay a tax that is a higher share of their income than higher income households).

Estimate Tax Increments

The first step of the tax analysis was determining how much each of the three taxes would need to be increased to generate enough revenue to cover the estimated maintenance costs. For our study, we considered tax increments required to pay for the repairs over 5 years. Changing the timeframe for completing the repairs would have affected the magnitude of our results, but the distribution of the tax burden would be the same. The general approach for calculating each tax increment is given by equation 1. Note that this simplified analysis does not account for possible substitution or other effects on the local economy (e.g., the potential of each tax increment to reduce consumer spending on the goods and services being taxed).

$$\Delta TR = \frac{C}{R} TR \qquad (1)$$

where,

ΔTR = tax rate increment,

C = estimated annual cost of annual sidewalk maintenance,

R = total annual revenue currently generated by the tax, and

TR = current tax rate.

Existing tax rates for Albuquerque were obtained from multiple state and local government sources. GRT rates were obtained from the New Mexico Taxation and Revenue Department, and Albuquerque GRT revenue forecasts were obtained from the City of Albuquerque's 2015 five-year budget. Property tax rates and revenue were obtained from the New Mexico Taxation and Revenue Department's "Property Tax Facts 2016" report. Gasoline excise tax revenue distributed to the City of Albuquerque was obtained from the New Mexico

Taxation and Revenue Department's Combined Fuel Tax Distribution Report. The current tax rates, current revenue produced by each tax and the required tax increment calculated from Equation 1 are shown in Table 1.

Table 1. Year 2016 Tax Rates, Tax Revenue and Estimated Tax Increments

	Actual Year 2016		**Increase to Cover Sidewalk Maintenance**	
Tax	**Tax Rate**	**Tax Revenue**	**Tax Increment**	**New Tax Rate**
GRT[a]	0.5678%	$87,868,000	0.0348%	0.6026%
Property Tax[b]	0.6389%	$80,907,542	0.04248%	0.68147%
Gasoline Excise Tax[c]	$0.01765	$4,832,434	$0.01964	$0.03729

[a] GRT collected by city for general purposes (estimated at .5678% out of total 7.1875% GRT).
[a] City portion of county property tax; revenue-weighted average of residential and nonresidential rates.
[b] State gasoline excise tax that is distributed to City of Albuquerque (10.38% of $0.17/gallon state gasoline excise tax).

Cost of Current City Policy

Under the City's current policy, property owners are responsible for maintenance of sidewalks adjacent to their property. We estimated the expected cost of this policy for the average household in each block group using equation 2. We first multiplied the total cost of sidewalk repairs estimated for each block group by the proportion of residential land area in each block group. This provided an estimate of household repair liability within each block group. Land use data identifying residential and non-residential land use by parcel was obtained from a GIS data file maintained by the city of Albuquerque. The total cost of residential repair liability in each block group was then divided by the number of households in each block group. Data for the number of households at the block group level were obtained from the 2016 ACS 5-year dataset. This method assumed that each household in each block group had an equal chance of having to repair the sidewalk adjacent to their property which caused some error in our calculations. For example, some households live in multifamily housing units, and therefore the cost of sidewalk repairs would be shared among multiple households (assuming costs are passed through to tenants in their rent). Additionally, some lots are larger than others, creating greater exposure to sidewalks in need of repair.

$$EC_i = C_{r,i} L_{res,i} / HH_i \quad (2)$$

where,

EC_i = the expected cost of annual sidewalk repairs for the average household in block group *i*,

$C_{r,i}$ = estimated total cost of sidewalk maintenance in block group *i*,

$L_{res,i}$ = estimated proportion of residential land area in block group *i* and,

HH_i = number of households in block group *i*.

To evaluate the burden of the current policy on households with different levels of household income, we divided the average household sidewalk repair cost in each block group by each block group's median household income. Block group level median household income data were obtained from the 2016 ACS 5-year dataset. This provided the share of the average household's income in each block group spent on sidewalk repairs.

Gross Receipts Tax Burden

To evaluate the average household repair costs by incrementing the GRT we first needed to determine how much households from different income groups spent on goods and services subject to the GRT. We obtained national expenditure data by income decile from the U.S. Bureau of Labor Statistics' 2016 Consumer Expenditure Survey. Expenditure data by income decile are tabulated nationally; for select metropolitan regions, but not Albuquerque, and the midwest, northeast, south and west regions of the country. Although Albuquerque is located in the western U.S., we chose to use the national dataset instead of the west dataset since Albuquerque's lower cost of living and lower incomes are somewhat unique among other western U.S. cities. We identified consumer expenditure categories subject to New Mexico's

GRT and summed expenditures in these categories for each of ten household income quantiles. We then estimated the share of household income subject to New Mexico GRT for each income decile (Table 2).

Table 2. Average 2016 Household Consumer Expenditures Subject to New Mexico GRT by Household Income Decile (dollars)

		Expenditure Deciles									
Expenditure Category	**All**	**1st**	**2nd**	**3rd**	**4th**	**5th**	**6th**	**7th**	**8th**	**9th**	**10th**
Food away from home	4,049	2,407	2,596	3,089	3,136	3,526	3,868	4,257	5,219	5,509	6,876
Alcoholic beverages	484	143	173	230	291	312	388	514	624	785	1,378
Household maintenance, repairs, insurance, and other expenses	1,437	544	703	909	1,149	1,128	1,207	1,379	1,877	2,121	3,353
Household operations	1,384	547	621	785	845	923	1,068	1,263	1,574	2,256	3,962
Housekeeping supplies	660	388	365	466	568	582	663	648	720	996	1,208
Household furnishings and equipment	1,829	638	672	1,015	1,222	1,374	1,700	1,798	2,198	2,990	4,686
Apparel and services	1,803	876	845	1,094	1,233	1,381	1,657	1,869	2,050	2,526	4,493
Other Vehicle Expenses	2,884	1,203	1,413	1,695	1,927	2,374	2,881	3,460	3,638	4,629	5,621
Vehicle Maintenance and repairs	849	397	375	518	637	718	936	871	1,138	1,319	1,584
Entertainment	2,913	1,036	1,256	1,663	1,902	2,042	2,646	2,916	3,902	4,604	7,165
Personal care products and services	707	317	350	453	527	534	605	734	820	1,085	1,643
Reading	118	65	63	79	92	98	95	124	105	157	300
Tobacco products and smoking supplies	337	290	319	311	359	360	363	404	361	386	219
Miscellaneous	959	355	316	573	719	1,016	999	1,082	1,042	1,462	2,031
Total Expenditure subject to GRT	20,413	9,206	10,067	12,880	14,607	16,368	19,076	21,319	25,268	30,825	44,519
Mean Income	74,664	6,502	16,229	24,432	33,499	43,931	57,192	73,568	94,739	127,268	269,644
Share of Income Subject to GRT	0.27	1.42	0.62	0.53	0.44	0.37	0.33	0.29	0.27	0.24	0.17

As shown in Table 2, lower-income households spend a larger share of their income on GRT than higher income households. For our analysis, we needed to estimate the share of household income subject to GRT for households of various income levels (i.e., income levels that differ from those tabulated by the Bureau of Labor Statistics). Therefore, we used ordinary least squares regression to develop a simple function to estimate the share of household income subject to GRT by income (see equation 3). The intercept and income coefficient estimate were both statistically significant with p-values less than 0.001 and the overall coefficient of determination (R^2 value) was 0.97.

$$\ln(S_{grt}) = 4.95 - 0.548 \cdot \ln(I) \quad (3)$$

where,

S_{grt} = share of household income subject to GRT,

I = average household income.

We then estimated the additional GRT paid by households earning different annual incomes using the share of household income subject to GRT from equation 3 in equation 4. The share of household income spent on the GRT increment could then be estimated by dividing equation 4 by annual household income.

$$\Delta T_{GRT,i} = I_i S_{GRT,i} \Delta TR_{GRT} \quad (4)$$

where,

$\Delta T_{GRT,i}$ = additional GRT paid by household with income level i,

I_i = annual household income,

$S_{GRT,i}$ = share of household income subject to GRT for households with income level i and,

ΔTR_{GRT} = increment in GRT tax rate.

Property Tax Burden

To evaluate the average household costs of paying for sidewalk repairs by incrementing the local property tax and the burden on different income groups, we first needed to determine how much households from different income groups spend on property taxes. The same CES dataset used in our analysis of the GRT contains household expenditures on property taxes by household income decile (Table 3).

Table 3. Average 2016 Household Consumer Expenditure on Property Taxes by Household Income Decile (dollars)

		Expenditure Deciles									
Expenditure Category	**All**	**1st**	**2nd**	**3rd**	**4th**	**5th**	**6th**	**7th**	**8th**	**9th**	**10th**
Property Tax	1,969	566	861	1,018	1,319	1,350	1,587	1,990	2,402	3,110	5,498
Mean Income	74,664	6,502	16,229	24,432	33,499	43,931	57,192	73,568	94,739	127,268	269,644
Share of Income Spent on Property Tax	0.03	0.09	0.05	0.04	0.04	0.03	0.03	0.03	0.03	0.02	0.02

Similar to the GRT, lower-income households spend a greater share of their annual income on property taxes (Table 3). Also, as with the GRT analysis, the CES data are from a national sample of household expenditures, therefore, there is some error in these estimates. For example, property tax rates and property values can vary significantly from across communities.

Like the GRT analysis, we used ordinary least squares regression to create a simple equation for estimating the share of a household's income spent on property taxes by income level (equation 5). The intercept and income coefficient estimate were both statistically significant with p-values 0.05 and less than 0.001, respectively, and the overall coefficient of determination (R^2 value) was 0.93.

$$\ln(S_{prop}) = 0.858 - 0.394 \cdot \ln(I) \qquad (5)$$

where,

S_{prop} = share of household income spent on property tax,

I = average household income.

We then estimated the additional property tax paid by households earning different annual incomes using the share of household income spent on property taxes from equation 5 in equation 6. The share of household income spent on the property tax increment could then be estimated by dividing equation 6 by annual household income.

$$\Delta T_{prop,i} = I_i S_{prop,i}\left(\frac{\Delta TR_{prop}}{TR_{prop}}\right) \quad (6)$$

where,

$\Delta T_{prop,i}$ = additional property tax paid by household with income level *i*,

I_i = annual household income,

$S_{prop,i}$ = share of household income spent on property tax for households with income level *i*,

ΔTR_{prop} = increment in property tax rate and,

TR_{prop} = current property tax rate.

Gas Tax Burden

To evaluate the average household costs of paying for sidewalk repairs by incrementing the gasoline excise tax and the burden on different income groups, we first needed to understand the relationship between household income and vehicle miles traveled (VMT). To do this, we evaluated household travel survey data collected by the Mid Region Council of Governments in 2013. The household travel survey questionnaire asked a sample of residents in the Albuquerque metropolitan area to record all of their travel for one weekday during 2013, from which the distance of each trip was calculated. The questionnaire also asked respondents about their household income (respondents reported income in one of 10 ranges) and other socio-economic information. The survey data also contained household and trip sample weights that we used to estimate population statics from the survey sample.

We evaluated the household travel survey data by first aggregating the number of households and the total distance of trips by household income category. We then estimated the average annual trip distance (annual vehicle miles traveled or "VMT") per household for each income group as shown in Figure 4. Since the relationship is nearly linear, we fit a linear equation to these data using ordinarily least squares regression (equation 7) so that we could estimate VMT for households of various income levels. The intercept and income coefficient estimate were both statistically significant with p-values less than 0.001 and the overall coefficient of determination (R^2 value) was 0.91. We excluded the high-income category in our regression analysis since it is based on a relatively small number of households and included a very wide range of incomes.

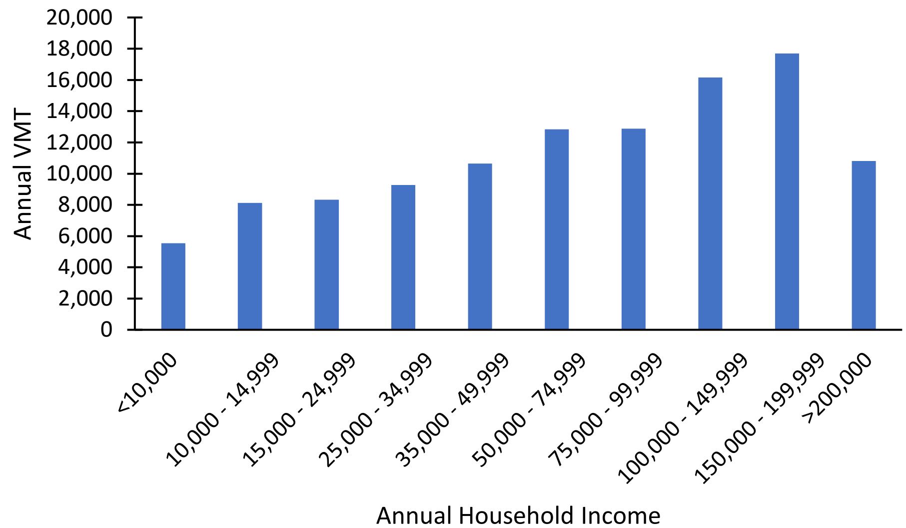


Figure 4. Relationship between household income and annual household vehicle travel.

$$VMT = 7{,}059 + 0.067 \cdot (I) \quad (7)$$

where,

VMT = annual household vehicle miles traveled,

I = average household income.

We then estimated the additional gas tax paid by households earning different annual incomes using VMT estimated from equation 7 and an average fuel economy of 22.0 miles per gallon in equation 8. The average fuel economy is an estimate of the 2016 U.S. light-duty fleet average fuel economy made by the Federal Highway Administration (Neckerman et al., 2009). The share of household income spent on the gas tax increment could then be estimated by dividing equation 8 by annual household income.

$$\Delta T_{gas,i} = \left(\frac{VMT_i}{22.0}\right) \Delta TR_{gas} \qquad (8)$$

where,

$\Delta T_{gas,i}$ = amount of additional gas tax paid by a household with income level *i*,

VMTi = annual vehicle miles traveled by a household with income level *i* and,

ΔTR_{gas} = increment in gas tax rate.

3. FINDINGS

In this section we first present aggregate cost and cost burden results for each sidewalk repair finance option and then present spatially detailed analysis of these same quantitates. In addition to our evaluation of costs, we also evaluated how defect rates correlate with neighborhood income levels. Figure 5 shows the distribution of block group average defect rates grouped by block group average median household income level. The results in Figure 5 indicate that lower income block groups tend to have higher defect rates, although defect rates are quite variable across all income groups. This result is similar to what prior studies have found, including an audit conducted by the City of Albuquerque inspector general (Harper, 2017).

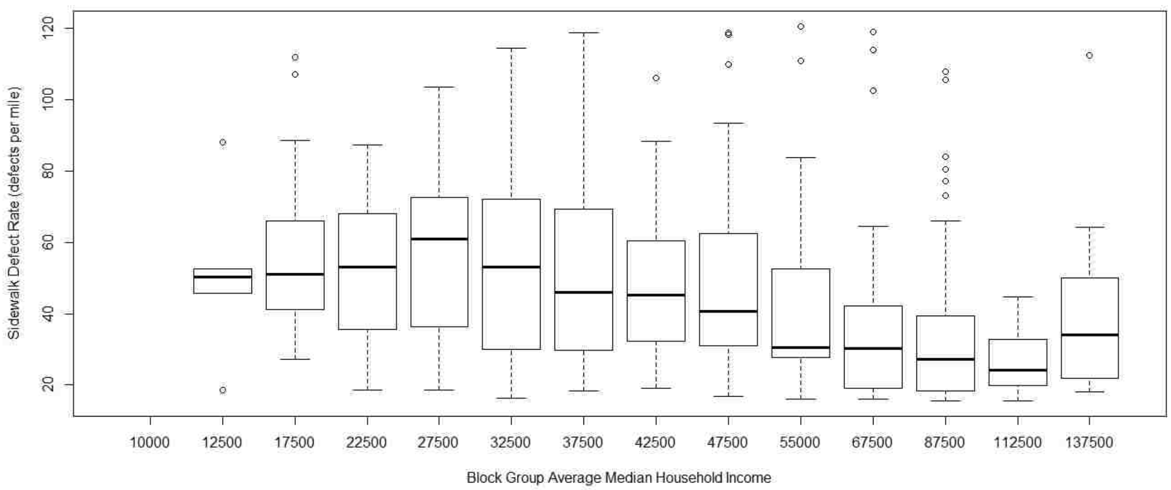
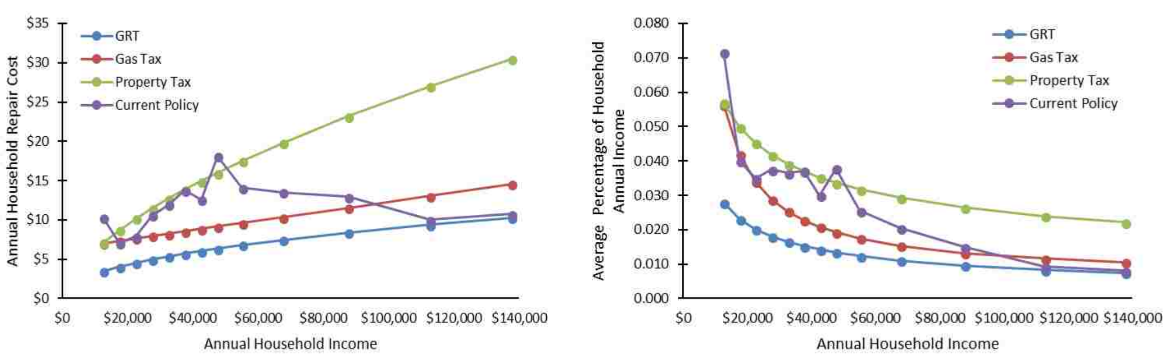


Figure 5. Defect rates by household income level.

Our analysis also found that each sidewalk finance alternative would affect the average annual cost paid by households in Albuquerque as well as how those costs are distributed across households of different income levels (Figure 6a). Incrementing the GRT would be the lowest cost option, with most households paying between \$3 to \$10 annually over five years. Incrementing the gas tax would also be a lower cost option for most households, with annual costs ranging from $7 to $15 annually. Some very low and high-income households would pay about the same or a little more annually under the gas tax alternative than the current policy. The property tax alternative would be the most expensive for almost all households with annual costs ranging from $7 to $30. Higher income households would have much higher costs than lower-income households with the property tax alternative. Finally, the current policy falls somewhere between the various alternatives with annual costs ranging from $7 to $18. The current policy would cost middle-income households the most.

While each finance option generally requires higher income households to pay more, these costs would be a smaller share of their annual household income (Figure 6b). In other words, all of the options we evaluated are regressive since they would require lower-income households to pay a larger share of their annual income towards sidewalk repairs. The current policy appears to be the most regressive option, followed by the gas tax. The property tax and GRT are similar in terms of repressiveness, although the GRT would cost all households less.



A **B**

Figure 6. Average annual household repair costs (A) and percentage of annual household income spent on sidewalk repairs (B) by household income for each sidewalk finance policy.

While looking at how each of the different policy alternatives affect different income groups, we also looked at the equity of these alternatives across age and race groups. Figure 7a shows the distribution of different median age groups by percentage of annual income spent on repairs. Although all the age groups seem to have similar cost burdens, the younger neighborhoods seem to pay a little higher share of their income towards repairs. To evaluate the disparities among race, the population was split into three categories of "White," "Hispanic," and "Other Race/Ethnicity" because the population in Albuquerque is predominantly white and Hispanic. Figure 7b-7d shows that neighborhoods with greater percentages of Hispanic residents pay higher shares of their income towards repairs when it comes to the current policy. Neighborhoods with higher percentages of white residents tend to pay a lower share of their income towards repairs for the current policy. The distribution among the other tax alternatives seems to be fairly even.

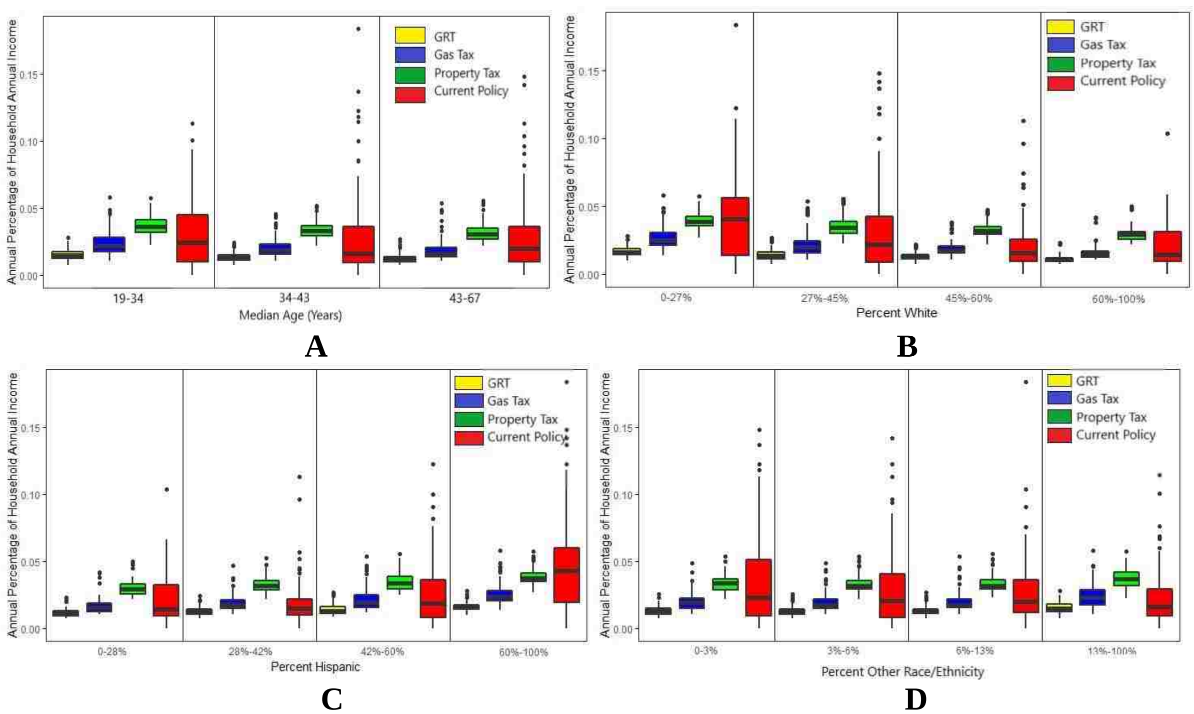


Figure 7. Percentage of annual household income spent on sidewalk repairs by age and race.

We also evaluated the spatial distribution of average household costs and cost burdens. As shown in Figure 8, each alternative affects the distribution of repair costs across neighborhoods. The current policy results in the greatest neighborhood to neighborhood variability in annual household repair costs followed by the property tax alternative. The current policy places the greatest costs on neighborhoods with the most defects, while the alternative policies distribute costs based on other factors (i.e., driving, property value, and spending) that are closely related to household income. The current policy and the property tax policy result in almost the complete opposite distribution of costs, with the property tax alternative placing greater costs on neighborhoods with fewer defects. The other alternatives spread costs out relatively evenly.

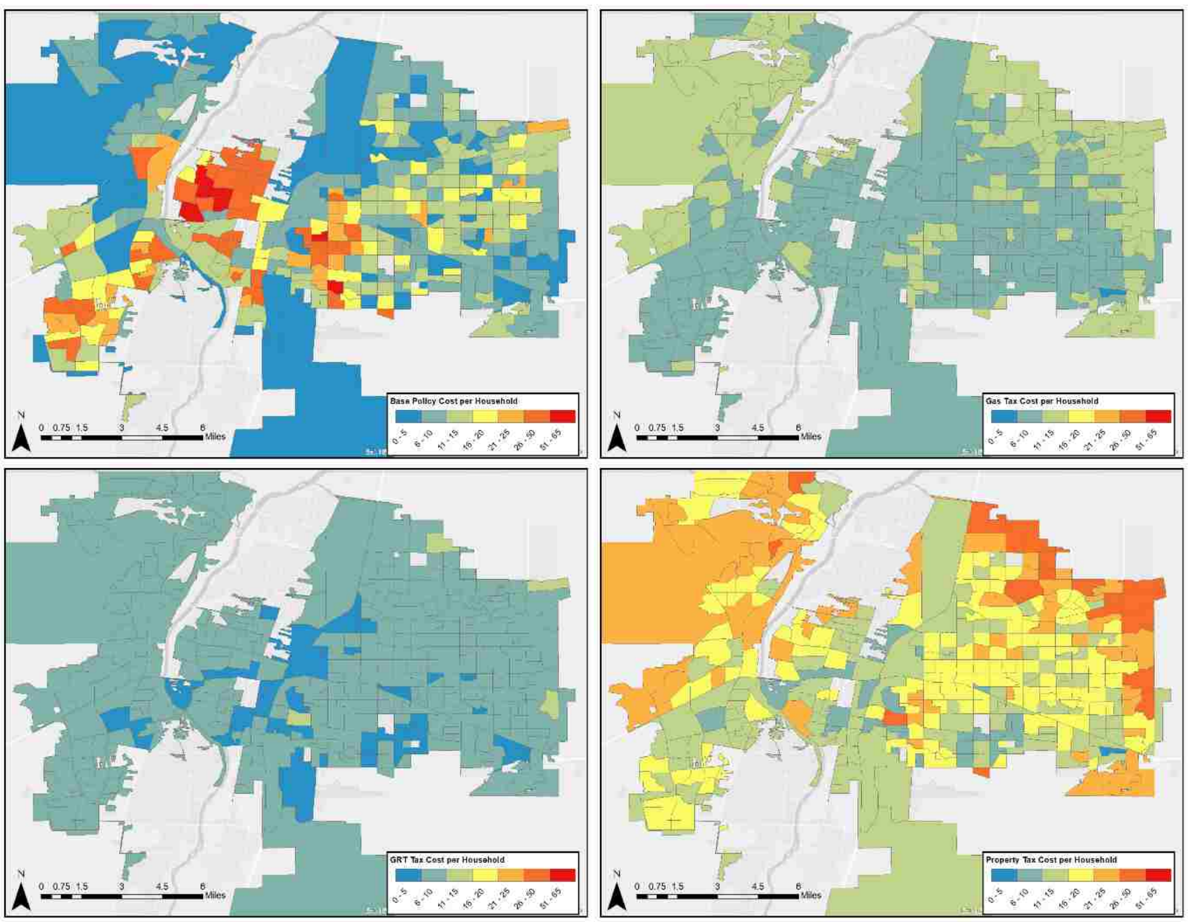


Figure 8. Block group level average household repair costs for each sidewalk finance policy.

Since each financing alternative distributes cost differently across the city's neighborhoods, and since household income levels also vary across the city, each financing alternative results in a different spatial distribution of cost burden (Figure 9). The current policy results in the greatest neighborhood to neighborhood disparities in the share of a household's income spent on sidewalk repairs. Incrementing the GRT would result in the smallest amount of spatial variation while the other alternatives would result in the most amount of disparity.

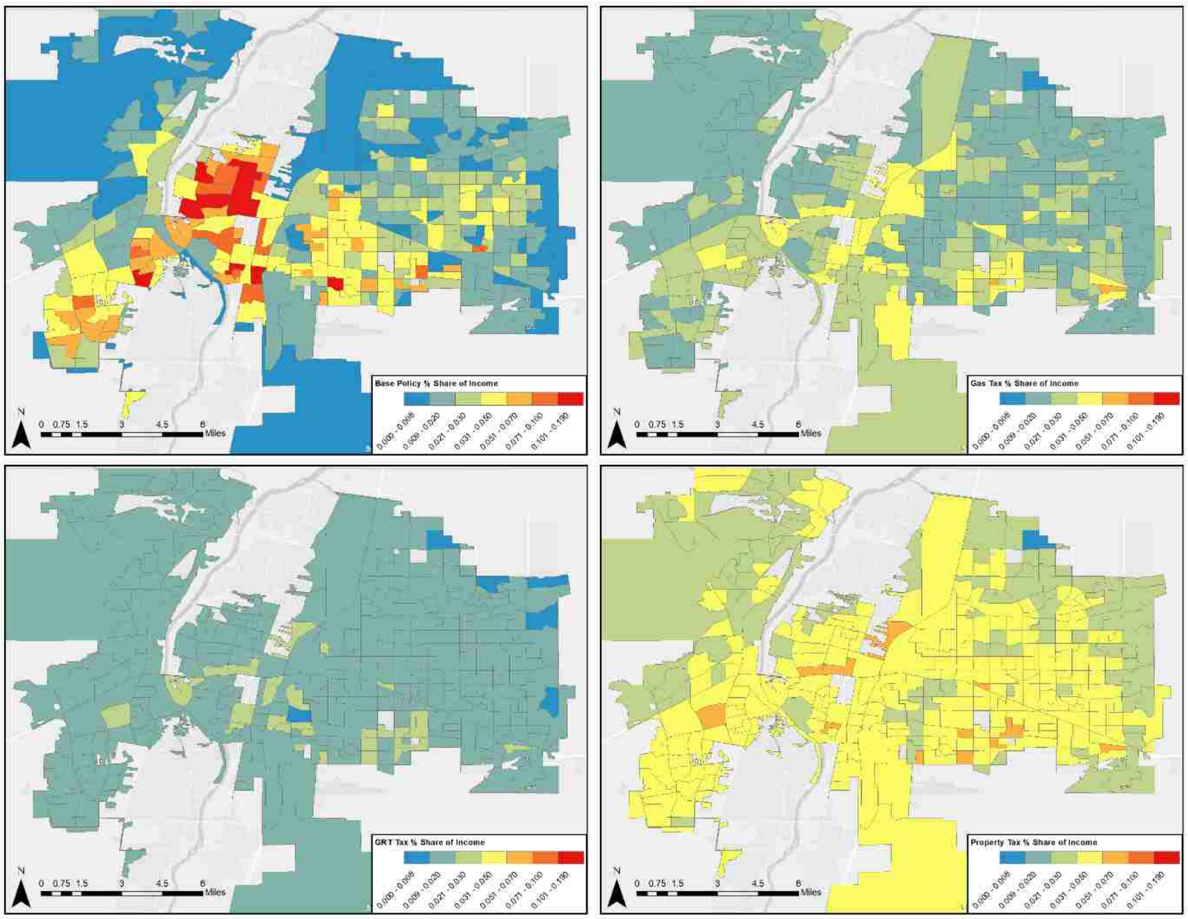


Figure 9. Block group level average percentage of household income spent on sidewalk repairs for each sidewalk finance policy.

4. CONCLUSIONS

In this study, we set out to evaluate alternatives to the common municipal policy of requiring property owners to maintain public sidewalks adjacent to their property. Our review of the literature did not turn up any evidence in support of either the efficiency or effectiveness of this common policy. The origins of this policy and why it differs from how streets are maintained are still unclear. That many municipalities, including Albuquerque, have failed to maintain sidewalks suggests that the adjacent property owner asset management and financing model is ineffective. Furthermore, we did not identify any prior research evaluating the equity and environmental justice concerns related to the adjacent property owner responsibility model. However, prior research suggests that this policy is likely to raise concerns since lower income communities may be more likely to have less maintained pedestrian facilities and because lower income households may also depend on walking for transportation to a greater degree than higher income households. Our analysis of sidewalk conditions in Albuquerque finds that lower income neighborhoods generally have a higher level of sidewalk defects and that the lack of maintenance presents equity and environmental justice concerns. While we cannot conclude that the property owner responsibility model is responsible for the inequitable state of sidewalk condition, the current policy seems unlikely to address these concerns.

The three alternatives we evaluated would all raise the same amount of additional revenue, which equals the current estimated cost of repairing all of Albuquerque's sidewalks (for routine maintenance issues and not for other ADA related issues) over a period of five years. We find that the current policy is both the most regressive (i.e., places a greater burden on lower-income households) and results in the most inequity in sidewalk repair costs across the city's neighborhoods among age and race with minority populations (i.e., Hispanic) burdened with higher repair costs. The current policy is also relatively expensive and places the highest costs on middle-income households. Increasing the GRT or gasoline excise tax would be the least costly options since they have the largest tax bases (they both also collect revenue from nonresidents) and have the lowest, most evenly distributed shares among all ages and races. Increasing the property tax would cost many residents about the same on average as the current policy. However, it should be kept in mind that our cost estimates are annualized and that the current policy, if enforced, would require affected residents to pay sidewalk repair costs all at once and not over a period of several years or more. All of the alternatives are also regressive, but less so than the current policy.

So, what should a city do? Any of the alternatives that we evaluated would be better options than what is currently in place, for several reasons. First, the alternatives would turn over responsibility to the municipality, which, in turn, could reduce costs through more effective asset management, lower administrative costs, and increase economies of scale. Additionally, sidewalks are generally publicly owned or on public easements. They are an essential part of a municipality's publicly owned and managed transportation network. Failure to maintain parts of the network can degrade the entire network. For example, a damaged sidewalk slab can require a large detour for a disabled pedestrian. The pedestrian network also connects most other modal trips to their final destinations (e.g., to walk to transit or to walk to a store from a parking space).

Second, the alternatives are more likely to address equity and environmental justice concerns. The alternatives are more likely to result in adequate sidewalk maintenance since they would not result in the enforcement difficulties of the current policy. This, alone, could eliminate the disparities in maintenance needs between neighborhoods. Furthermore, the alternatives are less regressive. They would place a smaller burden on low income and minority households.

Third, for most residents, the alternatives would be less expensive. Increasing the GRT would be the least expensive option followed by the gas tax because these taxes also generate revenue from non-residents. The property tax would cost about the same as the current policy since its tax base is Albuquerque residents and businesses – the same as the current policy.

An additional consideration should be the sustainability of each tax. Raising taxes is a difficult task; and therefore, a tax that requires fewer adjustments over time may be desirable. All of the taxes will generate more revenue as the region's population grows, although growth likely means greater sidewalk maintenance costs as well. The gas tax is the least sustainable because the vehicle fleet is expected to become more fuel efficient over time as more stringent federal fuel economy standards come into effect and the fleet turns over. Furthermore, an increasing market share of electric vehicles could further erode gas tax revenue. For a period of time VMT per capita was also declining, further eroding gas tax revenue; however, that trend has at least temporarily reversed. Revenue from the GRT depends on the region's economic activity. There is potential for both growth and decline. The GRT is likely the most volatile of the options but has a more sustainable future than the gas tax. Finally, property tax revenues are also tied to the regional economy but will likely respond more slowly to changing economic conditions than expenditures subject to the GRT.

While our analysis has been simplified in many ways, as described in the methods section, we believe it presents a very strong case for municipalities to reconsider how they manage sidewalks and how sidewalk repairs are financed. Our study is not necessarily about recommending a specific tax or tax level but rather to encourage municipalities to consider other funding alternatives that are more equitable and sustainable. Municipalities may consider conducting a more formal economic analysis of the wider economic impacts of any changes to current municipal tax rates that were not considered in our analysis. Since the increase in taxes that would be required are relatively small, significant economic impacts are unlikely. The potential benefits of the alternative sidewalk finance policies, which includes the potential of better-maintained sidewalks to increase property values and encourage economic development, reducing municipality liability to ADA and injury claims, and reducing overall sidewalk repair costs, would likely outweigh any negative economic impacts from increasing tax rates.

Chapter 3: Evaluating How the Quality of Pedestrian Infrastructure Affects the Choice to Walk

1. INTRODUCTION

In many cities across the country, including Albuquerque, New Mexico, sidewalks are in a state of disrepair with many having holes, cracks, and slab displacements (City of Albuquerque 2017; Evans-Cowley 2006b; Shoup 2010b). There has been little research on how the quality and condition of sidewalks and pedestrian infrastructure affect a person's decision to walk. Prior research has mainly focused on how large-scale features of the built environment such as density and land use affect a person's decision to walk (Ewing and Cervero 2010; Frank and Pivo n.d.; Handy et al. 2002), leaving us knowing comparatively little about how the quality and design of pedestrian infrastructure affects the decision to walk. Therefore, we ask the question, does the quality of pedestrian infrastructure affect the choice to walk and which attributes are most important?

We evaluated our research questions by conducting a household travel survey in Albuquerque, New Mexico. The survey asked respondents from households in different neighborhoods about their perceptions of the quality of certain pedestrian infrastructure attributes such as if sidewalks are maintained or if sidewalks are wide enough for two people to walk side by side. The survey also collected information about travel behavior, including how often respondents walked for transportation and recreation. We then evaluated summary statistics and developed linear regression models to evaluate possible associations between pedestrian infrastructure attributes and walking frequency.

2. LITERATURE REVIEW

Prior studies have investigated factors that may affect a person's decision to walk. Many have found an association between socioeconomic characteristics and walking. Others have found links between the built environment and walking. While much research has looked into the effects of the built environment and other social factors on the decision to walk, one area that has not been extensively researched is how the quality of pedestrian infrastructure affects walking.

2.1. Socioeconomics and Demographics

The decision to walk is affected by many different aspects of a person's life. Many studies have found that the socioeconomic status and demographics of individuals, households and neighborhoods affect walking. Minority and lower-income populations are found to be more likely to use active modes of transportation like walking and are also more likely to live in neighborhoods where the pedestrian infrastructure is in poor condition, raising equity concerns (Battelle 2000; Garasky et al. 2006; Kelly et al. 2007b; McDonald 2008). Safety factors and lower crime rates have been found to encourage walking (Alfonzo et al. 2008; Ariffin and Zahari 2013; Leslie et al. 2005; Saelens et al. 2003). Furthermore, differences in factors affecting walking have also been found between men and women as well as among different age groups. For example, women have been found to be more concerned about crime then men and older populations walk more for exercise (Carlin et al. 1997; Foster et al. 2004; Georggi and Pendyala n.d.; Humpel et al. 2004a; Kerr et al. 2007; Naumann et al. 2009).

2.2. Built Environment

The built environment is one of the main aspects of one's surroundings with which people interact when walking. The built environment can determine where you walk to or what route you might take. Certain characteristics of the built environment, specifically land-use mix, have been a focal point for many studies investigating how people travel.

Many studies have found an association between land-use diversity and walking. Prior studies have used information from household travel surveys to evaluate associations between land-use and walking using regression analysis. These studies have found that more walking trips are associated with greater land-use diversity (Alfonzo et al. 2008; Rodríguez et al. 2009; Wood et al. 2010), more urbanization and when traveling to shopping or recreational areas (Kemperman and Timmermans 2009). Cross sectional studies that compare attributes of different neighborhoods with walkability have also fould that land-use diversity is an important factor (Leslie et al. 2005; Saelens et al. 2003; Van Dyck et al. 2012).

Studies have also found that density is associated with increased walking. Prior studies using travel surveys and a cross sectional study design have investigated the impact of variation in residential density across neighborhoods and walking, finding a positive relationship (Leslie et al. 2005; Li et al. 2005; Moudon et al. 2007; Rodríguez et al. 2009; Saelens et al. 2003; Van Dyck et al. 2012) (Clark et al. 2014). At least one study has also found that both employment density (number of employers in a space) and population density have a positive effect on the number of work and shopping walking trips (Frank and Pivo n.d.).

2.3. Traffic

Another aspect of people's surroundings that they encounter while walking is vehicle traffic. Busy roads with heavy traffic and vehicles traveling at high speeds have been found to discourage people from walking (Ariffin and Zahari 2013; Giles-Corti et al. 2011; Gómez et al. 2010; Jacobsen et al. 2009; Montemurro et al. 2011; Owen et al. 2004; Timperio et al. 2004). Traffic is likely to present a real or perceived safety threat but may also discourage people from walking for other reasons such as creating noisy and uncomfortable environment; however, there has been little research into these possibilities.

2.4. Pedestrian Infrastructure

Prior research has found connections between certain pedestrian infrastructure characteristics and walking. Street lighting has been found to make people feel safer and therefore more inclined to walk (Addy et al. 2004; Ariffin and Zahari 2013). Crosswalks have been found to increase walking when they are present (McDonald et al. 2013). The aesthetics of one's surroundings such as more vegetation has also been shown to affect walking (Adkins et al. 2012; Ball et al. 2001; Humpel et al. 2004a; Rhodes et al. 2007). However, less attention has been given to smaller scale features of pedestrian infrastructure or its quality.

Of the few studies that have evaluated how the quality of pedestrian infrastructure affects the choice to walk, they have found a positive correlation between the quality of pedestrian infrastructure and walking. A study in Belgium conducted an online survey of adults 65 years of age and older (Van Cauwenberg et al. 2016). Participants were asked about their perceptions of sidewalk evenness, separation from traffic, sidewalk width, and other traffic related questions in their area. In order to determine what the quality of the pedestrian infrastructure was like in their neighborhood, participants were shown images of different conditions of sidewalks and asked if the sidewalks in their neighborhood matched any of the conditions (poor, ok, great). The study found that the most important sidewalk attribute for walking was sidewalk evenness. While this study is one of the only published studies evaluating the effect of infrastructure quality on walking, the focus on people over the age of 65 limits the ability to draw more general conclusions about the importance of different sidewalk attributes and their quality.

A study in Canada conducted a survey that asked participants about their attitudes, intentions, and planning habits related to walking (Rhodes et al. 2007). The survey also included questions about their perceptions of the walking environment such as proximity to retail, infrastructure quality, aesthetics, etc. The study found a small correlation (correlation coefficient of 0.17) between infrastructure quality and walking. However, infrastructure was not defined; therefore, it is unclear whether the quality of sidewalks were considered by study participants. Furthermore, the main focus of this study was on how attitudes and intentions affect walking choices rather than infrastructure.

Another study in Canada conducted focus groups with neighborhoods asking participants about perceptions of their neighborhood environment (Montemurro et al. 2011). Ten focus groups were held with each focus group consisting of 4 to 9 people. The participants had been recruited from a prior survey study several years before. The study found that path connectivity and quality were frequently referenced by participants as influencing their choice to walk.

Stated preference studies have also been used to evaluate the importance of sidewalk quality. Researchers asked participants in one study to watch video clips of sidewalks and then rate the level of service of the pedestrian environment in the video (Kang et al. 2013). They found that an increase in sidewalk width and the presence of a barrier between the sidewalk and street both improved the perceived level of service of the pedestrian environment. One limitation with this study design is that higher level of service is not necessarily associated with greater walking frequency.

2.5. Summary

While many studies have evaluated the association between socioeconomic status, demographics, and the built environment and a person's decision to walk, very few have looked into how specific attributes of pedestrian infrastructure, specifically sidewalks, affect the choice to walk. Pedestrian infrastructure is part of the built environment and the main aspect of the built environment people interact with when walking. However, studies evaluating the built environment have mainly focused on larger scale features like land-use and density while paying less attention to smaller scale attributes that could affect the choice to walk. Since prior studies have found that large scale features of the built environment affect the decision to walk, it is possible that various smaller scale attributes of pedestrian infrastructure are also important.

3. METHODOLOGY

Our study consisted of three tasks. In the first task, we determined where our survey would be distributed and how we would distribute the survey. For the second task, we developed the survey to be distributed. Finally, we analyzed the results from the survey to determine if there is a relationship between the amount of walking and pedestrian infrastructure quality.

3.1. Study Area & Survey Distribution

The main instrument to be used in our study was a household travel survey that was distributed to residents in Albuquerque, New Mexico. Albuquerque has a large amount of sidewalks in poor condition that need to be replaced and has one of the highest pedestrian fatality rates in the country. Therefore, understanding what might affect a person's decision to walk in Albuquerque could be of importance.

Our goal was to distribute our survey to as many adult residents from different areas of Albuquerque as possible. We did not have a budget for a paper based, mail out/mail back survey, so we developed a plan to deploy an internet-based survey. One challenge with an internet-based household travel survey is reaching respondents in specific areas of interest (e.g., email addresses are not tied to street addresses and there is no universal directory of e-mail addresses). One way to contact residents electronically is through neighborhood associations since many neighborhood associations in Albuquerque have an email distribution list for most residents within their neighborhood. The city of Albuquerque consists of over 200 neighborhood associations, and 64 of these neighborhood associations have up to date contact information listed on the City of Albuquerque's website. We contacted each of these 64 neighborhoods (see Figure 10) to ask if they could distribute a link to our internet survey.

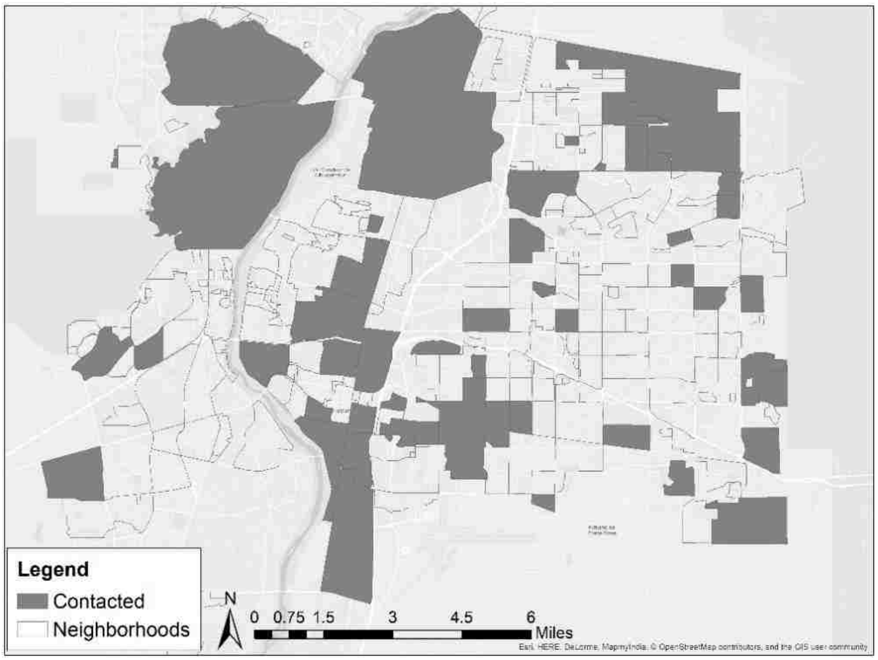


Figure 10. Map of all contacted neighborhoods in Albuquerque.

We used a commercial web-based survey platform (eSurvey) as our main distribution platform since it would allow us to not only distribute the survey to a large number of people for a low cost, but also allow us to distribute and obtain results faster than a paper-based survey. Following contact with neighborhood associations, we asked if they would be willing to send out a link for our online survey to residents in their neighborhood through their email distribution list. This allowed us to maintain participant anonymity since we did not have access to the email distribution lists but were able to track which responses came from which neighborhood. Tracking responses from individual neighborhoods allowed us to study how differences in neighborhood characteristics could affect walking. The survey link was open for two weeks. Paper-based surveys were also made available upon request.

3.2. Survey

Our survey asked respondents to report how frequently they travel in a typical week using each potential mode of transportation for various trip purposes, including recreation (i.e., non-transportation trips like walking for exercise or pleasure). We then asked respondents questions about their neighborhood's pedestrian infrastructure and street environment and the importance of pedestrian infrastructure and street environment attributes on the decision to walk. We also collected standard socioeconomic and demographic data. The full survey is provided in Appendix A.

Travel Behavior: Previous studies that have evaluated what affects the choice to walk have included questions in their surveys asking participants about their travel behavior and how often they walk or get physical activity in a week (Alfonzo et al. 2008; Handy et al. 2005; Humpel et al. 2004b; Li et al. 2005; Van Dyck et al. 2012; Wood et al. 2010). Therefore, we began the survey by asking the respondents to report how often within a typical week they drive a vehicle, ride the bus/public transit, walk, ride a bicycle, or ride a skateboard/scooter by ranking their number of trips using a 4-point scale (0 trips, 1 to 2 trips, 3 to 4 trips, 5 or more trips). This allowed us to compare how often people walk compared to other modes of transportation. The amount of walking was used as the dependent variable in our regression analysis.

Pedestrian Infrastructure Characteristics: Previous studies have asked respondents to rate their perceptions of built environment characteristics (Handy et al. 2005; Humpel et al. 2004b; Leslie et al. 2005; Rhodes et al. 2007; Van Dyck et al. 2012; Wood et al. 2010). Therefore, we asked respondents similar questions regarding pedestrian infrastructure in their neighborhoods (Table 4). In the first section of Table 4, we asked participants questions that were either indicators of sidewalk quality or asked for their perceptions of pedestrian infrastructure quality with response categories tailored to each question. For example, we asked if they thought sidewalks were well maintained and if they usually walked on sidewalks or the street. In the second section of Table 4, we asked participants to tell us if sidewalks in their neighborhood have certain features using a 4-point scale (1-Most Do, 2-Some Do, 3-Most Do Not, 4-Unsure). In the third section of Table 4, we asked participants to tell us if they thought certain pedestrian infrastructure characteristics encouraged or discouraged them from walking using a 5-point scale (1-strongly discourage from walking to 5-strongly encourage walking).

Table 4. Questions asked in Survey

Section	Statement
1. Indicators and Perceptions of Pedestrian Infrastructure Quality	Do residential streets, like the one you live on, in your neighborhood have sidewalks?
	When walking on streets in your neighborhood how often do you use the sidewalk?
	If you walk with someone else in your neighborhood, do both of you walk on the sidewalk?
	How well maintained are sidewalks in your neighborhood?
	How is the lighting at night on residential streets in your neighborhood?
	How do people park their cars in your neighborhood?
	How would you describe the speed of vehicle traffic in your neighborhood?
	How would you describe the amount of traffic on residential streets in your neighborhood?
2. Pedestrian Infrastructure Features (4-point scale)	Sidewalks wide enough for two or people to walk side by side
	Sidewalks mostly level where they cross driveways
	Sidewalks separated from street by landscaping, grass, etc.
	Sidewalks have ramps at street intersections
	Sidewalks have permanent obstacles in them such as utility poles or fire hydrants
	Sidewalks partially blocked by overgrown bushes, other vegetation
	Sidewalks are frequently blocked by parked cars
	Sidewalks are littered with potentially dangerous items such as broken glass
	There are marked crosswalks where local streets cross busier roads
3. Effect of pedestrian infrastructure characteristics (5 point scale)	Wider Sidewalks

Evenness of Sidewalks
Presence of sidewalks
Sidewalk curb ramps at intersections
Marked pedestrian crossings at busy streets
Separations between sidewalk and roadway
Lighting at night
Overgrown vegetation
Crime
High volume of vehicle traffic
High traffic speed
Maintained sidewalks
Obstacles in sidewalk such as utility poles or fire hydrants
Broken glass or other potentially dangerous items in sidewalk

Demographics: At the end of our survey, we asked participants to provide basic socioeconomic and demographic information including: age, annual income, education, employment status, number of vehicles owned, number of members in their household, if they had a disability, and race. Previous studies have found many of these factors to be important in understanding the choice to walk (Li et al. 2005; Van Dyck et al. 2012; Wood et al. 2010).

Focus Group/Pilot Survey: We conducted focus groups with two neighborhoods to understand if our initial set of survey questions captured the main concerns people had about walking. The focus groups had 3 and 7 attendees, respectively. We held the focus group meetings at the University of New Mexico on separate evenings to allow more people to attend whom might work during the day. We asked focus group participants to tell us about how they travel, what residential streets were like in their neighborhood, including maintenance issues, and what factors affected how much they walk. For the most part we allowed focus group participants to engage in dialog with each other in discussing these issues while we recorded the meeting and took notes.

The main concerns we heard were that many sidewalks in their neighborhoods are not level, many have holes and cracks from tree roots, there is not enough street lighting, intersection crossings are not safe, and there is too much traffic and too many speeding cars. Questions related to these concerns were included in our final survey. Once the focus groups were completed, we sent our survey to several graduate students within our department as a pilot to identify potential problems with how each question was stated or the logic of the survey questions.

3.3. Survey Response & Regression Analysis

The first task was understanding if the amount of walking varies between neighborhoods. We began by comparing the frequency and share of trips made by walking using boxplots. We also conducted a statistical analysis by constructing linear regression models to test the significance of differences in the share of walking trips between neighborhoods (Model A), and also while controlling for differences in respondent socioeconomic status and demographics (Model B).

Model A:

$$Share\ of\ walking = \alpha + \beta(Neighborhood)$$

where:

Share of walking = share of all trips made by walking

$Nieghborhood$ = categorical variables for each neighborhood (1 through 14)

$\alpha, and\ \ \beta$ = regression coefficients to be estimated.

Model B:

$$Share\ of\ walking = \alpha + \beta(Neighborhood) + \theta(Demographics)$$

where:

$Demogrpahics$ = independent demographic variables: Age, Income, Education, Employment, # Days you work from home, Household Size, # Vehicles per household, Do you have a disability, Race

$\alpha, \beta, and\ \theta$ = regression coefficients to be estimated.

Regression models A and B allowed us to determine which, if any, neighborhoods had a significant difference in walking. Understanding which neighborhoods walk more can help us identify potential characteristics within those neighborhoods that affect walking.

We also created four more linear regression models to further explore how various factors affect the share of walking trips: one model comparing the presence of certain pedestrian infrastructure features with the share of walking trips (model 1), another model comparing the perceptions and indicators of pedestrian infrastructure quality with the share of walking trips (model 2), a third model combining the first two models (model 3), and a fourth model comparing the effect of pedestrian infrastructure features with the share of walking trips (model 4).

The first regression model included pedestrian infrastructure features from Table 4, section 1 as the main independent variables. Respondent demographics were also incorporated into the model as another set of independent variables as were a set of independent variables describing large-scale built environment features: household density, the ratio of retail to residential land use area, if the neighborhood is a traditional street grid network or a cul-de-sac pattern, the distance to the nearest school, and if the neighborhood is near a Rapid Ride bus route which is an express bus service similar to a bus rapid transit system.

The large scale built environment feature variables (Table 5) were constructed from GIS data available from the city of Albuquerque and the state of New Mexico.

Table 5. Large Scale Neighborhood Features

Neighborhood	HH Density (units/sq. mi)	Ratio of Retail to Residential Land Use	Grid Network	Nearest School Distance (mi)	Near Rapid Ride Bus Route
1	7,554	0.088	No	0.128	Yes
2	53,641	0.046	Yes	0.572	No
3	116,525	0.178	Yes	0.413	Yes
4	41,258	0.028	No	0.500	No
5	18,153	0.149	No	0.663	No
6	13,569	0	No	0.788	No
7	56,916	0.309	Yes	0.175	Yes
8	144,582	0.896	Yes	0.203	Yes
9	88,385	0.247	Yes	0.093	No
10	56,788	0.859	Yes	0.318	Yes
11	25,182	0.089	No	0.844	Yes
12	96,350	0.689	Yes	0.426	Yes
13	28,577	0.724	Yes	0.558	Yes
14	22,502	0.191	No	00.329	Yes

A GIS shapefile of census block groups and their corresponding household density (household units per square mile) was obtained from the New Mexico Resource Geographic Information System Program's website. To determine the household density for each neighborhood, we intersected the neighborhood boundaries, which were found from a shapefile of neighborhood association boundaries from the City of Albuquerque's GIS Data website, with the census block groups containing household density information using ArcGIS. From there, we were able to determine which census block group corresponded with each neighborhood and identify the household density for that neighborhood.

GIS shapefiles of land use, street networks, school locations, bus routes, as well as neighborhood association boundaries were obtained from the City of Albuquerque's GIS Data website. To determine the ratio of retail to residential land use area, we first intersected the land use parcels from the land use shapefile with the neighborhood boundaries using ArcGIS.

From there, we determined how much area (square miles) in each neighborhood was for retail land use. We then determined how much area in each neighborhood was for residential land use. We divided the area retail land use by the area of residential land use to find the ratio of retail to residential land use in each neighborhood.

To determine if a neighborhood has a traditional gridded street network or cul-de-sac pattern, we intersected the street network for the city of Albuquerque by neighborhood boundaries. By focusing in on each neighborhood, we observed the street network in each neighborhood to determine if the streets were all connected or if they were mainly cul-de-sacs. Each neighborhood was ranked with a “Yes-there is a grid network” or “No-there is not a grid network.”

The distance to the nearest school location was found by identifying the location of every school within the city using the school location shapefile. The center of each neighborhood was then identified. Using the Near tool in ArcGIS, we calculated the distance (miles) from the center of each neighborhood to the nearest school.

To determine if a neighborhood was near a Rapid Ride bus route, we first created a quarter mile buffer around each neighborhood boundary. We chose a quarter mile buffer since that would most likely be the amount that people would walk to get to the bus. We then overlaid the bus routes over the buffered neighborhoods to determine if any Rapid Ride route was located within the neighborhood or quarter mile buffer around the neighborhood. Each neighborhood was ranked with a “Yes-it’s near a Rapid Ride route” or “No-it’s not near a Rapid Ride route.”

Since most variables are categorical and our sample size is not very large, we recoded many of them to combine similar categories to reduce the number of independent variables in the regression models and avoid overfitting. This simplification also made it easier to interpret the results. Table 6 shows how each variable was re-coded.

Table 6. Categorical Variable Re-coding

Original Variables	Condensed Variables
When walking on streets in your neighborhood how often do you use the sidewalk?	
-I sometimes use the sidewalks and sometimes walk in the street	All else
-I usually use the sidewalks	I usually use the sidewalks
-I usually walk in the street	All else
-I do not walk	All else
If you walk with someone else in your neighborhood, do both of you walk on the sidewalk?	
-Usually everyone I walk with uses the sidewalks	Usually everyone uses the sidewalks
-Usually I and the people I walk with walk in the street	All else
-Sometimes either I or someone I walk with walks in the street	All else
Do residential streets, like the one you live on, in your neighborhood have sidewalks?	
-Yes-Most of them	Yes – Most of them
-Yes-Some of them	Yes – Some of them
How well maintained are sidewalks in your neighborhood?	
-Most are well maintained	Most are well maintained
-A few sections need to be repaired or replaced	Need repairs
-Many sections need to be repaired or replaced	Need repairs
-Most need to be repaired or replaced	Need repairs
-I am not sure	Not sure
How is the lighting at night on residential streets in your neighborhood?	
-Good- most streets are evenly lit along their entire length	Good
-OK – some places have lighting and others are dark	Poor or OK
-Poor – there is very little light, most of the streets are dark	Poor or OK
How do people park their cars in your neighborhood?	
-Most people park off the street in driveways, garages or parking lots	Park off street
-There are a few cars usually parked on the street	Park on the street
-Most of the street is lined with parked cars	Park on street
How would you describe the speed of vehicle traffic in your neighborhood?	
-Most cars seem to travel at a safe speed	Travel at safe speed
-I have some concerns about the amount of speeding cars	Concerned about speeding
-I am very concerned about how many cars are speeding	Concerned about speeding
How would you describe the amount of traffic on residential streets in your neighborhood?	
-There is not much traffic	Not much traffic
-Sometimes I feel there is too much traffic for a residential area	Concerned about traffic
-There is too much traffic for a residential street	Concerned about traffic
Wide enough for two or more people to walk side by side	
-Most Do	They Do
-Some Do	They Do
-Most Do Not	Most Do Not
Are mostly level where they cross driveways	
-Most Do	They Do
-Some Do	They Do
-Most Do Not	Most Do Not
Are separated from the street by landscaping grass gravel dirt etc.	

-Most Do	They Do
-Some Do	They Do
-Most Do Not	Most Do Not
-Unsure	Unsure
Have ramps at street intersections	
-Most Do	They Do
-Some Do	They Do
-Most Do Not	Most Do Not
-Unsure	Unsure
Have permanent obstacles in them such as utility poles and fire hydrants	
-Most Do	They Do
-Some Do	They Do
-Most Do Not	Most Do Not
-Unsure	Unsure
Are partially blocked by overgrown bushes cactus or other plants	
-Most Do	They Do
-Some Do	They Do
-Most Do Not	Most Do Not
-Unsure	Unsure
Are frequently more than once per week blocked by parked cars or trucks	
-Most Do	They Do
-Some Do	They Do
-Most Do Not	Most Do Not
-Unsure	Unsure
Are littered with potentially dangerous items such as broken glass and hypoder mic needles	
-Most Do	They Do
-Some Do	They Do
-Most Do Not	Most Do Not
-Unsure	Unsure
Have marked crosswalks where local streets cross busier roads	
-Most Do	They Do
-Some Do	They Do
-Most Do Not	Most Do Not
-Unsure	Unsure
Age	
-25 – 34 years old	30
-35 – 44 years old	40
-45 – 54 years old	50
-55 – 65 years old	60
-65 – 75 years old	70
-Greater than 75	80
Annual Income	
-$20,000 – $34,999	27,500
-$35,000 – $49,999	42,500
-$50,000 – $74,999	62,500
-$75,000 – $99,999	87,500
-Less than $20,000	15,000
-Over $100,000	150,000
Education	
-Associate Degree	Some College or higher
-Bachelor's Degree	Some College or higher
-Doctorate	Some College or higher
-High School Degree or equivalent (GED)	High School or Less
-Less than a high school diploma	High School or Less
-Master's Degree	Some College or higher
-Some college, no degree	Some College or higher
Employment	
-Employed full time (including self-employed)	Employed
-Employed part time (including self-employed)	Employed
-Retired	Retired
-Unemployed and currently looking for work	Unemployed

-Unemployed and not currently looking for work	Unemployed
Work from Home	
-1-2 days	1.5
-3-4 days	3.5
-5 or more	7
-No	0
Household Size	
-1	1
-2	2
-3	3
-4	4
-5 or more	5
# Vehicles per Household	
-0	0
-1	1
-2	2
-3	3
-4	4
-5 or more	5
Disability	
-No	-No
-Yes	-Yes
Hispanic/Latinx?	**Hispanic/Lantinx & Race**
-Yes	Non-white
Asian	
-Yes	Non-white
Black or African American	
-Yes	Non-white
White	
-Yes	White
Household Density	Household Density
Ratio of Retail to Residential Land use	Ratio of Retail to Residential Land use
Grid Network	Grid Network
Nearest School Distance	Nearest School Distance
Near Rapid Ride Bus Route	Near Rapid Ride Bus Route

Model 1:

$$share\ of\ walking = \alpha + \beta(quality\ perceptions) + \gamma(neighborhood\ features) + \theta(demographics)$$

where:

$quality\ perceptions$ = Perceptions of pedestrian infrastructure quality = categorical variables for responses to questions in Table 4 section 1

$neighborhood\ features$ = neighborhood scale built environmental and land-use variables: household density, the ratio of retail to residential land use area, if the neighborhood a traditional street grid network or a cul-de-sac pattern, the distance to the nearest school, and the distance to the Rapid Ride bus route

$demographics$ = independent demographic variables: Age, Income, Education, Employment, # Days you work from home, Household Size, # Vehicles per household, Do you have a disability, Race

$\alpha, \beta, \gamma, and\ \theta$ = regression coefficients to be estimated.

The second regression model includes pedestrian infrastructure features (Table 4, section 2) along with the same demographic and neighborhood scale features as model 1.

Model 2:

$$share\ of\ walking = \alpha + \beta(infrastructure\ features) + \gamma(neighborhood\ features) + \theta(demographics)$$

where:

Share of walking = share of all trips made by walking

$infrastructure\ features$ = categorical variables indicating the presence of pedestrian infrastructure features from Table 4, section 2

Our third model includes both infrastructure features and quality perceptions.

Model 3:

$$share\ of\ walking = \alpha + \beta(infrastructure\ features, quality\ perceptions) + \gamma(neighborhood\ features) + \theta(demographics)$$

Our fourth model includes the effect of pedestrian infrastructure features (Table 4, section 3) along with the same demographic and neighborhood scale features as the previous models.

Model 4:

$$share\ of\ walking = \alpha + \beta(effect\ of\ pedestrian\ infrastructure\ features) + \gamma(neighborhood\ features) + \theta(demographics)$$

where:

$effect\ of\ pedestrian\ infrastructure\ features$ = variables of whether certain small scale neighborhood features encourage or discourage a person from walking from Table 4, section 3

4. ANALYSIS AND FINDINGS

4.1. Responses & Demographics

We received responses from 14 out of 64 neighborhoods that we contacted in Albuquerque with a total of 202 responses. Responses from each neighborhood ranged from 1 to 41. A map of where each of the 14 neighborhoods is located can be seen in Figure 11 below. The majority of responding neighborhoods are located near the central part of the city which is near the University of New Mexico Campus and downtown. These are urban, mixed use neighborhoods. The other neighborhoods are scattered across the north and southeast parts of the city which tend to be more residential neighborhoods. Table 7 provides a summary of demographics of the survey respondents along with demographics from the U.S. Census American Community Survey for Albuquerque. Generally, survey respondents were older, had higher incomes, had higher educational attainment, and were more likely to be white than the regional population. While survey respondents are not representative of the general population, their responses can still be used to identify important sidewalk quality attributes. The main limitation is that attributes important to underrepresented populations and neighborhoods in our survey may not be identified.

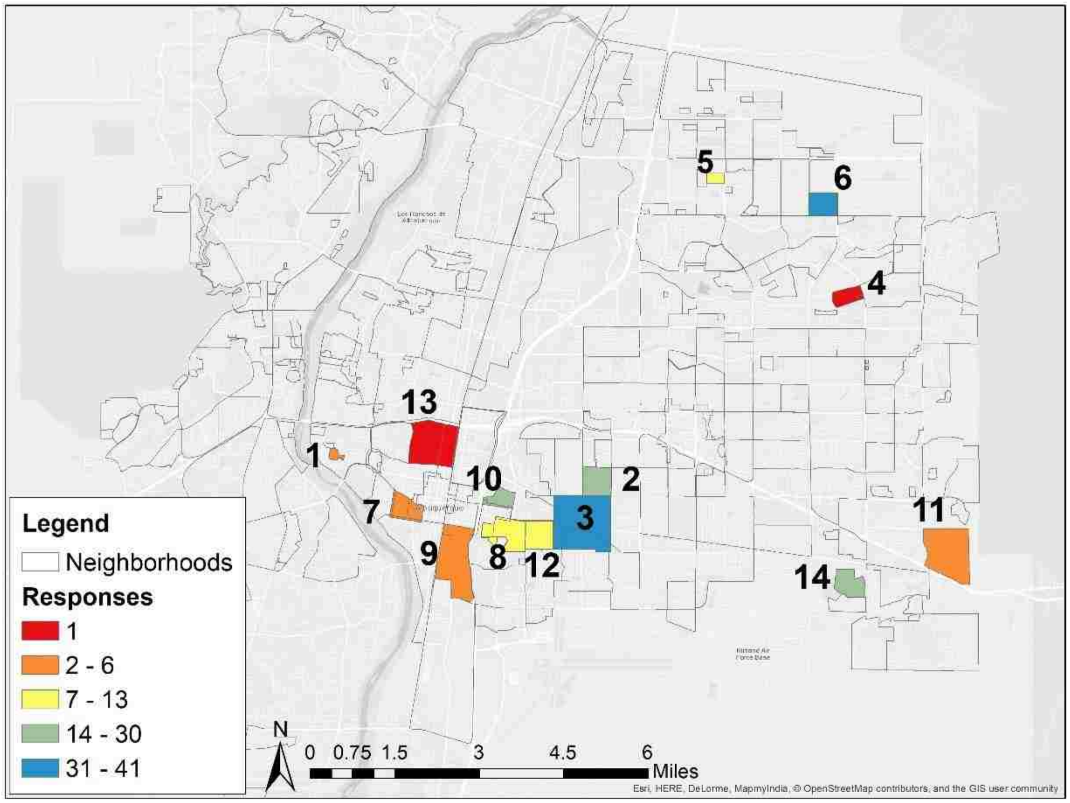


Figure 11. Map of 14 neighborhoods that responded.

Table 7. Demographics of respondents.

	Our Survey (n=202)	Census
Variable	**Percent**	**Percent**
Age		
25-35	8%	16%
35-45	14%	13%
45-55	14%	12%
55-65	26%	12%
65-75	31%	8%
>75	8%	6%
Annual Income		
<$20,000	1%	20%
$20,000-$35,000	4%	16%
$35,000-$50,000	10%	14%
$50,000-$75,000	24%	17%
$75,000-$100,000	17%	12%
>$100,000	43%	21%
Education		
Less than High School Diploma	0.5%	11%
High School Degree	0.5%	23%
Some College, No Degree	5%	24%
Associate Degree	5%	8%
Bachelor's Degree	32%	19%
Master's Degree	37%	15%
Doctorate	20%	
Employment Status		
Employed Full-time	45%	60%
Employed Part-time	12%	
Retired	39%	36% (Not in Civilian Labor Force)
Unemployed and looking for work	1%	4%
Unemployed and not looking for work	3%	
Work from Home		
1-2 days	12%	4.3% Work from home
3-4 days	5%	
5 or more	8%	
No	75%	
Household Size		
1	24%	Avg. HH Size =2.5
2	53%	
3	10%	
4	10%	
5+	3%	
# Vehicles per Household		
0	1%	-
1	27%	-
2	52%	-
3	14%	-
4	4%	-
5+	2%	-
Hispanic or Latinx & Race		
Hispanic/Latinx	14%	49%
Asian	0.5%	3%
Black or African American	1%	3%
White	85%	74%
Disability		
Yes	6%	13%
No	94%	-

4.2. Amount of Walking in Each Neighborhood

To understand what affects walking, we looked at how much each neighborhood walks. Knowing how walking varies by each neighborhood can help us identify if there are certain characteristics in each neighborhood that correlate with the amount they walk. Figure 12 shows boxplots of the share of trips for each mode of transportation reported by respondents. The two highest reported modes of transportation were walking and driving. The walking mode share is much higher than what most surveys tend to find. This may be because our survey asked respondents to report not just how much they walk for commuting trips and other transportation trips, but also how much they walk for recreational purposes such as how often they walk for exercise, for pleasure, or to walk their dog.

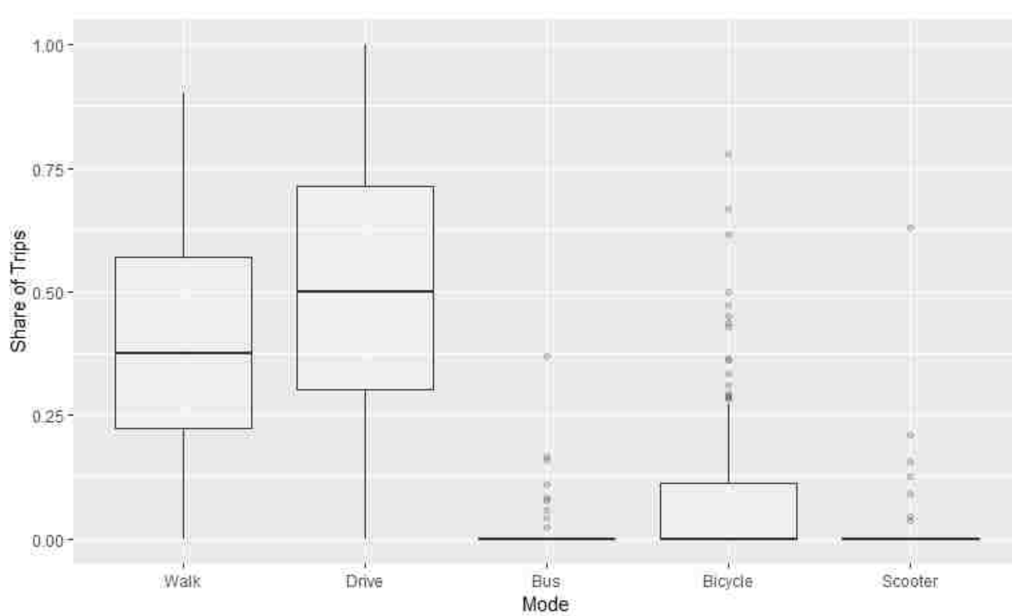


Figure 12. Share of trips for each mode.

Figure 13 shows boxplots for the number of walking trips reported in each neighborhood with the width of the boxplot corresponding to the number of response that came from each neighborhood (wider boxplots correspond to a greater number of responses). Figure 14 shows boxplots for the share of walking trips for respondents grouped by each neighborhood with the width of the boxplot corresponding to the number of responses from each neighborhood (wider boxplots correspond to a greater number of responses). Looking at the share of walking trips for each neighborhood, it appears that neighborhoods 5, 8, and 12 have higher shares of walking trips than other neighborhoods. Neighborhood 4 also has a very high share of walking trips, however, neighborhood 4 only has one observation and therefore it is unlikely to be representative of the neighborhood as a whole. Generally, the results seem to indicate that there is some variability in walking between neighborhoods.

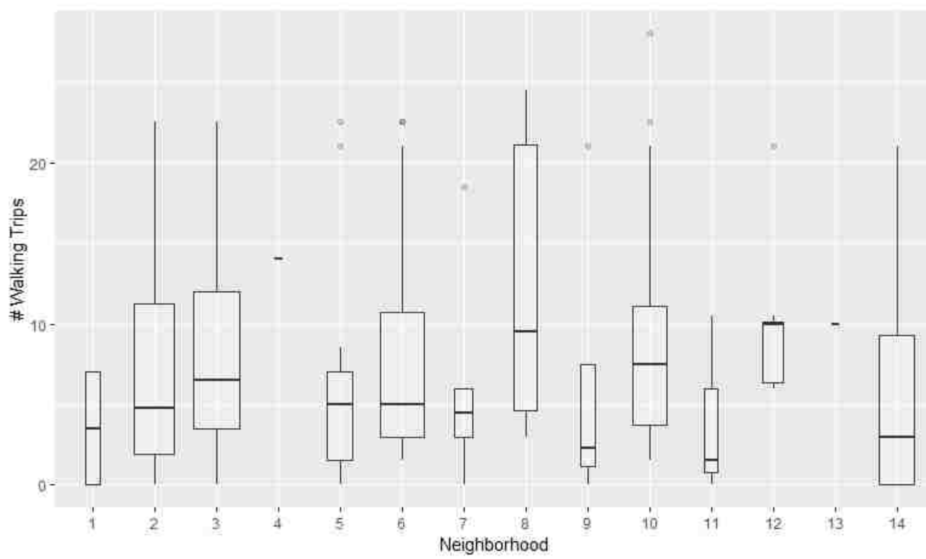


Figure 13. Boxplot of # of walking trips for each neighborhood.

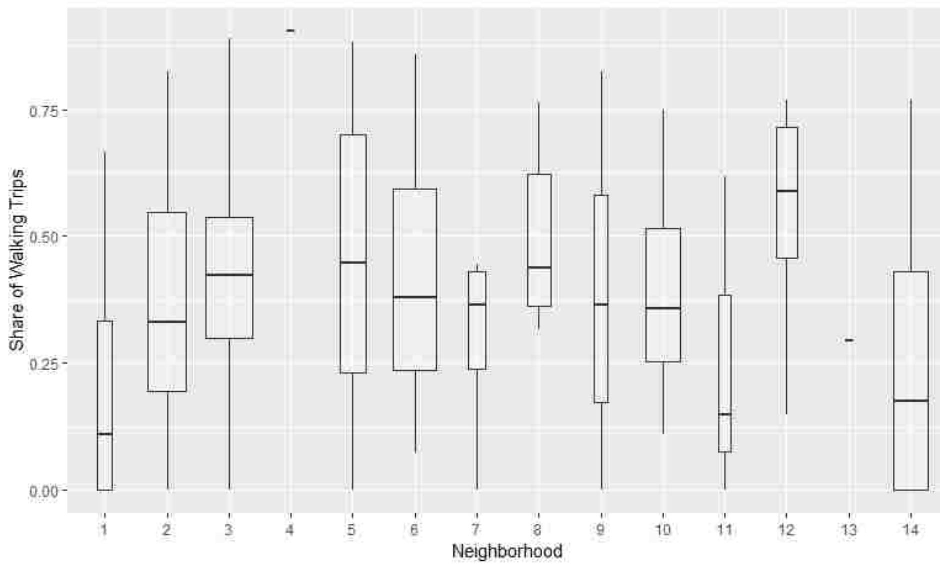


Figure 14. Boxplot of the share of walking trips for each neighborhood.

We also created two linear regression models to identify statistically significant differences in the share of walking trips between neighborhoods (Table 8). The first model includes a dummy variable for each neighborhood. The second model includes dummy variables for each neighborhood and controls for differences in socioeconomic status and demographics of respondents. The regression results in Table 8 indicate that neighborhoods 4, 8, and 12 have significantly higher rates of walking than all other neighborhoods; however, when we control for differences in demographics, only neighborhood 4 is statistically different (and neighborhood 4 has only one data point). The relatively small sample size compared to the number of neighborhoods likely affects the statistical power of our analysis and the ability to detect potentially significant differences. The full regression results are provided in Appendix C.

Table 8. Regression analysis results for the neighborhood regression model.

	Model A	Model B
Variable	**Coeff. Estimate**	**Coeff. Estimate**
Intercept	0.222 *	0.291 .
Neighborhood 2	0.153	0.034
Neighborhood 3	0.207 .	0.136
Neighborhood 4	0.681 **	0.510 *
Neighborhood 5	0.222 .	0.225
Neighborhood 6	0.188	0.110
Neighborhood 7	0.082	0.015
Neighborhood 8	0.267 *	0.235
Neighborhood 9	0.166	0.107
Neighborhood 10	0.159	0.107
Neighborhood 11	0.034	0.006
Neighborhood 12	0.327 *	0.195
Neighborhood 13	0.072	0.031
Neighborhood 14	0.016	-0.071
Education		
High School or Less		0.155
Employment		
Unemployed		0.005
Retired		0.093 .
Age		0.001
HH Annual Income		0.000
Days Work from Home		-0.014
HH Size		-0.006
# Vehicles per HH		0.000
Disability		
Yes		-0.100
Race		
Non-white		0.008
Adj. R^2	0.07	0.14
n	200	179
Signif. Levels: * 99.9% ** 99% * 95% . 90%**		

4.3. Neighborhood Pedestrian Infrastructure Characteristics

Table 9 provides a summary of responses from each neighborhood regarding questions that asked participants about their perceptions of the quality of pedestrian infrastructure in their neighborhood. The table reports the most frequent response reported in each neighborhood. The results indicate that respondents in 43% of the neighborhoods walk in the street at least some of the time rather than on sidewalks, and more so when walking with another person. This may be an indicator that sidewalks in these neighborhoods present a barrier to walking and are not wide enough for two or more people to walk together. Street lighting was reported to be sufficient in most neighborhoods, but 29% still felt it was inadequate. All but three neighborhoods reported that at least some sidewalk repair was needed. Most neighborhoods, 64%, also had at least some concern about traffic speed. All neighborhoods had sidewalks on most streets. Aggregate responses to these questions can be found in Appendix B.

Table 9. Most frequent response regarding perceptions of pedestrian infrastructure quality.

Quality Perception	Neighborhood						
	1 (4)	**2 (30)**	**3 (41)**	**4 (1)**	**5 (13)**	**6 (36)**	**7 (6)**
Sidewalks present?	Yes-mostly (75%)	Yes-mostly (100%)	Yes-mostly (100%)	Yes-mostly (100%)	Yes-mostly (100%)	Yes-mostly (97%)	Yes-mostly (100%)
How often do you use the sidewalk?	Sometimes use sidewalk, sometimes use street (50%)	Sometimes use sidewalk, sometimes use street (60%)	Sometimes use sidewalk, sometimes use street (49%)	Sometimes use sidewalk, sometimes use street (100%)	Usually (85%)	Usually (81%)	Usually (50%)
If you walk with someone else in your neighborhood, do both of you walk on the sidewalk?	One of us walks in street (50%)	One of us walks in street (77%)	One of us walks in street (61%)	One of us walks in street (100%)	Usually (69%)	Usually 64%)	Usually (50%)
Sidewalks maintained?	A few need repairs (50%)	A few need repairs (50%)	A few need repairs (54%)	A few need repairs (100%)	A few need repairs (69%)	Yes, most (58%)	A few need repairs (50%)
Lighting?	Poor (75%)	OK (67%)	OK (56%)	Poor (100%)	OK (62%)	OK (75%)	OK (67%)
Parked cars?	Driveway (100%)	Few in street (70%)	Few in street (73%)	Few in street (100%)	Few in street (85%)	Few in street (61%)	Most in street (67%)
Traffic speeding?	OK (75%)	Some concerns/OK (37%/37%)	Some concerns (54%)	OK (100%)	Some concerns (62%)	Some concerns (50%)	Some concerns (50%)
Traffic?	Not much (75%)	Not much (53%)	Not much (44%)	Sometimes too much (100%)	Not much (77%)	Not much (645)	Not much (100%)
Quality Perception	**Neighborhood**						
	8 (10)	**9 (4)**	**10 (22)**	**11 (3)**	**12 (8)**	**13 (1)**	**14 (23)**
Sidewalks present?	Yes-mostly (100%)	Yes-mostly (100%)	Yes-mostly (86%)	Yes-mostly (67%)	Yes-mostly (100%)	Yes-mostly (100%)	Yes-mostly (100%)
How often do you use the sidewalk?	Usually (90%)	Usually (75%)	Sometimes use sidewalk, sometimes use street (59%)	Sometimes use sidewalk, sometimes use street (67%)	Usually (100%)	Usually (100%)	Usually (96%)
If you walk with someone else in your neighborhood, do both of you	Usually 80%)	Usually 75%)	One of us walks in street (55%)	One of us walks in street 67%)	Usually (75%)	One of us walks in street (100%)	Usually (83%)

walk on the sidewalk?							
Sidewalks maintained?	Most need repairs (50%)	A few need repairs (50%)	A few need repairs 64%)	Yes, most (67%)	Most need repairs (50%)	Most need repairs (100%)	Yes, most (52%)
Lighting?	Poor (60%)	OK (100%)	OK (73%)	OK (67%)	OK (75%)	Poor (100%)	OK (61%)
Parked cars?	Most in street (80%)	Few in street (50%)	Few in street (68%)	Driveway (67%)	Most in street (75%)	Most in street (100%)	Few in street (61%)
Traffic speeding?	Some concerns (50%)	OK (50%)	Some concerns (55%)	OK (100%)	Very concerned (63%)	Some concerns (100%)	OK (48%)
Traffic?	Sometimes too much (50%)	Not much (75%)	Sometimes too much (50%)	Not much (100%)	Sometimes too much (50%)	Sometimes too much (100%)	Not much (52%)

We also asked respondents to identify if their neighborhood had certain pedestrian infrastructure attributes using a 4-point scale (1-Most Do, 2-Some Do, 3-Most Do Not, 4-Unsure). Figure 15 shows the average response to each question (excluding the responses of 4-Unsure) for each neighborhood along with the share of walking for each neighborhood. The average response to each question is represented by a symbol and the share of walking is represented by the bar plot. Overall, pedestrian infrastructure attributes varied across neighborhoods. Respondents in most neighborhoods generally indicated that sidewalks had a mix of positive and negative attributes. The main theme appears to be inconsistency in attributes within each neighborhood. Aggregate responses to these questions can be found in Appendix B.

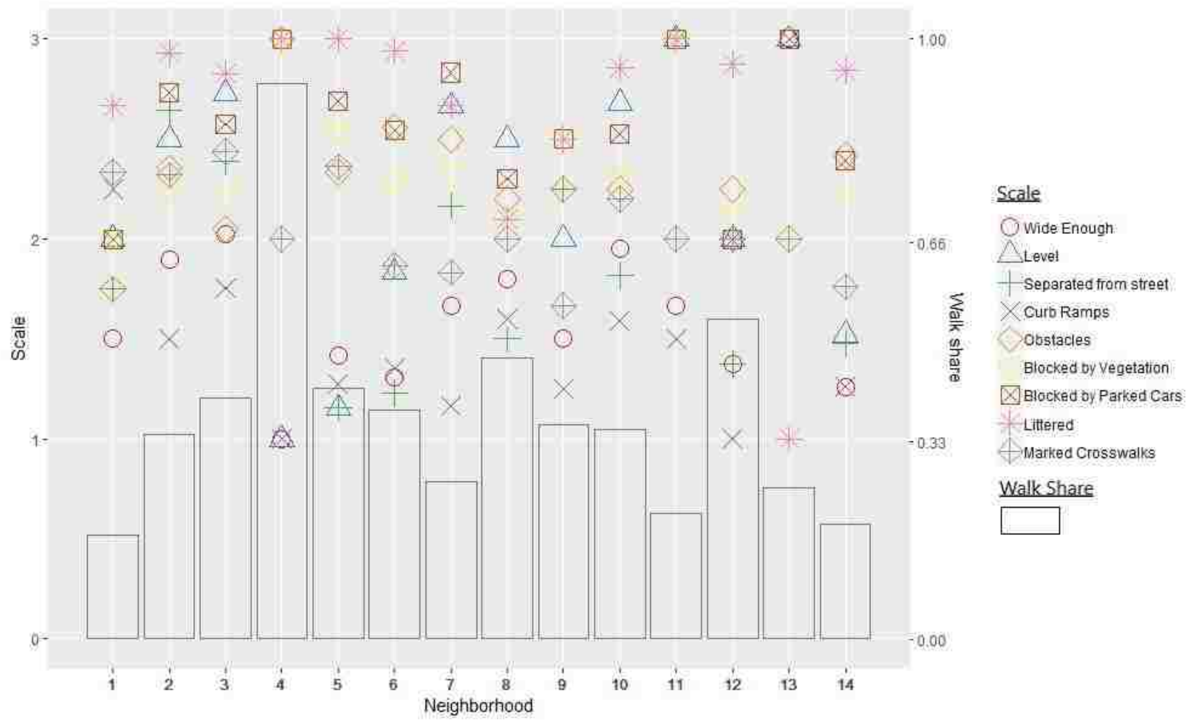


Figure 15. Average responses for whether certain pedestrian infrastructure features are present in one's neighborhood.

4.4. Regression Analysis

A regression analysis was completed comparing the effect of perceptions of pedestrian infrastructure quality on the share of walking trips. Table 10 provides a summary of the regression results showing the coefficient estimate for each independent variable in the linear regression model and indicators for which variables were found to be significant (full regression results are provided in Appendix C). Note that many of the independent variables are categorical (they are not numbers, they are discrete responses). The effect of the base level of each categorical variable is included in the intercept term. The coefficient estimates indicate the size and significance of categorical variable levels shown from the base level.

Models 1, 2, and 3 had a reasonable fit with all having an adjusted R^2 around 0.15 – 0.17. Overall, larger scale features of each neighborhood were most important in explaining differences in the share of walking trips made by respondents. Increasing household density and a greater mix of residential and retail land-use were both statistically significant. Household density and residential and retail land-use mix were associated with an increase in the share of walking trips. These results agree with what we would expect based on the results of previous studies. The presence of a grid like street network was associated with a decrease in the share of walking trips. This result is not what we would expect, as a gridded street network generally provides a shorter route to destination; however, many of the walking trips our respondents made were for recreation or pleasure, and therefore, the time saving potential of a grid network may not provide any benefit. Neighborhoods with a gridded street network may also be associated with more urban features that could deter walking trips for recreation and pleasure or be capturing the influence of other unique features of these neighborhoods that are not accounted for by the other independent variables. Being near a rapid ride bus route was also associated with a decrease in the share of walking trips. This is also not something we expected. Our hypothesis was that being near a rapid bus route would encourage more people to walk to or from the bus route or walk around the surrounding area where there might be more of a mixed land-use pattern. However, being near a rapid bus route may be a proxy for other factors, such as being located near Central Avenue which has high traffic volumes and passes through some areas known to have high crime rates. Being retired was also statistically significant and associated with an increase in the share of walking trips.

Some smaller scale attributes of the pedestrian environment show some significance, but the direction of the affect was not always what we would have expected. A lack of marked crosswalks at busy road crossings was statistically significant and associated with a decrease in the share of walking trips. Being unsure of how common curb ramps are in your neighborhood was also statistically significant and was associated with a large decrease in the share of walking trips. We are not sure what this result means. It could indicate respondents who don't walk frequently do not know about the presence of curb ramps. Parked cars on the street was statistically significant associated with a lower share of walking. We originally hypothesized that parked cars could act as a buffer from traffic, encouraging walking; however, in a residential street context this does not appear to be true. Parked cars could detract from walking if they are an indicator of a more urban or more heavily trafficked neighborhood. Lastly, the need for sidewalk maintenance was statistically significant and associated with an increase in the share of walking trips. This was not expected. This result may have several causes. Those who walk more may be more aware or critical of sidewalk maintenance needs, similar to how being unsure of the presence of curb ramps may be an indicator of not walking. Neighborhoods with more sidewalk maintenance needs may also be associated with other unique attributes that have not been captured by other variables in the regression models.

Table 10. Regression Modeling Results for Models 1, 2 and 3

	Model 1	Model 2	Model 3
Variable	**Coeff. Estimate**		
(Intercept)	0.315 .	0.180	0.281
When walking on streets in your neighborhood how often do you use the s idewalk?			
-I usually walk in street	0.004		-0.018
If you walk with someone else in your neighborhood, do both of you walk on the sidewalk?			
-Usually I and the people I walk with walk in the street	0.058		0.040
Do residential streets, like the one you live on, in your neighborhood have sidewalks?			
-Yes – Some of them	-0.127		-0.149
How well maintained are sidewalks in your neighborhood?			
-Some need repairs	0.064		0.095*
-Not sure	0.177		0.172
How is the lighting at night on residential streets in your neighborhood?			
-Poor or OK	-0.067		-0.094
How do people park their cars in your neighborhood?			
- Park on the street	-0.074		-0.106*
How would you describe the speed of vehicle traffic in your neighborhood ?			
-Concerned about speeding	0.031		0.052
How would you describe the amount of traffic on residential streets in yo ur neighborhood?			
-Too much traffic	0.042		0.021
Wide enough for two or more people to walk side by side			
-Most Do Not		-0.055	-0.055

Are mostly level where they cross driveways			
-Most Do Not		0.045	0.053
Are separated from the street by landscaping grass gravel dirt etc.			
-Most Do Not		0.050	0.081
-Unsure		0.520 .	0.526
Have ramps at street intersections			
-Most Do Not		-0.027	-0.070
-Unsure		-0.513*	-0.560**
Have permanent obstacles in them such as utility poles and fire hydrants			
-Most Do Not		0.004	-0.006
-Unsure		0.071	0.080
Are partially blocked by overgrown bushes cactus or other plants			
-Most Do Not		-0.007	-0.006
-Unsure		0.067	0.049
Are frequently more than once per week blocked by parked cars or truck s			
-Most Do Not		-0.042	-0.041
-Unsure		0.110	0.112
Are littered with potentially dangerous items such as broken glass and hy podermic needles			
-Most Do Not		0.041	0.066
-Unsure		0.082	0.050
Have marked crosswalks where local streets cross busier roads			
-Most Do Not		-0.106**	-0.104*
-Unsure		-0.066	-0.061
Age	0.001	0.001	0.001
Annual Income	-3.4e-7	-1.8e-7	-2.5e-7
Education			
-High School or Less	-0.031	0.061	-0.112
Employment			
-Unemployed	0.016	0.025	0.047
-Retired	0.111*	0.113*	0.129*
# Days Work from Home	-0.016	-0.009	-0.017
Household Size	-0.013	-0.014	-0.015
# Vehicles per Household	0.002	-0.001	0.005
Disability			
-Yes	-0.056	-0.067	-0.067
Race			
-Non-white	-0.009	-0.013	-0.004
Household Density	2.7e-6**	3.0e-6***	3.2e-6***
Ratio of Retail to Residential Land use	0.283**	0.250**	0.353***
Grid Network	-0.200*	-0.170*	-0.252**
Nearest School Distance	0.101	0.211	0.145
Near Rapid Ride Bus Route	-0.136*	-0.129*	-0.159*
Adj. R^2	0.15	0.15	0.17
n	168	176	166
Signif. Levels: * 99.9% ** 99% * 95% . 90%**			

We also built several reduced regression models for each of the three models shown above to determine if they resulted in any change in which variables were significant. Each of the three models were reduced by eliminating the most insignificant variables from each of the three models (Model 1*, Model 2*, Model 3*).

Table 11 provides a summary of the regression results (full regression results are provided in Appendix C). The new reduced models yielded slightly higher adjusted R^2 values between 0.19 – 0.24 and yielded similar significant variables as the initial models. In Model 1*, the same variables were found to be statistically significant like the large scale neighborhood features of density, land-use mix, grid network, near a rapid bus route. In model 3*, marked crosswalks and being unsure of presence of curb ramps were still found to be statistically significant, however, poor or ok street lighting was now slightly statistically significant instead of parking on the street and was associated with a slight decrease in the share of walking trips. This seems to make sense since poor lighting may deter people from walking at night.

We also built another reduced model from model 3 eliminating any repeating variables (Model 3**). Variables associated with sidewalks having obstacles, overgrown vegetation, or being littered were removed since they could also be represented by the variable asking if sidewalks were maintained. The variable asking if more than one person could walk on the sidewalk was removed since it could also be represented by the variable asking if the sidewalks are wide enough. The new model yielded the same significant variables as found in model 3 with one additional variable found to be statistically significant. Being unsure if sidewalks are separated from the roadway in your neighborhood was found to be statistically significant and was associated with a large increase in the share of walking trips. We are not sure what this result means. This could indicate that respondents are unsure of the question, or there may be some places where there is a separation and some places where there is not a separation in their neighborhood.

Table 11. Regression Modeling Results for reduced models.

Variable	Model 1*	Model 2*	Model 3*	Model 3**
	Coeff. Estimate			
(Intercept)	0.330***	0.089	0.149	0.283.
When walking on streets in your neighborhood how often do you use the sidewalk?				
-I usually walk in street				0.004
If you walk with someone else in your neighborhood, do both of you walk on the sidewalk?				
-Usually I and the people I walk with walk in th e street	0.068			
Do residential streets, like the one you live on, in your neighb orhood have sidewalks?				
-Yes – Some of them	-0.139		-0.140	-0.156
How well maintained are sidewalks in your neighborhood?				
-Some need repairs	0.066		0.076 .	0.085*
-Not sure				0.139
How is the lighting at night on residential streets in your neig hborhood?				
-Poor or OK	-0.072		-0.096 .	-0.084
How do people park their cars in your neighborhood?				
- Park on the street	-0.060		-0.075	-0.099*
How would you describe the speed of vehicle traffic in your n eighborhood?				
-Concerned about speeding	0.051		0.060	0.039
How would you describe the amount of traffic on residential s treets in your neighborhood?				
-Too much traffic				0.036
Wide enough for two or more people to walk side by side				
-Most Do Not		-0.073 .	-0.059	-0.045
-Unsure		0.233	0.224	
Are mostly level where they cross driveways				
-Most Do Not		0.034	0.069	0.067
Are separated from the street by landscaping grass gravel dir t etc.				
-Most Do Not			0.043	0.084.
-Unsure				0.507*
Have ramps at street intersections				
-Most Do Not		-0.017	-0.056	-0.074
-Unsure		-0.328**	-0.307**	-0.459**
Have permanent obstacles in them such as utility poles and fi re hydrants				
-Most Do Not				
-Unsure				
Are partially blocked by overgrown bushes cactus or other pl ants				
-Most Do Not				
-Unsure				
Are frequently more than once per week blocked by parked c ars or trucks				
-Most Do Not				-0.031
-Unsure				0.089
Are littered with potentially dangerous items such as broken g lass and hypodermic needles				
-Most Do Not				
-Unsure				
Have marked crosswalks where local streets cross busier road s				
-Most Do Not		-0.092*	-0.101**	-0.100*

-Unsure				-0.045
Age		0.001	0.001	0.002
Annual Income				-3.43-7
Education				
-High School or Less				-0.163
Employment				
-Unemployed				0.041
-Retired	0.140***	0.125**	0.111*	0.096.
# Days Work from Home	-0.013	-0.007	-0.011	-0.017.
Household Size				-0.020
# Vehicles per Household				0.013
Disability				
-Yes		-0.098	-0.071	-0.045
Race				
-Non-white				-0.008
Household Density	2.59e-6**	2.84e-6***	3.06e-6***	3.134-6 ***
Ratio of Retail to Residential Land use	0.262**	0.193*	0.277**	0.306***
Grid Network	-0.183*	-0.113	-0.189*	-0.244**
Nearest School Distance		0.308*	0.259 .	0.169
Near Rapid Ride Bus Route	-0.152**	-0.086	-0.104	-0.140*
Adj. R^2	0.19	0.22	0.24	0.19
n	170	166	161	174
Signif. Levels: * 99.9% ** 99% * 95% . 90%**				

We also reduced models 1-3 by eliminating insignificant smaller-scale attributes of the pedestrian environment but kept all demographic variables. For model 1 and 2 the statistically significant variables were the same as in models 1* and 2*. For model 3, the same statistically significant variables were found as in the initial model 3 except poor street lighting and concerns about speed traffic were also now statistically significant. Poor street lighting was associated with a decrease in the share of walking trips (coefficient estimate -0.13), and concerns about speed were associated with an increase in the share of walking trips. This is not something we expected. This could indicate that those who walk more may be more aware or critical of speeding cars or neighborhoods with more speeding cars may also be associated with other unique attributes that have not been captured by other variables in the regression model. Detailed results from these regression models can be found in Appendix C.

Lastly, we created a set of new models from models 1-3 eliminating the household density, retail and residential land-use mix, grid network, nearest school distance, and rapid ride bus route variables from the models while keeping all other variables. The new models without the large-scale built environment attributes yielded models with much lower adjusted R^2 values between 0.05 – 0.07 but with still the same significant variables as the initial models except in model 3 which found that parking on the street and sidewalks needing some repairs were no longer significant. These results indicate that large scale neighborhood attributes are a significant factor in affecting the share of walking trips and how much people walk. Detailed results from these regression models can be found in Appendix C.

4.5. Infrastructure Attributes that Encourage or Discourage People From Walking

Finally, we analyzed participants responses to whether they thought certain pedestrian infrastructure attributes encouraged or discouraged them from walking. Figure 16 is a summary of those results for each neighborhood (1-strongly discourage from walking to 5-strongly encourage walking) along with the share of walking for each neighborhood. Overall, responses were fairly consistent across neighborhoods. Having sidewalks and maintaining them well were reported to be most important for encouraging walking. Marked pedestrian crossings and street lighting were also relatively important for encouraging walking. Crime, hazardous litter, and high traffic speed (and almost to a similar extent high traffic volume) were the most important factors reported to discourage walking. Other factors were reported to be relatively less important than these at encouraging and discouraging walking but may also be important. Overall percentages of responses to these questions can be found in Appendix B.

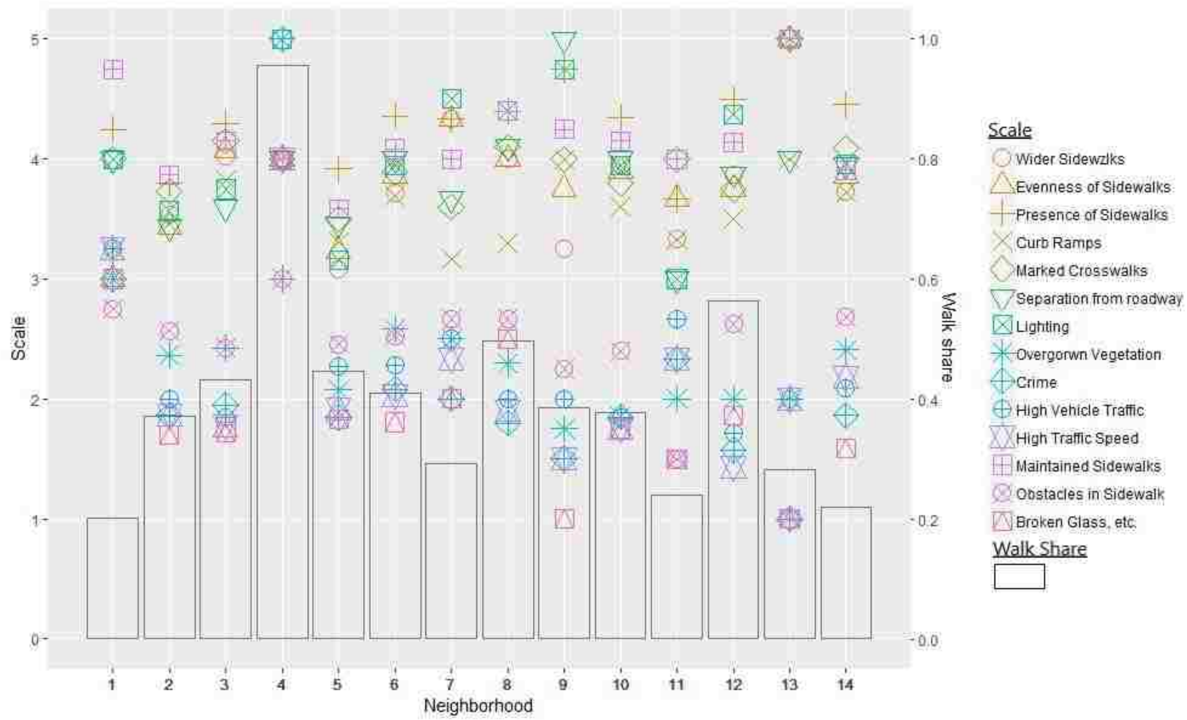


Figure 16. Responses to if certain sidewalk features encourage or discourage someone from walking.

A regression analysis was also completed comparing the effect of whether certain sidewalk features encourage or discourage someone from walking on the share of walking trips. Table 12 is a summary of the regression results with the coefficient estimates and indicators for which variables were found to be significant (full regression results are provided in Appendix C). Both household density and residential and retail land-use mix were found to be statistically significant and associated with an increase in the share of walking trips. The only small-scale attribute of the pedestrian environment found to be statistically significant was evenness of sidewalks and was associated with an increase in the share of walking trips. This tells us that evenness of sidewalks is an important consideration for people when walking and could mean that people who walk more are more aware of uneven conditions of sidewalks which they might like to see improved.

Table 12. Regression results for Model 4.

Variable	Coeff. Estimate
(Intercept)	-0.116
Wider Sidewalks	-0.042
Evenness of Sidewalks	0.068 **
Presence of sidewalks	0.018
Sidewalk curb ramps at intersections	-0.001
Marked pedestrian crossings at busy streets	-0.004
Separations between sidewalk and roadway	0.011
Lighting at night	0.009
Overgrown vegetation	0.013
Crime	-0.014
High volume of vehicle traffic	-0.026
High traffic speed	0.011
Maintained sidewalks	0.003
Obstacles in sidewalk such as utility poles or fire hydrants	-0.020
Broken glass or other potentially dangerous items in sidewalk	0.048 .
Age	0.002
Annual Income	5.450e-08
Education	
-High School or Less	0.057
Employment	
-Unemployed	-0.027
-Retired	0.089 .
# Days Work from Home	-0.016
Household Size	0.001
# Vehicles per Household	-0.010
Disability	
-Yes	-0.087
Race	
-Non-white	0.042
Household Density	2.384e-06 **
Ratio of Retail to Residential Land use	0.198 *
Grid Network	-0.094
Nearest School Distance	0.143
Near Rapid Ride Bus Route	-0.132 .
Adj. R^2	0.15
n	171
Signif. Levels: * 99.9% ** 99% * 95% . 90%**	

5. CONCLUSIONS

In this study, our goal was to understand the relationship between the quality of pedestrian infrastructure and the choice to walk. After reviewing previous studies, we found that many had evaluated how large-scale built environment characteristics affect walking; however, we found that very few studies had considered smaller scale features of the pedestrian environment and pedestrian infrastructure.

Our study conclusions were limited by a smaller sample size than we had anticipated and one that is generally older, wealthier and more white than the general population of the city. How we recode variables to reduce categories and which variables we include in regression results may have important impacts on the results, given the relatively small sample size.

Given the above limitations, there are several conclusions we can draw from our study. First, respondents make a surprisingly large share of trips by walking. We think this is a result of asking respondents to explicitly report walking trips for recreation and pleasure in addition to transportation trips. Many travel surveys are focused on commute and transportation trips and therefore may result in a general under appreciation for how much people walk. Given that most of our respondents walk very frequently, it seems important to consider the quality and safety of the infrastructure they use. Responses to many of our survey questions indicate that the provision and quality of pedestrian infrastructure is quite variable (see Table 9 and Figure 15), indicating opportunities for improvement.

We did not find much difference in walking rates between neighborhoods, but we believe this is largely due to the small sample size. However, we did find, as other studies have, that neighborhood scale land-use and transportation features were significantly associated with walking. Household density and greater land-use mix were both associated with greater shares of walking. While there may be opportunities to encourage walking through improved walking infrastructure, these results confirm that supportive land-use patterns are important too.

We also found that being retired was significantly associated with a larger share of walking trips which generally makes sense given that many walking trips in our sample are for recreation and pleasure, and retired individuals may have more time for these activities. We did not find any association with other socioeconomic status or demographic variables. This is not entirely surprising given that our sample was not as diverse as the general population. Additionally, prior studies have generally found mixed results regrading socioeconomic status and walking rates. Since retired, and presumably older, individuals appear to make more walking trips, this should reinforce the case for maintaining sidewalks and ensuring they meet accessibility standards.

We did find some association between smaller scale attributes of the pedestrian environment and walking. The lack of marked crosswalks at busy road crossings stands out as being important and significantly associated with lower shares of walking. Sidewalks were also indicated as being important for encouraging walking. Having curb cuts and maintaining sidewalks produced unexpected results (being unsure of the presence of curb cuts is a significant indicator of lower walking shares while less maintained sidewalks are a significant indicator of higher walking shares). We think that these variables may be proxies for walking experience. If you walk more, you may be more aware of maintenance issues, and if you walk less, you may not know if sidewalks have curb ramps. These variables could also be picking up unique attributes in certain neighborhoods that the variables we included in our study did not. Respondents also indicated that having sidewalks in general, sidewalks that are even, and sidewalks that are maintained were important for encouraging them to walk while crime, high traffic speeds and volumes, and dangerous litter were important factors that discouraged walking. Considering these results, we think that providing more marked crosswalks at high volume road crossings is most likely to increase walking although this may also raise safety concerns. Many high-volume roads in Albuquerque are multilane arterials with relatively high traffic speeds where additional traffic control devices and traffic calming measures would likely be needed to provide safe crossing opportunities. We think that other small-scale attributes of the street environment could also be important to increasing walking; however, without a larger and more representative sample we simply do not have the statistical power to evaluate these in a robust way.

We had originally planned to rank which pedestrian infrastructure attributes would be most important to address to cost effectively increase walking. Given the limited nature of our findings we have not done that. As noted, marked pedestrian crossings seem to be important but there is less evidence for other attributes. While respondents did indicate that other attributes are important (see Figure 16), these were not revealed in their walking behavior. We also envisioned collecting data as part of a larger effort to conduct a longitudinal (before and after) study. The data we collected could still be used for this purpose if changes in sidewalk attributes are made in neighborhoods where we received a relatively large number of responses (or where we are able to increase our sample size with additional recruitment efforts). It would be particularly interesting to evaluate if the addition of improved, marked, pedestrian crossings indeed correspond to an increase in the share of walking trips.

Weaknesses in our study can be addressed by additional efforts to increase our sample size and collect similar data from neighborhoods where the city is planning to make changes to residential streets or sidewalks. Collecting travel behavior data before projects are implemented in affected neighborhoods and a set of similar control neighborhoods would allow the city to learn over time how various changes affect walking and other travel behavior. This is something that is not regularly done by any municipality that we are aware of but could be a relatively inexpensive way to improve the function of residential streets and pedestrian infrastructure.

Chapter 4: Conclusions

By evaluating sidewalk funding policies and alternatives, we determined that the current policy of adjacent property owners being responsible for sidewalk maintenance and repairs is the most regressive policy and it results in the most inequity in sidewalk repair costs. Other alternatives, primarily incrementing the gross receipts tax or property tax, would be more equitable and provide a more sustainable source of revenue. Through evaluating how the quality of pedestrian infrastructure affects the choice to walk, we found that a lack of marked crosswalks is associated with less walking. We also found that the presence of sidewalks and maintaining them were important attributes for encouraging people to walk. These findings are important for several reasons. Poor sidewalk conditions are becoming a growing concern for many cities around the country (Evans-Cowley 2006b; Shoup 2010b) and a significantly low percentage of people are walking as a mode of transportation as reported by the National Household Travel Survey. Sidewalks and pedestrian infrastructure are an essential part of our transportation network. They provide a safe, designated space away from moving traffic for pedestrians and provide an accessible mode of transportation for those unable to own or operate a vehicle such as younger, older, or disabled populations. Also, with transportation accounting for almost one third of the greenhouse gas emissions emitted in the U.S. and almost two thirds of that coming from light-duty vehicles (U.S. Environmental Protection Agency (EPA) 2019), sidewalks also provide an environmental friendly mode of transportation (Frank and Pivo n.d.; Frumkin 2002). With sidewalks and pedestrian infrastructure being a crucial and fundamental part of our transportation system, we need to address their worsening conditions and better understand how they affect walking. The knowledge gained from this research could help municipalities and transportation planners begin thinking about how to improve pedestrian infrastructure and start to incorporate more pedestrian-friendly infrastructure into future transportation planning decisions, making our transportation system more accessible and welcoming to all.

APPENDICES

APPENDIX A: Survey

Dear Albuquerque Resident,

We invite you to participate in a research study being conducted by the Department of Civil, Construction and Environmental Engineering at the University of New Mexico. The purpose of this study is to better understand how people in Albuquerque travel around their neighborhoods and use neighborhood streets. The information that you provide through a survey for this study is expected to help cities like Albuquerque identify opportunities for improving neighborhood streets and the wellbeing of residents who use them.

There is no direct benefit to participating in this survey, but the information you provide us will be used in our study, which aims to better inform decisions affecting residential streets in Albuquerque and elsewhere. The survey should take about 15 minutes to complete. Your participation in this survey is completely voluntary and you can refuse to answer any of the questions at any time. There are no known risks to participating in this survey. We will not collect names, addresses or other identifying information about you. Your responses will remain anonymous and confidential. The data from this study will only be reported in aggregate and only used for this study. We will send you a copy of the study results when completed.

If you have any questions or concerns about the survey or our research, or if you would like a paper based survey form [or for paper based surveys: if you would like a second copy of the survey for an additional household member] please contact Alexis Corning-Padilla, Research Assistant at acorningpadilla@unm.edu or (505) 277-2877. If you have questions regarding your rights as a research participant, or about what you should do in case of any harm to you, or if you want to obtain information or offer input, please contact the UNM Office of the IRB (OIRB) at (505) 277-2644 or irb.unm.edu.

By clicking "OK" you verify that you are 18 years of age or older and will be agreeing to participate in the research described above.

Thank you for your help,

Alexis Corning-Padilla
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Civil, Construction &
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Assistant Professor
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Question 1
Are you at least 18 years old?

☐ Yes, please continue with the survey

☐ No (on electronic survey participant will be directed to a screen that states: "Thank you for your interest in this study; however, we are only collecting information through this survey on adults of at least 18 years of age." and on the paper based survey text will be included here stating "Thank you for your interest in this study; however, we are only collecting information through this survey on adults of at least 18 years of age.")

Section 1: How you travel
Please consider how you typically traveled during the year 2018 when answering the questions in this section of the survey.
Question 2
During a typical week, tell us how you traveled in the table below. Think about how you usually traveled in 2018 which may be different than how you traveled this week.

Drive alone or with someone else (including taxis, Uber, Lyft, etc.)	Monday – Friday 0	1-2	3-4	5 or more	Saturday - Sunday 0	1-2	3-4	5 or more
Work	☐	☐	☐	☐	☐	☐	☐	☐
School								
Shopping	☐	☐	☐	☐	☐	☐	☐	☐
Other: ________	☐	☐	☐	☐	☐	☐	☐	☐
Ride the bus	☐	☐	☐	☐	☐	☐	☐	☐
Work	☐	☐	☐	☐	☐	☐	☐	☐
School								
Shopping	☐	☐	☐	☐	☐	☐	☐	☐
Other: ________	☐	☐	☐	☐	☐	☐	☐	☐
Ride a bicycle	☐	☐	☐	☐	☐	☐	☐	☐
Trips for a specific purpose								
Work	☐	☐	☐	☐	☐	☐	☐	☐
School								
Shopping	☐	☐	☐	☐	☐	☐	☐	☐
Other: ________	☐	☐	☐	☐	☐	☐	☐	☐
Trips for Pleasure or Exercise	☐	☐	☐	☐	☐	☐	☐	☐
Bicycle for exercise	☐	☐	☐	☐	☐	☐	☐	☐
Bicycle for pleasure	☐	☐	☐	☐	☐	☐	☐	☐
Other: ___________								
Walk, jog, or run	☐	☐	☐	☐	☐	☐	☐	☐
Trips for a specific purpose								
Work	☐	☐	☐	☐	☐	☐	☐	☐
School								
Shopping	☐	☐	☐	☐	☐	☐	☐	☐
Other: ________	☐	☐	☐	☐	☐	☐	☐	☐
Trips for Pleasure or Exercise	☐	☐	☐	☐	☐	☐	☐	☐
Exercise (Running, etc.)	☐	☐	☐	☐	☐	☐	☐	☐
Walk for pleasure	☐	☐	☐	☐	☐	☐	☐	☐
Walk dog (other pet)	☐	☐	☐	☐	☐	☐	☐	☐
Other: ___________	☐	☐	☐	☐	☐	☐	☐	☐

Scooter, skateboard, etc.								
Trips for a specific purpose								
Work	☐	☐	☐	☐	☐	☐	☐	☐
School	☐	☐	☐	☐	☐	☐	☐	☐
Shopping	☐	☐	☐	☐	☐	☐	☐	☐
Other: ________	☐	☐	☐	☐	☐	☐	☐	☐
Trips for Pleasure or Exercise								
Exercise	☐	☐	☐	☐	☐	☐	☐	☐
Ride for pleasure	☐	☐	☐	☐	☐	☐	☐	☐
Other: ___________	☐	☐	☐	☐	☐	☐	☐	☐

Question 3

When walking on streets in your neighborhood how often do you use the sidewalk?

☐ I usually use the sidewalks

☐ I sometimes use the sidewalks and sometimes walk in the street

☐ I usually walk in the street

☐ I do not walk

If you walk with someone else in your neighborhood, do both of you walk on the sidewalk?

☐ Usually everyone I walk with uses the sidewalks

☐ Sometimes either I or someone I walk with walks in the street

☐ Usually I and the people I walk with walk in the street

When riding a bicycle in your neighborhood, do you ride in the street or on the sidewalk?

☐ I usually use the sidewalks

☐ I sometimes use the sidewalks and sometimes ride in the street

☐ I usually ride in the street

☐ I do not ride a bicycle

Section 2: What are the streets like in your neighborhood?

Describe the sidewalks on residential streets in your neighborhood.

Question 4

Do residential streets, like the one you live on, in your neighborhood have sidewalks?

☐ Yes – Most of them

☐ Yes – Some of them

☐ No – Most do not

Question 5

Do sidewalks in your neighborhood have the following features:

	Most Do	Some Do	Most Do Not	Unsure
Wide enough for two or more people to walk side by side	☐	☐	☐	☐
Are mostly level where they cross driveways	☐	☐	☐	☐
Are separated from the street by landscaping, grass, gravel, dirt, etc.	☐	☐	☐	☐
Have ramps at street intersections	☐	☐	☐	☐
Have permanent obstacles in them such as utility poles and fire hydrants	☐	☐	☐	☐
Are partially blocked by overgrown bushes, cactus, or other plants	☐	☐	☐	☐
Are frequently (more than once per week) blocked by parked cars or trucks	☐	☐	☐	☐
Are littered with potentially dangerous items such as broken glass and hypodermic needles	☐	☐	☐	☐
Have marked crosswalks where local streets cross busier roads?	☐	☐	☐	☐

Question 6

How well maintained are sidewalks in your neighborhood? For example, are there large cracks, holes, or crumbling surfaces that make it difficult to use sidewalks?

☐ Most are well maintained

☐ A few sections need to be repaired or replaced

☐ Many sections need to be repaired or replaced

☐ Most need to be repaired or replaced

☐ I am not sure

Describe the residential streets in your neighborhood.

Question 7

How is the lighting at night on residential streets in your neighborhood?

☐ Good – most streets are evenly lit along their entire length

☐ Ok – some places have lighting and others are dark

☐ Poor – there is very little light, most of the streets are dark

Question 8

How do people park their cars in your neighborhood?

☐ Most people park off the street in driveways, garages or parking lots

☐ There are a few cars usually parked on the street

☐ Most of the street is lined with parked cars

<u>Question 9</u>
How would you describe the speed of vehicle traffic in your neighborhood?

☐ Most cars seem to travel at a safe speed

☐ I have some concerns about the amount of speeding cars

☐ I am very concerned about how many cars are speeding

<u>Question 10</u>
How would you describe the amount of traffic on residential streets in your neighborhood?

☐ There is not much traffic

☐ Sometimes I feel there is too much traffic for a residential area

☐ I think there is too much traffic for a residential street

Section 3: In this section we are interested in knowing about how neighborhood streets might affect how much your walk or if you walk at all for any purpose.

<u>Question 11</u>
Please tell us how each of the following neighborhood street features or neighborhood conditions either encourage, discourage or have no affect on how much you walk or if you walk at all.

	Strongly Discourage 1	2	Has No Affect 3	4	Strongly Encourage 5
Wider sidewalks	☐	☐	☐	☐	☐
Evenness of sidewalks	☐	☐	☐	☐	☐
Presence of Sidewalks	☐	☐	☐	☐	☐
Sidewalk curb ramps at Intersections	☐	☐	☐	☐	☐
Marked Pedestrian Crossings at busy streets	☐	☐	☐	☐	☐
Separation between sidewalk & roadway	☐	☐	☐	☐	☐
Lighting at night	☐	☐	☐	☐	☐
Overgrown Vegetation	☐	☐	☐	☐	☐
Crime	☐	☐	☐	☐	☐
High vehicle traffic	☐	☐	☐	☐	☐
High Traffic speed	☐	☐	☐	☐	☐
Maintained sidewalks	☐	☐	☐	☐	☐
Obstacles in the sidewalk such as utility poles and fire hydrants	☐	☐	☐	☐	☐
Broken glass, hypodermic	☐	☐	☐	☐	☐

needles and other potentially
dangerous items

Now we would like to know about how you travel with other household members.
Question 12
If you have children under the age of 16 in your household, please tell us how each child usually gets to school.

	Drive with parent	Bus	Walk	Bike	Other
1st Child	☐	☐	☐	☐	☐
2nd Child	☐	☐	☐	☐	☐
3rd Child	☐	☐	☐	☐	☐
4th Child	☐	☐	☐	☐	☐
5th Child	☐	☐	☐	☐	☐
6th Child	☐	☐	☐	☐	☐
7th Child	☐	☐	☐	☐	☐
8th Child	☐	☐	☐	☐	☐
9th Child	☐	☐	☐	☐	☐
10th Child	☐	☐	☐	☐	☐

Section 4: In this last section, we would like to know a little bit more about you.
Question 13
What is your age?

☐ 18 – 24 years old

☐ 25 – 34 years old

☐ 35 – 44 years old

☐ 45 – 54 years old

☐ 55 – 65 years old

☐ 65 – 75 years old

☐ >75 years old

Question 14
What is the annual income for your household?

☐ Less than $20,000

☐ $20,000 – $34,999

☐ $35,000 – $49,999

☐ $50,000 – $74,999

☐ $75,000 – $99,999

☐ Over $100,000

Question 15
What is the highest level of education you have completed?

☐ Less than a high school diploma

☐ High School Degree or equivalent (GED)

☐ Some college, no degree

☐ Associate Degree

☐ Bachelor's Degree

☐ Master's Degree

☐ Doctorate

Question 16
Are you a student?

☐ Full time college student

☐ Part time college student

☐ High school student

☐ No

Question 17
What is your current employment status?

☐ Employed full time (including self-employed)

☐ Employed part time (including self-employed)

☐ Unemployed and currently looking for work

☐ Unemployed and not currently looking for work

☐ Retired

☐ Unable to work

Question 18
Do you work from home?

☐ No

☐ 1-2 days per week

☐ 3-4 days per week

☐ 5 or more days per week

Question 19
How many people live in your household?

☐ 1

☐ 2

☐ 3

☐ 4

☐ 5 or more

Question 20
How many vehicles does your household own?

☐ 0

☐ 1

☐ 2

☐ 3

☐ 4

☐ 5 or more

Question 21
Do you have a physical disability that limits your mobility?

☐ Yes

☐ No

Question 22
Are you of Hispanic, Latino, or Spanish origin?

☐ Yes

☐ No
How would you describe yourself?

☐ American Indian or Alaska Native

☐ Asian

☐ Black or African American

☐ Native Hawaiian or Other Pacific Islander

☐ White
Other:____________________

Is there anything else you wish to tell us about the streets or how you travel in your neighborhood?
____
____
____
____

If you have any questions or concerns about the survey or our research, please contact Alexis Corning-Padilla, Research Assistant at acorningpadilla@unm.edu or (505) 277-2877. If you have questions regarding your rights as a research participant, or about what you should do in case of any harm to you, or if you want to obtain information or offer input, please contact the UNM Office of the IRB (OIRB) at (505) 277-2644 or irb.unm.edu.

APPENDIX B: Survey Responses

Questions	Responses
When walking on streets in your neighborhood how often do you use the sidewalk?	
-I sometimes use the sidewalks and sometimes walk in the street	34%
-I usually use the sidewalks	56%
-I usually walk in the street	9%
-I do not walk	1%
If you walk with someone else in your neighborhood, do both of you walk on the sidewalk?	
-Usually everyone I walk with uses the sidewalks	44%
-Usually I and the people I walk with walk in the street	9%
-Sometimes either I or someone I walk with walks in the street	47%
Do residential streets, like the one you live on, in your neighborhood have sidewalks?	
-Yes-Most of them	97%
-Yes-Some of them	3%
How well maintained are sidewalks in your neighborhood?	
-Most are well maintained	30%
-A few sections need to be repaired or replaced	48%
-Many sections need to be repaired or replaced	20%
-Most need to be repaired or replaced	2%
-I am not sure	0% (1 respondent)
How is the lighting at night on residential streets in your neighborhood?	
-Good- most streets are evenly lit along their entire length	13%
-OK – some places have lighting and others are dark	64%
-Poor – there is very little light, most of the streets are dark	23%
How do people park their cars in your neighborhood?	
-Most people park off the street in driveways, garages or parking lots	21%
-There are a few cars usually parked on the street	61%
-Most of the street is lined with parked cars	19%
How would you describe the speed of vehicle traffic in your neighborhood?	
-Most cars seem to travel at a safe speed	35%
-I have some concerns about the amount of speeding cars	46%
-I am very concerned about how many cars are speeding	19%
How would you describe the amount of traffic on residential streets in your neighborhood?	
-There is not much traffic	52%
-Sometimes I feel there is too much traffic for a residential area	38%
-There is too much traffic for a residential street	9%
Wide enough for two or more people to walk side by side	
-Most Do	53%
-Some Do	26%
-Most Do Not	20%
-Unsure	1%
Are mostly level where they cross driveways	
-Most Do	29%
-Some Do	20%
-Most Do Not	51%
Are separated from the street by landscaping grass gravel dirt etc.	
-Most Do	41%
-Some Do	30.5%
-Most Do Not	27.5%
-Unsure	1%
Have ramps at street intersections	
-Most Do	60%
-Some Do	27%
-Most Do Not	10%
-Unsure	3%

Have permanent obstacles in them such as utility poles and fire hydrants	
-Most Do	10%
-Some Do	46.5%
-Most Do Not	38%
-Unsure	5.5%
Are partially blocked by overgrown bushes cactus or other plants	
-Most Do	5%
-Some Do	63%
-Most Do Not	31%
-Unsure	1%
Are frequently more than once per week blocked by parked cars or trucks	
-Most Do	5%
-Some Do	34%
-Most Do Not	59%
-Unsure	2%
Are littered with potentially dangerous items such as broken glass and hypoder mic needles	
-Most Do	2%
-Some Do	13%
-Most Do Not	81%
-Unsure	4%
Have marked crosswalks where local streets cross busier roads	
-Most Do	23.5%
-Some Do	31.5%
-Most Do Not	35.5%
-Unsure	9.5%
Wider Sidewalks	
1-Strongly Discourage	3%
2	0%
3-Has No Effect	44%
4	26%
5-Strongly Encourage	27%
Evenness of Sidewalks	
1-Strongly Discourage	1%
2	6%
3-Has No Effect	33%
4	31%
5-Strongly Encourage	29%
Presence of sidewalks	
1-Strongly Discourage	1%
2	0%
3-Has No Effect	21%
4	28%
5-Strongly Encourage	50%
Sidewalk curb ramps at intersections	
1-Strongly Discourage	1%
2	2%
3-Has No Effect	52%
4	25%
5-Strongly Encourage	20%
Marked pedestrian crossings at busy streets	
1-Strongly Discourage	0%
2	2%
3-Has No Effect	37%
4	29%
5-Strongly Encourage	32%
Separations between sidewalk and roadway	
1-Strongly Discourage	1%
2	2%
3-Has No Effect	40%
4	33%
5-Strongly Encourage	24%

Lighting at night	
1-Strongly Discourage	5%
2	11%
3-Has No Effect	16%
4	28%
5-Strongly Encourage	40%
Overgrown vegetation	
1-Strongly Discourage	22%
2	37%
3-Has No Effect	30%
4	10%
5-Strongly Encourage	2%
Crime	
1-Strongly Discourage	51%
2	21%
3-Has No Effect	18%
4	3%
5-Strongly Encourage	7%
High volume of vehicle traffic	
1-Strongly Discourage	34%
2	35%
3-Has No Effect	24%
4	4%
5-Strongly Encourage	3%
High traffic speed	
1-Strongly Discourage	44%
2	30%
3-Has No Effect	17%
4	5%
5-Strongly Encourage	4%
Maintained sidewalks	
1-Strongly Discourage	1%
2	4%
3-Has No Effect	22%
4	33%
5-Strongly Encourage	40%
Obstacles in sidewalk such as utility poles or fire hydrants	
1-Strongly Discourage	15%
2	29%
3-Has No Effect	48%
4	6%
5-Strongly Encourage	2%
Broken glass or other potentially dangerous items in sidewalk	
1-Strongly Discourage	56%
2	20%
3-Has No Effect	16%
4	3%
5-Strongly Encourage	5%

APPENDIX C: Regression Results

Model A

```
Call:
lm(formula = walkshare ~ as.factor(Neighborhood), data = x, na.action = na
.omit)

Residuals:
     Min       1Q   Median       3Q      Max 
-0.44376 -0.16907 -0.02201  0.16373  0.53070 

Coefficients:
                          Estimate Std. Error t value Pr(>|t|)   
(Intercept)                0.22222    0.11171   1.989  0.04813 * 
as.factor(Neighborhood)2   0.15328    0.11942   1.284  0.20090   
as.factor(Neighborhood)3   0.20725    0.11703   1.771  0.07821 . 
as.factor(Neighborhood)4   0.68100    0.24978   2.726  0.00702 **
as.factor(Neighborhood)5   0.22154    0.12774   1.734  0.08452 . 
as.factor(Neighborhood)6   0.18827    0.11775   1.599  0.11153   
as.factor(Neighborhood)7   0.08171    0.14421   0.567  0.57166   
as.factor(Neighborhood)8   0.26692    0.13217   2.020  0.04487 * 
as.factor(Neighborhood)9   0.16635    0.15798   1.053  0.29369   
as.factor(Neighborhood)10  0.15931    0.12144   1.312  0.19117   
as.factor(Neighborhood)11  0.03366    0.17063   0.197  0.84383   
as.factor(Neighborhood)12  0.32696    0.13681   2.390  0.01785 * 
as.factor(Neighborhood)13  0.07190    0.24978   0.288  0.77379   
as.factor(Neighborhood)14  0.01630    0.12103   0.135  0.89298   
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1 

Residual standard error: 0.2234 on 186 degrees of freedom
  (2 observations deleted due to missingness)
Multiple R-squared:  0.134,	Adjusted R-squared:  0.07346 
F-statistic: 2.214 on 13 and 186 DF,  p-value: 0.0105
```

Model B

```
Call:
lm(formula = walkshare ~ as.factor(Neighborhood) + as.factor(Education) +
    as.factor(Employment) + Age + Income + WorkHome + HHSize +
    Vehicles + as.factor(Disability) + as.factor(Race), data = x,
    na.action = na.omit)

Residuals:
     Min       1Q   Median       3Q      Max
-0.46940 -0.15685 -0.01065  0.17152  0.45249

Coefficients:
                            Estimate Std. Error t value Pr(>|t|)
(Intercept)                2.914e-01  1.755e-01   1.661   0.0988 .
as.factor(Neighborhood)2   3.403e-02  1.349e-01   0.252   0.8012
as.factor(Neighborhood)3   1.359e-01  1.314e-01   1.034   0.3026
as.factor(Neighborhood)4   5.100e-01  2.521e-01   2.023   0.0448 *
as.factor(Neighborhood)5   2.254e-01  1.470e-01   1.533   0.1272
as.factor(Neighborhood)6   1.099e-01  1.338e-01   0.821   0.4127
as.factor(Neighborhood)7   1.500e-02  1.629e-01   0.092   0.9267
as.factor(Neighborhood)8   2.354e-01  1.470e-01   1.601   0.1115
as.factor(Neighborhood)9   1.065e-01  1.695e-01   0.628   0.5307
as.factor(Neighborhood)10  1.073e-01  1.378e-01   0.779   0.4373
as.factor(Neighborhood)11  6.062e-03  1.789e-01   0.034   0.9730
as.factor(Neighborhood)12  1.950e-01  1.530e-01   1.274   0.2044
as.factor(Neighborhood)13  3.110e-02  2.597e-01   0.120   0.9048
as.factor(Neighborhood)14 -7.139e-02  1.371e-01  -0.521   0.6033
as.factor(Education)2      1.545e-01  2.246e-01   0.688   0.4925
as.factor(Employment)2     4.661e-03  8.818e-02   0.053   0.9579
as.factor(Employment)3     9.290e-02  4.811e-02   1.931   0.0553 .
Age                        6.686e-04  1.700e-03   0.393   0.6946
Income                    -3.872e-07  6.058e-07  -0.639   0.5236
WorkHome                  -1.384e-02  9.541e-03  -1.451   0.1488
HHSize                    -6.435e-03  2.177e-02  -0.296   0.7679
Vehicles                  -4.297e-04  2.206e-02  -0.019   0.9845
as.factor(Disability)2    -1.004e-01  7.511e-02  -1.336   0.1834
as.factor(Race)2           8.498e-03  5.605e-02   0.152   0.8797
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.2157 on 155 degrees of freedom
  (23 observations deleted due to missingness)
Multiple R-squared:  0.2507,   Adjusted R-squared:  0.1395
F-statistic: 2.255 on 23 and 155 DF,  p-value: 0.001852
```

Model 1

```
Call:
lm(formula = walkshare ~ as.factor(Use_Sidewalk) + as.factor(Walk_others)
+
    as.factor(Sidewalks_Present) + as.factor(Maintained) + as.factor(Light
ing) +
    as.factor(Parking) + as.factor(Speeding) + as.factor(Traffic) +
    Age + Income + as.factor(Education) + as.factor(Employment) +
    WorkHome + HHSize + Vehicles + as.factor(Disability) + as.factor(Race)
+
    Density + Retail_to_Residential + Grid + Nearest_School_Distance +
    Near_Rapid_Ride, data = x, na.action = na.omit)

Residuals:
     Min       1Q   Median       3Q      Max
-0.48393 -0.16849 -0.00873  0.17427  0.47272

Coefficients:
                                Estimate Std. Error t value Pr(>|t|)
(Intercept)                    3.149e-01  1.615e-01   1.950  0.05317 .
as.factor(Use_Sidewalk)2       4.481e-03  5.162e-02   0.087  0.93094
as.factor(Walk_others)2        5.778e-02  5.034e-02   1.148  0.25296
as.factor(Sidewalks_Present)2 -1.275e-01  1.111e-01  -1.147  0.25315
as.factor(Maintained)2         6.388e-02  4.354e-02   1.467  0.14449
as.factor(Maintained)3         1.774e-01  2.310e-01   0.768  0.44374
as.factor(Lighting)2          -6.732e-02  5.620e-02  -1.198  0.23295
as.factor(Parking)2           -7.436e-02  4.921e-02  -1.511  0.13299
as.factor(Speeding)2           3.068e-02  4.331e-02   0.708  0.47989
as.factor(Traffic)2            4.222e-02  4.105e-02   1.028  0.30546
Age                            6.081e-04  1.814e-03   0.335  0.73799
Income                        -3.430e-07  6.104e-07  -0.562  0.57507
as.factor(Education)2         -3.126e-02  2.312e-01  -0.135  0.89264
as.factor(Employment)2         1.594e-02  9.111e-02   0.175  0.86138
as.factor(Employment)3         1.109e-01  5.147e-02   2.155  0.03284 *
WorkHome                      -1.573e-02  9.714e-03  -1.619  0.10766
HHSize                        -1.271e-02  2.291e-02  -0.555  0.57989
Vehicles                       1.899e-03  2.258e-02   0.084  0.93309
as.factor(Disability)2        -5.616e-02  8.281e-02  -0.678  0.49872
as.factor(Race)2              -8.684e-03  5.870e-02  -0.148  0.88260
Density                        2.690e-06  8.235e-07   3.267  0.00136 **
Retail_to_Residential          2.834e-01  8.623e-02   3.287  0.00128 **
Grid                          -2.000e-01  8.052e-02  -2.484  0.01414 *
Nearest_School_Distance        1.009e-01  1.474e-01   0.684  0.49498
Near_Rapid_Ride               -1.362e-01  6.263e-02  -2.175  0.03128 *
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.2189 on 143 degrees of freedom
  (34 observations deleted due to missingness)
Multiple R-squared:  0.2712,   Adjusted R-squared:  0.1488
F-statistic: 2.217 on 24 and 143 DF,  p-value: 0.002145
```

Model 2

```
Call:
lm(formula = walkshare ~ as.factor(Wide_enough) + as.factor(Level) + 
    as.factor(Separated) + as.factor(Ramps) + as.factor(Obstacles) + 
    as.factor(Vegetation) + as.factor(Blockedcars) + as.factor(Littered) + 
    as.factor(Crosswalks) + Age + Income + as.factor(Education) + 
    as.factor(Employment) + WorkHome + HHSize + Vehicles + as.factor(Disab
ility) + 
    as.factor(Race) + Density + Retail_to_Residential + Grid + 
    Nearest_School_Distance + Near_Rapid_Ride, data = x, na.action = na.om
it)

Residuals:
     Min       1Q   Median       3Q      Max 
-0.47958 -0.14189 -0.00126  0.15302  0.53271 

Coefficients:
                          Estimate Std. Error t value Pr(>|t|)    
(Intercept)              1.796e-01  1.594e-01   1.127  0.26179    
as.factor(Wide_enough)2 -5.451e-02  4.569e-02  -1.193  0.23481    
as.factor(Level)2        4.455e-02  4.030e-02   1.105  0.27083    
as.factor(Separated)2    5.043e-02  4.812e-02   1.048  0.29645    
as.factor(Separated)3    5.201e-01  2.840e-01   1.831  0.06915 .  
as.factor(Ramps)2       -2.669e-02  6.024e-02  -0.443  0.65835    
as.factor(Ramps)3       -5.131e-01  1.984e-01  -2.587  0.01068 *  
as.factor(Obstacles)2    3.571e-03  4.072e-02   0.088  0.93023    
as.factor(Obstacles)3    7.150e-02  9.109e-02   0.785  0.43381    
as.factor(Vegetation)2  -7.489e-03  4.124e-02  -0.182  0.85618    
as.factor(Vegetation)3   6.672e-02  2.005e-01   0.333  0.73980    
as.factor(Blockedcars)2 -4.247e-02  3.742e-02  -1.135  0.25827    
as.factor(Blockedcars)3  1.098e-01  1.520e-01   0.722  0.47145    
as.factor(Littered)2     4.071e-02  5.452e-02   0.747  0.45652    
as.factor(Littered)3     8.248e-02  1.224e-01   0.674  0.50131    
as.factor(Crosswalks)2  -1.056e-01  3.913e-02  -2.699  0.00778 ** 
as.factor(Crosswalks)3  -6.609e-02  6.679e-02  -0.990  0.32406    
Age                      1.360e-03  1.740e-03   0.781  0.43589    
Income                  -1.753e-07  5.947e-07  -0.295  0.76862    
as.factor(Education)2    6.053e-02  2.362e-01   0.256  0.79814    
as.factor(Employment)2   2.510e-02  8.918e-02   0.281  0.77881    
as.factor(Employment)3   1.134e-01  5.120e-02   2.214  0.02838 *  
WorkHome                -9.263e-03  9.869e-03  -0.939  0.34951    
HHSize                  -1.438e-02  2.350e-02  -0.612  0.54151    
Vehicles                -9.030e-04  2.256e-02  -0.040  0.96813    
as.factor(Disability)2  -6.673e-02  8.036e-02  -0.830  0.40765    
as.factor(Race)2        -1.272e-02  6.175e-02  -0.206  0.83714    
Density                  2.995e-06  7.875e-07   3.804  0.00021 ***
Retail_to_Residential    2.502e-01  8.838e-02   2.831  0.00531 ** 
Grid                    -1.696e-01  7.805e-02  -2.173  0.03143 *  
Nearest_School_Distance  2.115e-01  1.532e-01   1.380  0.16961    
Near_Rapid_Ride         -1.290e-01  6.467e-02  -1.995  0.04797 *  
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.2144 on 144 degrees of freedom
  (26 observations deleted due to missingness)
Multiple R-squared:  0.2988,	Adjusted R-squared:  0.1478 
F-statistic: 1.979 on 31 and 144 DF,  p-value: 0.003868
```

Model 3

```
Call:
lm(formula = walkshare ~ as.factor(Use_Sidewalk) + as.factor(Walk_others) 
+ 
    as.factor(Sidewalks_Present) + as.factor(Maintained) + as.factor(Light
ing) + 
    as.factor(Parking) + as.factor(Speeding) + as.factor(Traffic) + 
    as.factor(Wide_enough) + as.factor(Level) + as.factor(Separated) + 
    as.factor(Ramps) + as.factor(Obstacles) + as.factor(Vegetation) + 
    as.factor(Blockedcars) + as.factor(Littered) + as.factor(Crosswalks) + 
    Age + Income + as.factor(Education) + as.factor(Employment) + 
    WorkHome + HHSize + Vehicles + as.factor(Disability) + as.factor(Race) 
+ 
    Density + Retail_to_Residential + Grid + Nearest_School_Distance + 
    Near_Rapid_Ride, data = x, na.action = na.omit)

Residuals:
     Min       1Q   Median       3Q      Max 
-0.51482 -0.14284  0.00393  0.14961  0.44671 

Coefficients:
                                Estimate Std. Error t value Pr(>|t|)    
(Intercept)                    2.806e-01  1.780e-01   1.576 0.117554    
as.factor(Use_Sidewalk)2      -1.759e-02  5.658e-02  -0.311 0.756353    
as.factor(Walk_others)2        4.049e-02  5.246e-02   0.772 0.441668    
as.factor(Sidewalks_Present)2 -1.486e-01  1.135e-01  -1.309 0.192942    
as.factor(Maintained)2         9.473e-02  4.596e-02   2.061 0.041358 *  
as.factor(Maintained)3         1.717e-01  2.377e-01   0.722 0.471469    
as.factor(Lighting)2          -9.370e-02  6.023e-02  -1.556 0.122312    
as.factor(Parking)2           -1.062e-01  5.291e-02  -2.008 0.046817 *  
as.factor(Speeding)2           5.242e-02  4.743e-02   1.105 0.271239    
as.factor(Traffic)2            2.051e-02  4.348e-02   0.472 0.637882    
as.factor(Wide_enough)2       -5.476e-02  4.904e-02  -1.117 0.266255    
as.factor(Level)2              5.332e-02  4.446e-02   1.199 0.232738    
as.factor(Separated)2          8.112e-02  5.274e-02   1.538 0.126533    
as.factor(Separated)3          5.262e-01  3.353e-01   1.569 0.119096    
as.factor(Ramps)2             -6.968e-02  6.349e-02  -1.097 0.274542    
as.factor(Ramps)3             -5.598e-01  2.058e-01  -2.720 0.007456 ** 
as.factor(Obstacles)2         -5.648e-03  4.325e-02  -0.131 0.896323    
as.factor(Obstacles)3          8.038e-02  9.773e-02   0.823 0.412359    
as.factor(Vegetation)2        -5.957e-03  4.478e-02  -0.133 0.894396    
as.factor(Vegetation)3         4.929e-02  2.120e-01   0.232 0.816553    
as.factor(Blockedcars)2       -4.105e-02  4.056e-02  -1.012 0.313423    
as.factor(Blockedcars)3        1.117e-01  1.576e-01   0.709 0.479713    
as.factor(Littered)2           6.565e-02  5.679e-02   1.156 0.249934    
as.factor(Littered)3           4.977e-02  1.286e-01   0.387 0.699341    
as.factor(Crosswalks)2        -1.038e-01  4.274e-02  -2.428 0.016600 *  
as.factor(Crosswalks)3        -6.146e-02  7.244e-02  -0.848 0.397850    
Age                            9.865e-04  1.998e-03   0.494 0.622355    
Income                        -2.454e-07  6.324e-07  -0.388 0.698664    
as.factor(Education)2         -1.119e-01  2.468e-01  -0.453 0.651022    
as.factor(Employment)2         4.746e-02  9.289e-02   0.511 0.610268    
as.factor(Employment)3         1.287e-01  5.473e-02   2.352 0.020260 *  
WorkHome                      -1.667e-02  1.065e-02  -1.565 0.120097    
HHSize                        -1.542e-02  2.510e-02  -0.614 0.540308    
Vehicles                       4.659e-03  2.375e-02   0.196 0.844764    
as.factor(Disability)2        -6.654e-02  8.616e-02  -0.772 0.441413    
as.factor(Race)2              -3.898e-03  6.530e-02  -0.060 0.952493    
Density                        3.225e-06  8.477e-07   3.804 0.000221 ***
Retail_to_Residential          3.534e-01  9.565e-02   3.695 0.000328 ***
Grid                          -2.523e-01  8.994e-02  -2.805 0.005843 ** 
Nearest_School_Distance        1.452e-01  1.630e-01   0.891 0.374763    
Near_Rapid_Ride               -1.588e-01  6.807e-02  -2.332 0.021283 *  
```

```
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.2149 on 125 degrees of freedom
  (36 observations deleted due to missingness)
Multiple R-squared:  0.3743,   Adjusted R-squared:  0.1741
F-statistic:  1.87 on 40 and 125 DF,  p-value: 0.004778
```

Model 1*

```
Call:
lm(formula = walkshare ~ as.factor(Walk_others) + as.factor(Sidewalks_Pres
ent) +
    as.factor(Maintained) + as.factor(Lighting) + as.factor(Parking) +
    as.factor(Speeding) + as.factor(Employment) + WorkHome +
    Density + Retail_to_Residential + Grid + Near_Rapid_Ride,
    data = x, na.action = na.omit)

Residuals:
     Min       1Q   Median       3Q      Max
-0.53452 -0.18116 -0.01702  0.18604  0.49939

Coefficients:
                                Estimate Std. Error t value Pr(>|t|)
(Intercept)                    3.301e-01  6.646e-02   4.967 1.76e-06 ***
as.factor(Walk_others)2        6.759e-02  4.093e-02   1.651 0.100695
as.factor(Sidewalks_Present)2 -1.393e-01  1.176e-01  -1.184 0.238207
as.factor(Maintained)2         6.555e-02  4.211e-02   1.557 0.121586
as.factor(Lighting)2          -7.205e-02  5.437e-02  -1.325 0.187047
as.factor(Parking)2           -5.984e-02  4.618e-02  -1.296 0.196972
as.factor(Speeding)2           5.075e-02  3.726e-02   1.362 0.175097
as.factor(Employment)3         1.396e-01  3.850e-02   3.624 0.000391 ***
WorkHome                      -1.335e-02  9.237e-03  -1.445 0.150493
Density                        2.589e-06  7.938e-07   3.261 0.001361 **
Retail_to_Residential          2.617e-01  8.310e-02   3.149 0.001960 **
Grid                          -1.830e-01  7.184e-02  -2.548 0.011808 *
Near_Rapid_Ride               -1.522e-01  4.907e-02  -3.101 0.002286 **
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.2198 on 157 degrees of freedom
  (32 observations deleted due to missingness)
Multiple R-squared:  0.2477,   Adjusted R-squared:  0.1902
F-statistic: 4.309 on 12 and 157 DF,  p-value: 6.737e-06
```

Model 1* With All Demographic Variables

```
Call:
lm(formula = walkshare ~ as.factor(Walk_others) + as.factor(Sidewalks_Pres
ent) +
    as.factor(Maintained) + as.factor(Lighting) + as.factor(Parking) +
    as.factor(Speeding) + Age + Income + as.factor(Education) +
    as.factor(Employment) + WorkHome + HHSize + Vehicles + as.factor(Disab
ility) +
    as.factor(Race) + Density + Retail_to_Residential + Grid +
    Nearest_School_Distance + Near_Rapid_Ride, data = x, na.action = na.om
it)

Residuals:
    Min      1Q  Median      3Q     Max
-0.4863 -0.1670 -0.0073  0.1712  0.4784

Coefficients:
                                Estimate Std. Error t value Pr(>|t|)
(Intercept)                    3.157e-01  1.595e-01   1.979 0.049714 *
as.factor(Walk_others)2        6.126e-02  4.405e-02   1.391 0.166438
as.factor(Sidewalks_Present)2 -1.278e-01  1.066e-01  -1.199 0.232379
as.factor(Maintained)2         6.204e-02  4.329e-02   1.433 0.153958
as.factor(Lighting)2          -7.154e-02  5.554e-02  -1.288 0.199787
as.factor(Parking)2           -7.263e-02  4.902e-02  -1.482 0.140583
as.factor(Speeding)2           5.179e-02  3.805e-02   1.361 0.175576
Age                            4.932e-04  1.719e-03   0.287 0.774518
Income                        -3.473e-07  6.081e-07  -0.571 0.568815
as.factor(Education)2         -1.595e-02  2.297e-01  -0.069 0.944726
as.factor(Employment)2         1.178e-02  9.039e-02   0.130 0.896477
as.factor(Employment)3         1.167e-01  5.101e-02   2.287 0.023625 *
WorkHome                      -1.561e-02  9.677e-03  -1.613 0.109021
HHSize                        -1.130e-02  2.276e-02  -0.497 0.620125
Vehicles                       2.539e-03  2.248e-02   0.113 0.910238
as.factor(Disability)2        -6.259e-02  8.176e-02  -0.765 0.445224
as.factor(Race)2              -1.166e-02  5.804e-02  -0.201 0.841060
Density                        2.646e-06  8.165e-07   3.241 0.001479 **
Retail_to_Residential          2.890e-01  8.484e-02   3.407 0.000852 ***
Grid                          -1.924e-01  7.805e-02  -2.465 0.014876 *
Nearest_School_Distance        1.061e-01  1.468e-01   0.723 0.470905
Near_Rapid_Ride               -1.284e-01  6.167e-02  -2.081 0.039164 *
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.2182 on 145 degrees of freedom
  (35 observations deleted due to missingness)
Multiple R-squared:  0.2657,   Adjusted R-squared:  0.1593
F-statistic: 2.498 on 21 and 145 DF,  p-value: 0.0007799
```

Model 1 with No Large-Scale Built Environment Variables

```
Call:
lm(formula = walkshare ~ as.factor(Use_Sidewalk) + as.factor(Walk_others) 
+ 
    as.factor(Sidewalks_Present) + as.factor(Maintained) + as.factor(Light
ing) + 
    as.factor(Parking) + as.factor(Speeding) + as.factor(Traffic) + 
    Age + Income + as.factor(Education) + as.factor(Employment) + 
    WorkHome + HHSize + Vehicles + as.factor(Disability) + as.factor(Race)
, 
    data = x, na.action = na.omit)

Residuals:
     Min       1Q   Median       3Q      Max 
-0.49890 -0.15817 -0.00627  0.16640  0.49892 

Coefficients:
                                Estimate Std. Error t value Pr(>|t|)   
(Intercept)                    3.798e-01  1.347e-01   2.819  0.00547 **
as.factor(Use_Sidewalk)2      -2.386e-02  5.119e-02  -0.466  0.64186   
as.factor(Walk_others)2        3.528e-02  4.890e-02   0.721  0.47183   
as.factor(Sidewalks_Present)2 -1.201e-01  1.116e-01  -1.076  0.28370   
as.factor(Maintained)2         5.588e-02  4.394e-02   1.272  0.20543   
as.factor(Maintained)3         1.292e-01  2.379e-01   0.543  0.58786   
as.factor(Lighting)2          -5.796e-02  5.781e-02  -1.003  0.31770   
as.factor(Parking)2           -3.256e-02  4.979e-02  -0.654  0.51421   
as.factor(Speeding)2           3.978e-02  4.485e-02   0.887  0.37651   
as.factor(Traffic)2            4.714e-02  4.179e-02   1.128  0.26108   
Age                            3.818e-04  1.860e-03   0.205  0.83768   
Income                        -1.530e-07  6.227e-07  -0.246  0.80622   
as.factor(Education)2         -1.097e-01  2.373e-01  -0.462  0.64471   
as.factor(Employment)2         3.189e-02  9.384e-02   0.340  0.73444   
as.factor(Employment)3         1.320e-01  5.179e-02   2.549  0.01182 * 
WorkHome                      -1.082e-02  9.827e-03  -1.101  0.27260   
HHSize                        -1.035e-02  2.343e-02  -0.442  0.65917   
Vehicles                      -6.481e-03  2.298e-02  -0.282  0.77834   
as.factor(Disability)2        -1.101e-01  8.446e-02  -1.304  0.19432   
as.factor(Race)2              -4.830e-02  5.849e-02  -0.826  0.41024   
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1 

Residual standard error: 0.2285 on 148 degrees of freedom
  (34 observations deleted due to missingness)
Multiple R-squared:  0.1775,	Adjusted R-squared:  0.0719 
F-statistic: 1.681 on 19 and 148 DF,  p-value: 0.04539
```

Model 2*

```
Call:
lm(formula = walkshare ~ as.factor(Wide_enough) + as.factor(Level) +
    as.factor(Ramps) + as.factor(Crosswalks) + Age + as.factor(Employment)
+
    WorkHome + as.factor(Disability) + Density + Retail_to_Residential +
    Grid + Nearest_School_Distance + Near_Rapid_Ride, data = x,
    na.action = na.omit)

Residuals:
     Min       1Q   Median       3Q      Max
-0.46608 -0.14953 -0.02291  0.16474  0.53750

Coefficients:
                          Estimate Std. Error t value Pr(>|t|)
(Intercept)              8.922e-02  1.292e-01   0.691  0.49074
as.factor(Wide_enough)2 -7.307e-02  4.349e-02  -1.680  0.09502 .
as.factor(Wide_enough)3  2.335e-01  2.173e-01   1.074  0.28448
as.factor(Level)2        3.380e-02  4.039e-02   0.837  0.40412
as.factor(Ramps)2       -1.729e-02  5.612e-02  -0.308  0.75839
as.factor(Ramps)3       -3.278e-01  1.126e-01  -2.910  0.00416 **
as.factor(Crosswalks)2  -9.208e-02  3.635e-02  -2.533  0.01232 *
Age                      1.000e-03  1.632e-03   0.613  0.54073
as.factor(Employment)3   1.250e-01  4.726e-02   2.646  0.00902 **
WorkHome                -6.888e-03  9.519e-03  -0.724  0.47043
as.factor(Disability)2  -9.771e-02  8.381e-02  -1.166  0.24551
Density                  2.839e-06  7.610e-07   3.731  0.00027 ***
Retail_to_Residential    1.931e-01  7.765e-02   2.486  0.01401 *
Grid                    -1.126e-01  7.079e-02  -1.590  0.11393
Nearest_School_Distance  3.076e-01  1.446e-01   2.127  0.03504 *
Near_Rapid_Ride         -8.570e-02  6.361e-02  -1.347  0.17991
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.2114 on 150 degrees of freedom
  (36 observations deleted due to missingness)
Multiple R-squared:  0.293,    Adjusted R-squared:  0.2223
F-statistic: 4.145 on 15 and 150 DF,  p-value: 2.449e-06
```

Model 2* With All Demographic Variables

```
Call:
lm(formula = walkshare ~ as.factor(Wide_enough) + as.factor(Level) +
    as.factor(Separated) + as.factor(Ramps) + as.factor(Blockedcars) +
    as.factor(Crosswalks) + Age + Income + as.factor(Education) +
    as.factor(Employment) + WorkHome + HHSize + Vehicles + as.factor(Disab
ility) +
    as.factor(Race) + Density + Retail_to_Residential + Grid +
    Nearest_School_Distance + Near_Rapid_Ride, data = x, na.action = na.om
it)

Residuals:
     Min       1Q   Median       3Q      Max
-0.46504 -0.13563 -0.00786  0.15628  0.53885

Coefficients:
                          Estimate Std. Error t value Pr(>|t|)
(Intercept)              2.027e-01  1.531e-01   1.324 0.187542
as.factor(Wide_enough)2 -5.515e-02  4.356e-02  -1.266 0.207465
as.factor(Level)2        4.151e-02  3.863e-02   1.075 0.284296
as.factor(Separated)2    5.444e-02  4.617e-02   1.179 0.240218
as.factor(Separated)3    4.913e-01  2.514e-01   1.954 0.052573 .
as.factor(Ramps)2       -3.206e-02  5.846e-02  -0.548 0.584287
as.factor(Ramps)3       -4.481e-01  1.727e-01  -2.594 0.010431 *
as.factor(Blockedcars)2 -3.530e-02  3.468e-02  -1.018 0.310418
as.factor(Blockedcars)3  1.337e-01  1.417e-01   0.943 0.347044
as.factor(Crosswalks)2  -1.040e-01  3.754e-02  -2.772 0.006282 **
as.factor(Crosswalks)3  -5.088e-02  6.010e-02  -0.847 0.398598
Age                      1.638e-03  1.662e-03   0.986 0.325951
Income                  -1.974e-07  5.817e-07  -0.339 0.734789
as.factor(Education)2    1.600e-03  2.229e-01   0.007 0.994280
as.factor(Employment)2   2.120e-02  8.749e-02   0.242 0.808861
as.factor(Employment)3   1.051e-01  4.817e-02   2.182 0.030692 *
WorkHome                -1.037e-02  9.571e-03  -1.084 0.280156
HHSize                  -1.898e-02  2.218e-02  -0.856 0.393609
Vehicles                 5.506e-03  2.171e-02   0.254 0.800127
as.factor(Disability)2  -7.120e-02  7.808e-02  -0.912 0.363291
as.factor(Race)2        -2.135e-02  5.814e-02  -0.367 0.713975
Density                  2.851e-06  7.657e-07   3.724 0.000277 ***
Retail_to_Residential    2.392e-01  8.603e-02   2.780 0.006131 **
Grid                    -1.721e-01  7.554e-02  -2.278 0.024133 *
Nearest_School_Distance  2.174e-01  1.472e-01   1.478 0.141581
Near_Rapid_Ride         -1.138e-01  6.258e-02  -1.819 0.070965 .
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.2114 on 150 degrees of freedom
  (26 observations deleted due to missingness)
Multiple R-squared:   0.29,    Adjusted R-squared:  0.1717
F-statistic: 2.451 on 25 and 150 DF,  p-value: 0.0004713
```

Model 2 With No Large-Scale Built Environment Variables

```
Call:
lm(formula = walkshare ~ as.factor(Wide_enough) + as.factor(Level) +
    as.factor(Separated) + as.factor(Ramps) + as.factor(Obstacles) +
    as.factor(Vegetation) + as.factor(Blockedcars) + as.factor(Littered) +
    as.factor(Crosswalks) + Age + Income + as.factor(Education) +
    as.factor(Employment) + WorkHome + HHSize + Vehicles + as.factor(Disab
ility) +
    as.factor(Race), data = x, na.action = na.omit)

Residuals:
     Min       1Q   Median       3Q      Max
-0.47993 -0.13715 -0.00406  0.15692  0.52492

Coefficients:
                          Estimate Std. Error t value Pr(>|t|)
(Intercept)              4.261e-01  1.214e-01   3.509 0.000594 ***
as.factor(Wide_enough)2 -5.411e-02  4.792e-02  -1.129 0.260648
as.factor(Level)2        4.302e-02  3.939e-02   1.092 0.276559
as.factor(Separated)2    6.732e-03  4.422e-02   0.152 0.879197
as.factor(Separated)3    4.680e-01  2.902e-01   1.612 0.108981
as.factor(Ramps)2       -2.505e-02  6.257e-02  -0.400 0.689406
as.factor(Ramps)3       -4.487e-01  2.068e-01  -2.170 0.031577 *
as.factor(Obstacles)2    7.335e-03  4.226e-02   0.174 0.862454
as.factor(Obstacles)3    3.075e-02  9.435e-02   0.326 0.744929
as.factor(Vegetation)2  -9.244e-03  4.312e-02  -0.214 0.830549
as.factor(Vegetation)3   7.505e-02  2.104e-01   0.357 0.721825
as.factor(Blockedcars)2 -5.299e-02  3.892e-02  -1.361 0.175442
as.factor(Blockedcars)3  4.369e-02  1.590e-01   0.275 0.783923
as.factor(Littered)2     1.663e-02  5.525e-02   0.301 0.763845
as.factor(Littered)3    -5.033e-02  1.206e-01  -0.417 0.676937
as.factor(Crosswalks)2  -1.070e-01  4.047e-02  -2.644 0.009072 **
as.factor(Crosswalks)3  -4.183e-02  6.892e-02  -0.607 0.544805
Age                      8.045e-04  1.820e-03   0.442 0.659121
Income                  -1.019e-07  6.062e-07  -0.168 0.866744
as.factor(Education)2   -5.384e-02  2.404e-01  -0.224 0.823115
as.factor(Employment)2   2.496e-02  9.314e-02   0.268 0.789074
as.factor(Employment)3   1.352e-01  5.302e-02   2.551 0.011757 *
WorkHome                -4.516e-03  9.990e-03  -0.452 0.651868
HHSize                  -1.498e-02  2.397e-02  -0.625 0.532796
Vehicles                -5.979e-03  2.298e-02  -0.260 0.795103
as.factor(Disability)2  -1.335e-01  8.244e-02  -1.619 0.107577
as.factor(Race)2        -8.536e-02  6.126e-02  -1.394 0.165527
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.2259 on 149 degrees of freedom
  (26 observations deleted due to missingness)
Multiple R-squared:  0.1949,   Adjusted R-squared:  0.05441
F-statistic: 1.387 on 26 and 149 DF,  p-value: 0.1157
```

Model 3*

```
Call:
lm(formula = walkshare ~ as.factor(Sidewalks_Present) + as.factor(Maintain
ed) +
    as.factor(Lighting) + as.factor(Parking) + as.factor(Speeding) +
    as.factor(Wide_enough) + as.factor(Level) + as.factor(Separated) +
    as.factor(Ramps) + as.factor(Crosswalks) + Age + as.factor(Employment)
+
    WorkHome + as.factor(Disability) + Density + Retail_to_Residential +
    Grid + Nearest_School_Distance + Near_Rapid_Ride, data = x,
    na.action = na.omit)

Residuals:
     Min       1Q   Median       3Q      Max
-0.46677 -0.14990 -0.00559  0.16172  0.47501

Coefficients:
                              Estimate Std. Error t value Pr(>|t|)
(Intercept)                  1.495e-01  1.440e-01   1.038 0.301037
as.factor(Sidewalks_Present)2 -1.400e-01  1.140e-01  -1.228 0.221518
as.factor(Maintained)2        7.627e-02  4.191e-02   1.820 0.070920 .
as.factor(Lighting)2         -9.645e-02  5.681e-02  -1.698 0.091816 .
as.factor(Parking)2          -7.450e-02  4.650e-02  -1.602 0.111362
as.factor(Speeding)2          6.014e-02  3.885e-02   1.548 0.123859
as.factor(Wide_enough)2      -5.921e-02  4.493e-02  -1.318 0.189756
as.factor(Wide_enough)3       2.242e-01  2.179e-01   1.029 0.305430
as.factor(Level)2             6.862e-02  4.221e-02   1.626 0.106313
as.factor(Separated)2         4.314e-02  4.501e-02   0.958 0.339541
as.factor(Ramps)2            -5.610e-02  5.794e-02  -0.968 0.334652
as.factor(Ramps)3            -3.074e-01  1.131e-01  -2.718 0.007408 **
as.factor(Crosswalks)2       -1.010e-01  3.754e-02  -2.691 0.008001 **
Age                           1.376e-03  1.654e-03   0.832 0.406716
as.factor(Employment)3        1.107e-01  4.809e-02   2.302 0.022850 *
WorkHome                     -1.142e-02  9.897e-03  -1.154 0.250518
as.factor(Disability)2       -7.091e-02  8.427e-02  -0.842 0.401507
Density                       3.062e-06  7.911e-07   3.871 0.000166 ***
Retail_to_Residential         2.774e-01  8.806e-02   3.150 0.001998 **
Grid                         -1.887e-01  7.777e-02  -2.427 0.016518 *
Nearest_School_Distance       2.588e-01  1.466e-01   1.765 0.079818 .
Near_Rapid_Ride              -1.037e-01  6.459e-02  -1.605 0.110739
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.2102 on 139 degrees of freedom
  (41 observations deleted due to missingness)
Multiple R-squared:  0.3448,   Adjusted R-squared:  0.2458
F-statistic: 3.483 on 21 and 139 DF,  p-value: 5.132e-06
```

Model 3* with All Demographic Variables

```
Call:
lm(formula = walkshare ~ as.factor(Walk_others) + as.factor(Sidewalks_Pres
ent) + 
    as.factor(Maintained) + as.factor(Lighting) + as.factor(Parking) + 
    as.factor(Speeding) + as.factor(Wide_enough) + as.factor(Level) + 
    as.factor(Separated) + as.factor(Ramps) + as.factor(Crosswalks) + 
    Age + Income + as.factor(Education) + as.factor(Employment) + 
    WorkHome + HHSize + Vehicles + as.factor(Disability) + as.factor(Race) 
+ 
    Density + Retail_to_Residential + Grid + Nearest_School_Distance + 
    Near_Rapid_Ride, data = x, na.action = na.omit)

Residuals:
     Min       1Q   Median       3Q      Max 
-0.48513 -0.14437 -0.00222  0.15390  0.41969 

Coefficients:
                                Estimate Std. Error t value Pr(>|t|)    
(Intercept)                    3.434e-01  1.826e-01   1.880 0.062526 .  
as.factor(Walk_others)2        4.842e-02  4.985e-02   0.971 0.333367    
as.factor(Sidewalks_Present)2 -1.535e-01  1.071e-01  -1.433 0.154507    
as.factor(Maintained)2         8.744e-02  4.566e-02   1.915 0.057902 .  
as.factor(Lighting)2          -1.289e-01  6.121e-02  -2.106 0.037315 *  
as.factor(Parking)2           -9.699e-02  5.259e-02  -1.844 0.067604 .  
as.factor(Speeding)2           9.564e-02  4.400e-02   2.174 0.031701 *  
as.factor(Wide_enough)2       -7.688e-02  4.721e-02  -1.629 0.106027    
as.factor(Level)2              4.731e-02  4.688e-02   1.009 0.314923    
as.factor(Separated)2          7.604e-02  5.156e-02   1.475 0.142894    
as.factor(Ramps)2             -6.021e-02  6.185e-02  -0.974 0.332233    
as.factor(Ramps)3             -4.125e-01  1.577e-01  -2.616 0.010032 *  
as.factor(Crosswalks)2        -8.419e-02  4.005e-02  -2.102 0.037645 *  
Age                           -3.061e-05  1.852e-03  -0.017 0.986842    
Income                        -1.333e-07  6.312e-07  -0.211 0.833102    
as.factor(Education)2         -1.713e-01  2.328e-01  -0.736 0.463321    
as.factor(Employment)2         5.109e-02  1.023e-01   0.499 0.618552    
as.factor(Employment)3         1.273e-01  5.272e-02   2.415 0.017239 *  
WorkHome                      -2.421e-02  1.092e-02  -2.216 0.028583 *  
HHSize                        -1.041e-02  2.519e-02  -0.413 0.680258    
Vehicles                       8.865e-03  2.437e-02   0.364 0.716636    
as.factor(Disability)2        -6.776e-02  8.772e-02  -0.772 0.441354    
as.factor(Race)2              -2.557e-02  6.801e-02  -0.376 0.707631    
Density                        3.060e-06  8.592e-07   3.561 0.000530 ***
Retail_to_Residential          3.631e-01  9.468e-02   3.835 0.000202 ***
Grid                          -2.623e-01  8.810e-02  -2.977 0.003518 ** 
Nearest_School_Distance        1.485e-01  1.666e-01   0.891 0.374574    
Near_Rapid_Ride               -1.332e-01  6.824e-02  -1.953 0.053204 .  
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.211 on 120 degrees of freedom
  (54 observations deleted due to missingness)
Multiple R-squared:  0.3703,	Adjusted R-squared:  0.2286 
F-statistic: 2.613 on 27 and 120 DF,  p-value: 0.0001979
```

Model 3 with No Large-Scale Built Environment Variables

```
Call:
lm(formula = walkshare ~ as.factor(Use_Sidewalk) + as.factor(Walk_others)
+
    as.factor(Sidewalks_Present) + as.factor(Maintained) + as.factor(Light
ing) +
    as.factor(Parking) + as.factor(Speeding) + as.factor(Traffic) +
    as.factor(Wide_enough) + as.factor(Level) + as.factor(Separated) +
    as.factor(Ramps) + as.factor(Obstacles) + as.factor(Vegetation) +
    as.factor(Blockedcars) + as.factor(Littered) + as.factor(Crosswalks) +
    Age + Income + as.factor(Education) + as.factor(Employment) +
    WorkHome + HHSize + Vehicles + as.factor(Disability) + as.factor(Race)
,
    data = x, na.action = na.omit)

Residuals:
     Min       1Q   Median       3Q      Max
-0.53866 -0.13209 -0.01393  0.14469  0.44115

Coefficients:
                              Estimate Std. Error t value Pr(>|t|)
(Intercept)                  4.282e-01  1.482e-01   2.889  0.00453 **
as.factor(Use_Sidewalk)2    -3.309e-02  5.919e-02  -0.559  0.57710
as.factor(Walk_others)2      2.056e-02  5.417e-02   0.380  0.70492
as.factor(Sidewalks_Present)2 -1.587e-01  1.168e-01  -1.359  0.17638
as.factor(Maintained)2       7.938e-02  4.775e-02   1.662  0.09889 .
as.factor(Maintained)3       1.078e-01  2.528e-01   0.426  0.67057
as.factor(Lighting)2        -6.494e-02  6.227e-02  -1.043  0.29894
as.factor(Parking)2         -5.574e-02  5.431e-02  -1.026  0.30664
as.factor(Speeding)2         4.919e-02  4.952e-02   0.993  0.32234
as.factor(Traffic)2          1.916e-02  4.500e-02   0.426  0.67107
as.factor(Wide_enough)2     -5.433e-02  5.222e-02  -1.040  0.30010
as.factor(Level)2            5.046e-02  4.521e-02   1.116  0.26643
as.factor(Separated)2        1.413e-02  5.143e-02   0.275  0.78394
as.factor(Separated)3        3.960e-01  3.505e-01   1.130  0.26058
as.factor(Ramps)2           -6.783e-02  6.667e-02  -1.017  0.31085
as.factor(Ramps)3           -4.996e-01  2.172e-01  -2.300  0.02307 *
as.factor(Obstacles)2        4.091e-03  4.566e-02   0.090  0.92874
as.factor(Obstacles)3        4.548e-02  1.024e-01   0.444  0.65753
as.factor(Vegetation)2       4.439e-03  4.689e-02   0.095  0.92472
as.factor(Vegetation)3       8.341e-02  2.250e-01   0.371  0.71144
as.factor(Blockedcars)2     -5.595e-02  4.269e-02  -1.311  0.19233
as.factor(Blockedcars)3      5.389e-02  1.666e-01   0.323  0.74684
as.factor(Littered)2         3.306e-02  5.800e-02   0.570  0.56970
as.factor(Littered)3        -7.398e-02  1.286e-01  -0.575  0.56598
as.factor(Crosswalks)2      -1.078e-01  4.434e-02  -2.431  0.01643 *
as.factor(Crosswalks)3      -3.285e-02  7.605e-02  -0.432  0.66651
Age                          5.510e-04  2.116e-03   0.260  0.79497
Income                      -9.938e-08  6.588e-07  -0.151  0.88034
as.factor(Education)2       -1.513e-01  2.558e-01  -0.592  0.55518
as.factor(Employment)2       4.590e-02  9.854e-02   0.466  0.64212
as.factor(Employment)3       1.512e-01  5.706e-02   2.649  0.00906 **
WorkHome                    -8.877e-03  1.084e-02  -0.819  0.41430
HHSize                      -1.882e-02  2.606e-02  -0.722  0.47159
Vehicles                     2.676e-03  2.449e-02   0.109  0.91314
as.factor(Disability)2      -1.334e-01  9.011e-02  -1.480  0.14116
as.factor(Race)2            -7.573e-02  6.539e-02  -1.158  0.24890
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.2298 on 130 degrees of freedom
  (36 observations deleted due to missingness)
Multiple R-squared:  0.256,    Adjusted R-squared:  0.05568
F-statistic: 1.278 on 35 and 130 DF,  p-value: 0.1635
```

Model 3**

```
Call:
lm(formula = walkshare ~ as.factor(Use_Sidewalk) + as.factor(Sidewalks_Pre
sent) + 
    as.factor(Maintained) + as.factor(Lighting) + as.factor(Parking) + 
    as.factor(Speeding) + as.factor(Traffic) + as.factor(Wide_enough) + 
    as.factor(Level) + as.factor(Separated) + as.factor(Ramps) + 
    as.factor(Blockedcars) + as.factor(Crosswalks) + Age + Income + 
    as.factor(Education) + as.factor(Employment) + WorkHome + 
    HHSize + Vehicles + as.factor(Disability) + as.factor(Race) + 
    Density + Retail_to_Residential + Grid + Nearest_School_Distance + 
    Near_Rapid_Ride, data = x, na.action = na.omit)

Residuals:
     Min       1Q   Median       3Q      Max 
-0.49429 -0.15300 -0.00147  0.15407  0.45924 

Coefficients:
                                Estimate Std. Error t value Pr(>|t|)    
(Intercept)                    2.835e-01  1.635e-01   1.734 0.085077 .  
as.factor(Use_Sidewalk)2       4.458e-03  4.660e-02   0.096 0.923917    
as.factor(Sidewalks_Present)2 -1.557e-01  1.086e-01  -1.433 0.153977    
as.factor(Maintained)2         8.492e-02  4.111e-02   2.066 0.040700 *  
as.factor(Maintained)3         1.387e-01  2.275e-01   0.610 0.542949    
as.factor(Lighting)2          -8.418e-02  5.679e-02  -1.482 0.140492    
as.factor(Parking)2           -9.880e-02  4.810e-02  -2.054 0.041838 *  
as.factor(Speeding)2           3.928e-02  4.421e-02   0.889 0.375794    
as.factor(Traffic)2            3.650e-02  4.001e-02   0.912 0.363161    
as.factor(Wide_enough)2       -4.503e-02  4.534e-02  -0.993 0.322372    
as.factor(Level)2              6.695e-02  4.053e-02   1.652 0.100778    
as.factor(Separated)2          8.419e-02  4.886e-02   1.723 0.087106 .  
as.factor(Separated)3          5.070e-01  2.563e-01   1.979 0.049831 *  
as.factor(Ramps)2             -7.377e-02  6.042e-02  -1.221 0.224142    
as.factor(Ramps)3             -4.587e-01  1.752e-01  -2.618 0.009814 ** 
as.factor(Blockedcars)2       -3.114e-02  3.649e-02  -0.854 0.394809    
as.factor(Blockedcars)3        8.861e-02  1.451e-01   0.611 0.542428    
as.factor(Crosswalks)2        -1.003e-01  3.900e-02  -2.572 0.011165 *  
as.factor(Crosswalks)3        -4.509e-02  6.318e-02  -0.714 0.476637    
Age                            1.700e-03  1.804e-03   0.943 0.347511    
Income                        -3.365e-07  5.855e-07  -0.575 0.566392    
as.factor(Education)2         -1.627e-01  2.290e-01  -0.710 0.478656    
as.factor(Employment)2         4.096e-02  8.906e-02   0.460 0.646272    
as.factor(Employment)3         9.596e-02  4.907e-02   1.956 0.052495 .  
WorkHome                      -1.663e-02  9.954e-03  -1.671 0.097018 .  
HHSize                        -1.961e-02  2.265e-02  -0.866 0.388092    
Vehicles                       1.264e-02  2.239e-02   0.565 0.573236    
as.factor(Disability)2        -4.464e-02  7.855e-02  -0.568 0.570768    
as.factor(Race)2              -8.270e-03  5.860e-02  -0.141 0.887972    
Density                        3.134e-06  7.910e-07   3.962 0.000118 ***
Retail_to_Residential          3.063e-01  8.966e-02   3.416 0.000831 ***
Grid                          -2.436e-01  8.196e-02  -2.972 0.003480 ** 
Nearest_School_Distance        1.690e-01  1.480e-01   1.142 0.255364    
Near_Rapid_Ride               -1.400e-01  6.370e-02  -2.199 0.029552 *  
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.2094 on 140 degrees of freedom
  (28 observations deleted due to missingness)
Multiple R-squared:  0.3474,	Adjusted R-squared:  0.1936 
F-statistic: 2.259 on 33 and 140 DF,  p-value: 0.0005561
```

Model 4

```
Call:
lm(formula = walkshare ~ Wider.sidewalks + Evenness.of.sidewalks + 
    Presence.of.Sidewalks + Sidewalk.curb.ramps.at.Intersections + 
    Marked.Pedestrian.Crossings.at.busy.streets + Separation.between.sidewalk..amp..roadway + 
    Lighting.at.night + Overgrown.Vegetation + Crime + High.volume.of.vehicle.traffic + 
    High.traffic.speed + Maintained.sidewalks + Obstacles.in.the.sidewalk.such.as.utility.poles.and.fire.hydrants + 
    Broken.glass..hypodermic.needles.and.other.potentially.dangerous.items + 
    Age + Income + as.factor(Education) + as.factor(Employment) + 
    WorkHome + HHSize + Vehicles + as.factor(Disability) + as.factor(Race) + 
    Density + Retail_to_Residential + Grid + Nearest_School_Distance + 
    Near_Rapid_Ride, data = x, na.action = na.omit)

Residuals:
     Min       1Q   Median       3Q      Max 
-0.47424 -0.15409 -0.00624  0.14649  0.47971 

Coefficients:
                                                                         Estimate Std. Error t value Pr(>|t|)   
(Intercept)                                                            -1.160e-01  2.398e-01  -0.484  0.62939   
Wider.sidewalks                                                        -4.229e-02  2.761e-02  -1.532  0.12782   
Evenness.of.sidewalks                                                   6.761e-02  2.248e-02   3.008  0.00312 **
Presence.of.Sidewalks                                                   1.756e-02  2.968e-02   0.592  0.55503   
Sidewalk.curb.ramps.at.Intersections                                   -1.414e-03  2.723e-02  -0.052  0.95867   
Marked.Pedestrian.Crossings.at.busy.streets                            -3.799e-03  2.597e-02  -0.146  0.88393   
Separation.between.sidewalk..amp..roadway                               1.140e-02  2.716e-02   0.420  0.67535   
Lighting.at.night                                                       9.331e-03  1.653e-02   0.564  0.57344   
Overgrown.Vegetation                                                    1.266e-02  2.459e-02   0.515  0.60760   
Crime                                                                  -1.361e-02  2.559e-02  -0.532  0.59565   
High.volume.of.vehicle.traffic                                         -2.611e-02  3.532e-02  -0.739  0.46108   
High.traffic.speed                                                      1.149e-02  3.232e-02   0.356  0.72266   
Maintained.sidewalks                                                    2.602e-03  2.376e-02   0.110  0.91294   
Obstacles.in.the.sidewalk.such.as.utility.poles.and.fire.hydrants      -2.012e-02  2.562e-02  -0.785  0.43367   
Broken.glass..hypodermic.needles.and.other.potentially.dangerous.items  4.826e-02  2.547e-02   1.895  0.06016 . 
Age                                                                     2.197e-03  1.839e-03   1.195  0.23405   
Income                                                                  5.450e-08  5.970e-07   0.091  0.92740   
as.factor(Education)2                                                   5.722e-02  2.375e-01   0.241  0.80996   
as.factor(Employment)2                                                 -2.706e-02  9.320e-02  -0.290  0.77198   
as.factor(Employment)3                                                  8.863e-02  5.189e-02   1.708  0.08984 . 
WorkHome                                                               -1.551e-02  9.883e-03  -1.570  0.11874   
HHSize                                                                  1.028e-03  2.317e-02   0.044  0.96468   
Vehicles                                                               -9.839e-03  2.283e-02  -0.431  0.66707   
as.factor(Disability)2                                                 -8.663e-02  8.363e-02  -1.036  0.30202   
as.factor(Race)2                                                        4.242e-02  6.218e-02   0.682  0.49620   
Density                                                                 2.384e-06  8.238e-07   2.894  0.00441 **
Retail_to_Residential                                                   1.977e-01  8.599e-02   2.299  0.02299 * 
Grid                                                                   -9.357e-02  7.380e-02  -1.268  0.20695   
Nearest_School_Distance                                                 1.429e-01  1.601e-01   0.892  0.37367   
Near_Rapid_Ride                                                        -1.318e-01  6.721e-02  -1.960  0.05192 . 
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.2184 on 141 degrees of freedom
  (31 observations deleted due to missingness)
Multiple R-squared:  0.2917,	Adjusted R-squared:  0.146 
F-statistic: 2.002 on 29 and 141 DF,  p-value: 0.004128
```

REFERENCES

Addy, C. L., Wilson, D. K., Kirtland, K. A., Ainsworth, B. E., Sharpe, P., and Kimsey, D. (2004). "Associations of Perceived Social and Physical Environmental Supports With Physical Activity and Walking Behavior." *American Journal of Public Health*, 94(3), 440–443.

Adkins, A., Dill, J., Luhr, G., and Neal, M. (2012). "Unpacking Walkability: Testing the Influence of Urban Design Features on Perceptions of Walking Environment Attractiveness." *Journal of Urban Design*, 17(4), 499–510.

Agrawal, A. W., and Schimek, P. (2007). "Extent and correlates of walking in the USA." *Transportation Research Part D: Transport and Environment*, 12(8), 548–563.

Alfonzo, M., Boarnet, M. G., Day, K., Mcmillan, T., and Anderson, C. L. (2008). "The Relationship of Neighbourhood Built Environment Features and Adult Parents' Walking." *Journal of Urban Design*, 13(1), 29–51.

"An ordinance to cause the removal of obstructions on the sidewalks caused by snow or ice." (1857). *Norfolk County Journal Press*, 3.

Ariffin, R. N. R., and Zahari, R. K. (2013). "Perceptions of the Urban Walking Environments." *Procedia - Social and Behavioral Sciences*, AicE-Bs 2013 London (Asia Pacific International Conference on Environment-Behaviour Studies), 4-6 September 2013, 105, 589–597.

Ball, K., Bauman, A., Leslie, E., and Owen, N. (2001). "Perceived Environmental Aesthetics and Convenience and Company Are Associated with Walking for Exercise among Australian Adults." *Preventive Medicine*, 33(5), 434–440.

Battelle. (2000). "Travel patterns of People of Color: (440822008-001)." American Psychological Association.

Bostock, L. (2001). "Pathways of disadvantage? Walking as a mode of transport among low-income mothers." *Health & Social Care in the Community*, 9(1), 11–18.

Carlin, J. B., Stevenson, M. R., Roberts, I., Bennett, C. M., Gelman, A., and Nolan, T. (1997). "Walking to school and traffic exposure in Australian children." *Australian and New Zealand Journal of Public Health*, 21(3), 286–292.

Carrillo, E., Maddox, C., Maier, G., Mingus, C., and Sotnikova, M. (2012). *The Costs of Owning and Operating Sidewalks: A Strategy for the City of Atlanta*. Georgia Institute of Technology.

City of Albuquerque. (2017). *City of Albuquerque ADA Transition Plan Update*. Albuquerque, NM.

Clark, A. F., Scott, D. M., and Yiannakoulias, N. (2014). "Examining the relationship between active travel, weather, and the built environment: a multilevel approach using a GPS-enhanced dataset." *Transportation*, 41(2), 325–338.

Ehrenfeucht, R., and Loukaitou-Sideris, A. (2007). "Constructing the sidewalks: municipal government and the production of public space in Los Angeles, California, 1880–1920." *Journal of Historical Geography*, 33(1), 104–124.

Evans-Cowley, J. (2006a). "Sidewalk Planning and Policies in Small Cities." *Journal of Urban Planning and Development*, 132(2), 71–75.

Evans-Cowley, J. (2006b). "Sidewalk Planning and Policies in Small Cities." *Journal of Urban Planning and Development*, 132(2), 71–75.

Ewing, R., and Cervero, R. (2010). “Travel and the Built Environment.” *Journal of the American Planning Association*, 76(3), 265–294.

Foster, C., Hillsdon, M., and Thorogood, M. (2004). “Environmental perceptions and walking in English adults.” *Journal of Epidemiology & Community Health*, 58(11), 924–928.

Frank, L. D., and Pivo, G. (n.d.). “Impacts of Mixed Use and Density on Utilization of Three Modes of Travel: Single-Occupant Vehicle, Transit, and Walking.” *TRANSPORTATION RESEARCH RECORD*, 9.

Frank, L. D., Sallis, J. F., Conway, T. L., Chapman, J. E., Saelens, B. E., and Bachman, W. (2006). “Many Pathways from Land Use to Health: Associations between Neighborhood Walkability and Active Transportation, Body Mass Index, and Air Quality.” *Journal of the American Planning Association*, 72(1), 75–87.

Frumkin, H. (2002). “Urban Sprawl and Public Health.” *Public Health Reports*, 117(3), 201–217.

Garasky, S., Fletcher, C. N., and Jensen, H. H. (2006). “Transiting to Work: The Role of Private Transportation for Low-Income Households.” *Journal of Consumer Affairs*, 40(1), 64–89.

Georggi, N. L., and Pendyala, R. M. (n.d.). “Analysis of Long-Distance Travel Behavior of the Elderly and Low Income.” 30.

Giles-Corti, B., Wood, G., Pikora, T., Learnihan, V., Bulsara, M., Van Niel, K., Timperio, A., McCormack, G., and Villanueva, K. (2011). “School site and the potential to walk to school: The impact of street connectivity and traffic exposure in school neighborhoods.” *Health & Place*, 17(2), 545–550.

Gómez, L. F., Parra, D. C., Buchner, D., Brownson, R. C., Sarmiento, O. L., Pinzón, J. D., Ardila, M., Moreno, J., Serrato, M., and Lobelo, F. (2010). "Built Environment Attributes and Walking Patterns Among the Elderly Population in Bogotá." *American Journal of Preventive Medicine*, 38(6), 592–599.

Gunn, L. D., Lee, Y., Geelhoed, E., Shiell, A., and Giles-Corti, B. (2014). "The cost-effectiveness of installing sidewalks to increase levels of transport-walking and health." *Preventive Medicine*, 67, 322–329.

Handy, S., Cao, X., and Mokhtarian, P. (2005). "Correlation or causality between the built environment and travel behavior? Evidence from Northern California." *Transportation Research Part D: Transport and Environment*, 10(6), 427–444.

Handy, S. L., Boarnet, M. G., Ewing, R., and Killingsworth, R. E. (2002). "How the built environment affects physical activity." *American Journal of Preventive Medicine*, 23(2), 64–73.

Harper, D. (2017a). *Inspection of American with Disabilities Act Compliance by City of Albuquerque*. City of Albuquerque Office of the Inspector General, Albuquerque, NM.

Harper, D. T. (2017b). "OFFICE OF INSPECTOR GENERAL." 33.

Hicks, G. C. (2014). "But It's Your Sidewalk! Sidewalk Repair and Liability."

Humpel, N., Owen, N., Iverson, D., Leslie, E., and Bauman, A. (2004a). "Perceived environment attributes, residential location, and walking for particular purposes." *American Journal of Preventive Medicine*, 26(2), 119–125.

Humpel, N., Owen, N., Leslie, E., Marshall, A. L., Bauman, A. E., and Sallis, J. F. (2004b). “Associations of Location and Perceived Environmental Attributes with Walking in Neighborhoods.” *American Journal of Health Promotion*, 18(3), 239–242.

Jacobsen, P. L., Racioppi, F., and Rutter, H. (2009). “Who owns the roads? How motorised traffic discourages walking and bicycling.” *Injury Prevention*, 15(6), 369–373.

Kang, L., Xiong, Y., and Mannering, F. L. (2013). “Statistical analysis of pedestrian perceptions of sidewalk level of service in the presence of bicycles.” *Transportation Research Part A: Policy and Practice*, 53, 10–21.

Kelly, C. M., Schootman, M., Baker, E. A., Barnidge, E. K., and Lemes, A. (2007a). “The association of sidewalk walkability and physical disorder with area-level race and poverty.” *Journal of Epidemiology and Community Health*, 61(11), 978–983.

Kelly, C. M., Schootman, M., Baker, E. A., Barnidge, E. K., and Lemes, A. (2007b). “The association of sidewalk walkability and physical disorder with area-level race and poverty.” *Journal of Epidemiology & Community Health*, 61(11), 978–983.

Kemperman, A., and Timmermans, H. (2009). “Influences of Built Environment on Walking and Cycling by Latent Segments of Aging Population.” *Transportation Research Record*, 2134(1), 1–9.

Kerr, J., Frank, L., Sallis, J. F., and Chapman, J. (2007). “Urban form correlates of pedestrian travel in youth: Differences by gender, race-ethnicity and household attributes.” *Transportation Research Part D: Transport and Environment*, 12(3), 177–182.

Legarza, D. (2000). “City of Las Vegas sidewalk maintenance and repair: Who is responsible?” University of Nevada, Las Vegas.

Leslie, E., Saelens, B., Frank, L., Owen, N., Bauman, A., Coffee, N., and Hugo, G. (2005). “Residents’ perceptions of walkability attributes in objectively different neighbourhoods: a pilot study.” *Health & Place*, 11(3), 227–236.

Li, F., Fisher, K. J., Brownson, R. C., and Bosworth, M. (2005). “Multilevel modelling of built environment characteristics related to neighbourhood walking activity in older adults.” *Journal of Epidemiology & Community Health*, 59(7), 558–564.

McDonald, N. C. (2008). “Critical Factors for Active Transportation to School Among Low-Income and Minority Students.” *American Journal of Preventive Medicine*, 34(4), 341–344.

McDonald, N. C., Yang, Y., Abbott, S. M., and Bullock, A. N. (2013). “Impact of the Safe Routes to School program on walking and biking: Eugene, Oregon study.” *Transport Policy*, 29, 243–248.

Messier, J. (2017). “Discussion with Former CIty of Albuquerque Planning Director.”

Montemurro, G. R., Berry, T. R., Spence, J. C., Nykiforuk, C., Blanchard, C., and Cutumisu, N. (2011). “‘Walkable by Willpower’: Resident perceptions of neighbourhood environments.” *Health & Place*, 17(4), 895–901.

Moudon, A. V., Lee, C., Cheadle, A. D., Garvin, C., Johnson, D. B., Schmid, T. L., and Weathers, R. D. (2007). “Attributes of Environments Supporting Walking.” *American Journal of Health Promotion*, 21(5), 448–459.

Mueller, N., Rojas-Rueda, D., Cole-Hunter, T., de Nazelle, A., Dons, E., Gerike, R., Götschi, T., Int Panis, L., Kahlmeier, S., and Nieuwenhuijsen, M. (2015). “Health impact assessment of active transportation: A systematic review.” *Preventive Medicine*, 76, 103–114.

Naumann, R. B., Dellinger, A. M., Anderson, M. L., Bonomi, A. E., Rivara, F. P., and Thompson, R. S. (2009). "Preferred modes of travel among older adults: What factors affect the choice to walk instead of drive?" *Journal of Safety Research*, 40(5), 395–398.

Neckerman, K. M., Lovasi, G. S., Davies, S., Purciel, M., Quinn, J., Feder, E., Raghunath, N., Wasserman, B., and Rundle, A. (2009). "Disparities in Urban Neighborhood Conditions: Evidence from GIS Measures and Field Observation in New York City." *Journal of Public Health Policy*, 30(1), S264–S285.

New Jersey DOT. (2006). *Constructing, Maintaining and Financing Sidewalks in New Jersey*. Prepared by Alan M. Voorhees Transportation Center and Charles R. Carmalt.

Owen, N., Humpel, N., Leslie, E., Bauman, A., and Sallis, J. F. (2004). "Understanding environmental influences on walking: Review and research agenda." *American Journal of Preventive Medicine*, 27(1), 67–76.

Perez, C., and Zipf, M. (2010). "A Streamlined Approach to Prioritize Sidewalk Investments." Presented at the ITE 2010 Annual Meeting and Exhibit.

Rannila, P., and Mitchell, D. (2016). "Syracuse, sidewalks, and snow: the slippery realities of public space." *Urban Geography*, 37(7), 1070–1090.

Rhodes, R. E., Courneya, K. S., Blanchard, C. M., and Plotnikoff, R. C. (2007). "Prediction of leisure-time walking: an integration of social cognitive, perceived environmental, and personality factors." *International Journal of Behavioral Nutrition and Physical Activity*, 4(1), 51.

Rodríguez, D. A., Evenson, K. R., Diez Roux, A. V., and Brines, S. J. (2009). "Land Use, Residential Density, and Walking: The Multi-Ethnic Study of Atherosclerosis." *American Journal of Preventive Medicine*, 37(5), 397–404.

Saelens, B. E., Sallis, J. F., Black, J. B., and Chen, D. (2003). "Neighborhood-Based Differences in Physical Activity: An Environment Scale Evaluation." *American Journal of Public Health*, 93(9), 1552–1558.

Shoup, D. (2010a). "Putting Cities Back on Their Feet." *Journal of Urban Planning and Development*, 136(3), 225–233.

Shoup, D. (2010b). "Putting Cities Back on Their Feet." *Journal of Urban Planning and Development*, 136(3), 225–233.

Timperio, A., Crawford, D., Telford, A., and Salmon, J. (2004). "Perceptions about the local neighborhood and walking and cycling among children." *Preventive Medicine*, 38(1), 39–47.

Truong, T., and Meyer, T. (2015). "Accounting for Geographic Equity in Prioritizing Sidewalks." Presented at the Transportation Research Board 94th Annual Meeting.

U.S. Environmental Protection Agency (EPA). (2019). "Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2017."

Van Cauwenberg, J., De Bourdeaudhuij, I., Clarys, P., Nasar, J., Salmon, J., Goubert, L., and Deforche, B. (2016). "Street characteristics preferred for transportation walking among older adults: a choice-based conjoint analysis with manipulated photographs." *International Journal of Behavioral Nutrition and Physical Activity*, 13(1), 6.

Van Dyck, D., Cerin, E., Conway, T. L., De Bourdeaudhuij, I., Owen, N., Kerr, J., Cardon, G., Frank, L. D., Saelens, B. E., and Sallis, J. F. (2012). "Perceived neighborhood environmental attributes associated with adults' transport-related walking and cycling: Findings from the USA, Australia and Belgium." *International Journal of Behavioral Nutrition and Physical Activity*, 9(1), 70.

Warburton, D. E. R., Nicol, C. W., and Bredin, S. S. D. (2006). "Health benefits of physical activity: the evidence." *CMAJ*, 174(6), 801–809.

Wood, L., Frank, L. D., and Giles-Corti, B. (2010). "Sense of community and its relationship with walking and neighborhood design." *Social Science & Medicine*, 70(9), 1381–1390.

Zhu, X., and Lee, C. (2008). "Walkability and Safety Around Elementary Schools: Economic and Ethnic Disparities." *American Journal of Preventive Medicine*, 34(4), 282–290.