Neighborhood Design and Aging: An Empirical Analysis in Northern California

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Disclaimer

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Abstract

The low mobility of seniors may be due in part to a history of auto-oriented transportation and land use policy decisions. More recently, land use policies that make it possible to drive less show promise of effectiveness for the population as a whole. However, little attention has been paid to the implications of such policies for older people. Using data collected from Northern California in 2003, this study focuses on residential and travel choices of the elderly. The results show that the elderly have stronger preferences for driving-reducing neighborhood attributes, but are less likely to live in a place that meets their preferences than younger people. Generally, older people drive less and use alternative modes more often than younger people. After controlling for attitudes and socio-demographics, various elements of neighborhood design are associated with travel behavior. Overall, although neighborhood design has limited effects on reducing driving and promoting transit use, enhancing accessibility tends to be a promising strategy for promoting walking trips. In particular, the shorter the distance to the closest grocery store, the higher the frequency of walking to the store. Further, this enhanced accessibility has a much larger effect on the elderly than on the younger generation. Therefore, neighborhood design seems to be an important aspect of sustaining the accessibility of older people.

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1. INTRODUCTION

Urban sprawl has been widely criticized for its contribution to auto dependence and its consequences – traffic congestion, air pollution, climate change, and oil reliance. Conceptually, the logical premise is that sprawl development greatly increases the length of trips and makes alternative modes uncompetitive with driving. Empirically, many studies have explored the relationship between the built environment and travel behavior during the past two decades. It is evident that residents of traditional neighborhoods (characterized by greater land use mix and street connectivity) drive less, take transit more, and walk more than do inhabitants of suburban neighborhoods (e.g., Cervero and Duncan, 2003; Crane and Crepeau, 1998; Friedman et al., 1994).

However, few studies have focused on the relationship of the built environment to the travel choices of older individuals. The elderly account for a sizable share of the US population: according to the 2000 US Census data, 35.0 million persons (12.4% of the population) were age 65 or over. Because many elderly have physical and/or financial constraints that limit driving, the design of residential neighborhoods potentially has an important influence on their travel behavior by facilitating or limiting their travel choices. In particular, conventional auto-oriented development patterns make vehicular trips a necessity rather than a choice in most situations. This means that elderly living in these areas are dependent on driving, with important consequences − if they drive, they have access to the services and other activities they need; if they don't drive, their mobility and thus their access is significantly restricted. Indeed, older people worldwide have become more dependent on autos than ever before, even as their mobility continues to follow the pattern of declining with age (e.g., Newbold et al., 2005; Rosenbloom, 2001). By contrast, traditional neighborhood design that facilitates pedestrian or transit travel to daily activities has the potential to reduce auto dependence and ensure access even for those who lack the ability to drive. In these neighborhoods, a shift from driving to walking has health benefits for the elderly as well as environmental benefits for society as a whole. Further, land use policies that bring residents closer to destinations can also enhance accessibility by reducing travel distances even when auto trips are still made. Both effects enhance quality of life for seniors facing a decline in their ability to drive.

The purpose of this study is to explore the ability of neighborhood design to preserve accessibility for the elderly by enabling a shift from driving to transit and walking, while controlling for neighborhood preferences and attitudes toward transportation. The study compares the residential choices of the elderly and younger people, and its influence on their travel behavior. Specifically, this paper addresses the following two questions: (1) What are the preferences and reality of the residential choices of older people? (2) Does neighborhood design influence the travel behavior of older people and younger people differently? The next section reviews some literature regarding travel behavior of the elderly and its association with neighborhood design. Section 3 describes the data and variables. Section 4 presents the comparative analysis and multivariate modeling results. The final section recapitulates the key findings and suggests some policy implications.

2. LITERATURE REVIEW

Mobility declines as people age. According to the 2001 National Household Travel Survey, older people, who comprised 12.6% of the population, took approximately 10% of all daily trips and 8% of the long-distance trips, while younger adults (19-64), who accounted for 62% of the population, took 68% of all daily trips and 72% of the long-distance trips. On average, the elderly also traveled shorter distances and less time than younger adults (Collia et al., 2003). What factors explain their mobility decline? Previous research has identified health constraints, changing activity patterns such as retirement from the work force, and heavy traffic as potentially contributing to their lower mobility (Metz, 2003; Raitanen et al., 2003).

The lower mobility of older people is also due in part (though *only* in part) to a history of transportation and land use policy decisions that have systematically privileged the automobile over collective and nonmotorized forms of travel (Pucher, 2004). To keep seniors on the move, policy makers have promoted a variety of transportation services. For example, the American with Disabilities Act requires that fixed-route transit operators provide comparable paratransit or other special services to individuals with disabilities, most of whom are elderly (Code of Federal Regulation: 49, part 37.121); many senior service centers offer various transportation services to meet the diverse needs of their constituents. In addition, though they have rarely been justified on this basis, land use policies that make it possible to drive less have the potential to reduce mobility but sustain or enhance accessibility for the elderly. Traditional neighborhood design may reduce vehicle trip frequencies (if alternative modes become competitive with driving) and distances without a reduction in the degree to which the needs of elderly citizens are met. The result is a benefit to the elderly, given the financial and sometimes physical and emotional burdens of driving, and a benefit to society, given the environmental impacts of vehicle trips.

Previous research has shed light on the influence of neighborhood design on senior travel. Using the 1995 Nationwide Personal Transportation Survey, Waldorf (2003) and Giuliano (2004) found that older individuals in urban areas were less likely to depend on an automobile than those in suburban areas. A case study of senior travel and land use demonstrated that the elderly in mixed-use and compact communities were more likely to walk and use public transportation than were their counterparts in suburban communities (Lynott, 2005). Overall, these findings suggest that the built environment is associated with seniors' travel behavior. However, these studies generally used discrete variables (such as urban vs. suburban) to differentiate the built environment. These indicators are too simplistic to identify the elements of the built environment that truly influence travel behavior.

Along the same lines, Raitanen et al. (2003) found that "I can reach and do everything without a car" is one of the commonly stated reasons for the reduced driving of older Europeans. That is, local shopping and services can improve the accessibility of the elderly. A qualitative study on neighborhood design and active aging also revealed that (1) diverse services within walking distance provide older people options to walk instead of driving the car to daily activities; (2) roads with heavy traffic make walking unsafe but some traffic calming devices make it pleasant; (3) attractive neighborhoods increase enjoyment while walking; and (4) public transit is important to the elderly and is essential to people with mobility constraints (Michael et al., 2006). Moreover, several quantitative studies concluded that retail stores within walking distance (King et al., 2003), sidewalks, light traffic, and safe neighborhoods (Wilcox et al., 2003), and walking paths/trails and access to a park (Booth et al., 2000; King et al., 2003) are positively associated with walking levels of older people. In general, these studies point to influential characteristics of the built environment. However, they mainly focused on active travel from the perspective of public health, but did not pay much attention to motorized travel behavior. Further, most studies considered only older people and hence lacked a comparison group. As a result, these studies are unable to quantitatively

identify whether, and if so, how neighborhood design influences the travel behavior of older and younger people differently.

Further, individuals may choose their neighborhoods to meet their residential and travel preferences. For instance, in addition to the influence of neighborhood design on travel behavior, Michael et al. (2006) also found that some of their older participants chose to relocate to or stay in their current neighborhoods at least partly due to their proximity to shopping and services. In this case, the association between neighborhood design and travel behavior is likely to be confounded by attitudinal factors. It may be residential preference rather than neighborhood design itself that has a true influence on travel behavior. Therefore, it is essential to account for the sorting effects of different tastes when we investigate the influence of neighborhood design on travel behavior.

This study examines the influence of neighborhood design, residential preferences, and travel attitudes on travel behavior. The analyses examine in depth the differences between older people and their younger counterparts, and the differences between older people living in traditional and suburban neighborhoods. These contrasts have not previously been extensively investigated with respect to the relationship between neighborhood design and travel behavior.

3. DATA AND VARIABLES

This paper uses data collected from residents of four "traditional" neighborhoods and four "suburban" neighborhoods in Northern California (see Handy et al., 2004 for details). These designations were made based on neighborhood age, the street network, age and design of houses, and the location and type of commercial centers. The neighborhoods chosen as "traditional" included Mountain View (Downtown), Sacramento (Midtown), Santa Rosa (Junior College area), and Modesto (Central). The neighborhoods chosen as "suburban" were Sunnyvale (I-280 area), Sacramento (Natomas area), Santa Rosa (Rincon Valley area), and Modesto (Suburban area). For each neighborhood, we purchased two databases of residents from New Neighbors Contact Service (www.nncs.com), a database of "movers" and a database of "nonmovers." The "movers" included all current residents of the neighborhood who had moved within the previous year. From this database, we drew a random sample of 500 residents for each of the eight neighborhoods. The "nonmovers" invited to participate consisted of a random sample of 500 residents not included in the "movers" list for each neighborhood.

The survey was administered in October and November 2003, using a mail-out, mail-back approach. This approach resulted in 1682 responses, a 24.9% response rate based on the valid addresses only. A comparison of sample characteristics to population characteristics, based on the 2000 US Census (Table 1), shows that median household income for survey respondents was higher than the census median for all but the Rincon Valley area in Santa Rosa, a typical result for voluntary self-administered surveys. Further, survey respondents tend to be older on average than residents of their neighborhood as a whole, a reasonable result for a survey including only adult respondents. Although these univariate distributions may not be representative, we expect conditional relationships (e.g., travel behaviors given age) to be reasonably well estimated (Babbie, 1998). In this study, 251 individuals 65 years old and above (of which 115 lived in traditional neighborhoods) were classified as elderly, which account for 15.3% of respondents who reported their ages. The variables used here were classified into five groups: travel behavior, neighborhood characteristics, neighborhood preferences, travel attitudes, and socio-demographics.

Table 1 Sample vs. Population Characteristics

	Traditional				Suburban			
	Mountain View	SR Junior College	MD Central	SC Midtown	Sunnyvale	SR Rincon Valley	MD Suburban	SC Natomas
Sample Characteristics								
Number	228	215	184	271	217	165	220	182
Percent females	47.3	54.3	56.3	58.2	46.9	50.9	50.9	54.9
Average auto ownership	1.80	1.63	1.59	1.50	1.79	1.66	1.88	1.68
Age	43.3	47.0	51.3	43.4	47.1	54.7	53.2	45.6
Average HH size	2.08	2.03	2.13	1.78	2.58	2.19	2.41	2.35
Percent HHs w/kids	21.1	18.6	21.7	8.9	42.4	24.8	25.5	31.9
Percent home owners	51.1	57.8	75.6	47.0	61.1	68.7	81.0	82.4
Median HH income ($k)	98.7	55.5	45.5	64.2	95.0	49.5	55.5	55.3
Population Characteristics								
Population	5,493	9,886	13,295	7,259	14,973	13,617	19,045	13,295
Age	36.1	36.3	36.5	42.7	35.9	38.3	38.1	31.7
Average HH size	2.08	2.21	2.46	1.79	2.66	2.48	2.51	2.57
Percent HHs w/kids	19.3	20.3	32.9	12.4	35.3	35.4	34.2	41.7
Percent home owners	34.3	31.2	58.8	34.3	53.2	63.5	61.4	55.2
Median HH income ($k)	74.3	40.2	42.5	43.8	88.4	49.6	40.2	46.2

Notes: SR = Santa Rosa, MD = Modesto, SC = Sacramento, HH = household

3.1 Travel Behavior

The survey included several measures of travel behavior. Respondents were asked to record how many miles they drive in a typical week and to indicate their approximate frequencies of driving and taking transit to selected destinations in a typical month with good weather. In addition, respondents were asked to report the number of times they walked to the store, and the number of times they strolled around the neighborhood in the last 30 days.

3.2 Neighborhood Characteristics and Neighborhood Preferences

Respondents were asked to indicate how true 34 characteristics were for their current and previous (only for movers) neighborhoods, on a four-point scale from “not at all true” (1) to “entirely true” (4). The characteristics of these neighborhoods as perceived by survey respondents reflect fundamental differences in neighborhood design. The importance of these items to respondents when/if they were looking for a new place to live was also measured on a four-point scale from “not at all important” (1) to “extremely important” (4). We conducted a factor analysis to identify the underlying constructs of perceived and preferred neighborhood characteristics. Ultimately, these items were reduced to six factors: accessibility, physical activity options, safety, socializing, attractiveness, and outdoor spaciousness (Table 2).

Table 2 Key Variables Loading on the Neighborhood Characteristic and Travel Attitude Factors

Factor	Statement
Perceived and Preferred Neighborhood Characteristics	
Accessibility	Easy access to a regional shopping mall (0.854); easy access to downtown (0.830); other amenities such as a pool or a community center available nearby (0.667); shopping areas within walking distance (0.652); easy access to the freeway (0.528); good public transit service (bus or rail) (0.437)
Physical activity options	Good bicycle routes beyond the neighborhood (0.882); sidewalks throughout the neighborhood (0.707); parks and open spaces nearby (0.637); good public transit service (bus or rail) (0.353)
Safety	Quiet neighborhood (0.780); low crime rate within neighborhood (0.759); low level of car traffic on neighborhood streets (0.752); safe neighborhood for walking (0.741); safe neighborhood for kids to play outdoors (0.634); good street lighting (0.751)
Socializing	Diverse neighbors in terms of ethnicity, race, and age (0.789); lots of people out and about within the neighborhood (0.785); lots of interaction among neighbors (0.614); economic level of neighbors similar to my level (0.476)
Attractiveness	Attractive appearance of neighborhood (0.780); high level of upkeep in neighborhood (0.723); variety in housing styles (0.680); big street trees (0.451)
Outdoor spaciousness	Large back yards (0.876); large front yards (0.858); lots of off-street parking (garages or driveways) (0.562); big street trees (0.404)
Travel Attitudes	
Pro-bike/walk	I like riding a bike (0.880); I prefer to bike rather than drive whenever possible (0.865); biking can sometimes be easier for me than driving (0.818); I prefer to walk rather than drive whenever possible (0.461); I like walking (0.400); walking can sometimes be easier for me than driving (0.339)
Pro-transit	I like taking transit (0.778); I prefer to take transit rather than drive whenever possible (0.771); public transit can sometimes be easier for me than driving (0.757); I like walking (0.363); walking can sometimes be easier for me than driving (0.344); traveling by car is safer overall than riding a bicycle (0.338)
Safety of car	Traveling by car is safer overall than riding a bicycle (0.489); traveling by car is safer overall than walking (0.753); traveling by car is safer overall than taking transit (0.633); the region needs to build more highways to reduce traffic congestion (0.444); the price of gasoline affects the choices I make about my daily travel (0.357)
Car dependent	I need a car to do many of the things I like to do (0.612); getting to work without a car is a hassle (0.524); we could manage pretty well with one fewer car than we have (or with no car) (-0.418); traveling by car is safer overall than riding a bicycle (0.402); I like driving (0.356)

Note: The numbers in parentheses are the pattern matrix loadings for the obliquely rotated factors.
Source: Handy et al. (2004).

Following the survey, objective measures of accessibility were estimated for each respondent, based on distance along the street network from home to a variety of destinations classified as institutional (bank, church, library, and post office), maintenance (grocery store and pharmacy), eating-out (bakery, pizza, ice cream, and take-out), and leisure (health club, bookstore, bar, theater, and video rental). Commercial establishments were identified using online yellow pages, and ArcGIS was used to calculate network distances between addresses for survey respondents and commercial establishments. Accessibility measures included the number of different types of businesses within specified distances, the distance to the nearest establishment of each type, and the number of establishments of each business type within specified distances.

3.3 Travel Attitudes

To measure attitudes regarding travel, the survey asked respondents whether they agreed or disagreed with a series of 32 statements on a five-point scale from “strongly disagree” (1) to “strongly agree” (5). Factor analysis was then used to extract the fundamental dimensions spanned by these 32 items. As shown in Table 2, six underlying dimensions were identified: pro-bike/walk, pro-transit, car dependent, safety of car, pro-travel, and travel minimizing (the latter two are not presented here since they are not significant in the analyses).

3.4 Socio-demographics

Finally, the survey contained a list of socio-demographic variables. These variables include gender, age, employment status, educational background, household income, household size, the number of children in the household, mobility constraints, residential tenure, and so on.

4. RESULTS

Comparative and multivariate analyses are presented in this section. First, t-tests were used to show the differences in travel and residential choices of the older and younger individuals. Second, we applied t-tests to compare the travel and residential choices of seniors in traditional and suburban neighborhoods. Finally, four multivariate models were developed to explore how the built environment influences travel behaviors (driving, transit, walking to the store, and strolling, respectively) of the younger and older groups differently.

4.1 Comparison of Travel and Residential Choices by Age Category

As stated in Section 2, previous research has shown that age has an important influence on individuals' travel behavior. Our findings also support this influence (Table 3): the elderly in both traditional and suburban neighborhoods drive less than the younger. However, the difference is greater for those in traditional neighborhoods (76 vehicle-miles/week) than for those in suburbia (59 vehicle-miles/week), suggesting (if all else is equal) that the built environment in the former type of neighborhood is more conducive to reductions in driving on the part of the elderly. Similar patterns hold with respect to driving frequency to restaurants and exercise places. On the other hand, the seniors in both neighborhood types drive more frequently to church/civic and service destinations than do their younger counterparts. Further, older people take transit to shops, church/civic and service destinations more frequently than do the younger (the latter two differences are significant at the 0.1 level), especially for individuals in traditional neighborhoods. For walking trips, older individuals stroll around the neighborhood more frequently than the younger group, especially for suburban residents; by contrast, younger people walk to the store more often than do seniors, especially for residents in traditional neighborhoods.

Table 3 Travel Behavior and Residential Preference Factor Score Means by Neighborhood Type and Age (t-tests)[a]

	Neighborhood		Age		Interaction				N
	S[b]	T	Y	E	Y&S	Y&T	E&S	E&T	
Sample Size [c]	756	883	1388	251	620	768	136	115	1639
%	46.1	53.9	84.7	15.3	37.8	46.9	8.3	7.0	100
Travel Behavior									
Weekly vehicle miles driven	**176.8**[d]	**148.9**	**170.9**	**107.7**	187.1	157.9	**128.2**	**81.7**	1554
Monthly strolling frequency	**7.70**	**9.84**	**8.51**	**10.80**	6.87	9.83	11.57	9.86	1623
Monthly walking to store frequency	**1.86**	**4.82**	**3.63**	**2.45**	1.86	5.06	*1.86*	*3.15*	1625
Frequency of driving to [from "never" (1) to "two or more times per week" (6)]									
Church/civic	**3.18**	**2.72**	**2.79**	**3.76**	3.05	2.57	3.81	3.72	1605
Service	3.72	3.61	**3.61**	**3.97**	3.67	3.56	3.99	3.94	1612
Restaurant	*4.28*[e]	*4.44*	**4.42**	**4.08**	4.32	4.49	4.11	4.04	1618
Shop	4.87	4.88	4.87	4.96	4.86	4.87	4.94	4.98	1605
Exercise place	3.10	3.19	**3.23**	**2.69**	3.17	3.28	2.80	2.56	1603
No particular destination	2.69	2.79	2.74	2.79	2.69	2.78	2.71	2.88	1595
Frequency of taking transit to [from "never" (1) to "two or more times per week" (6)]									
Church/civic	1.09	1.13	*1.10*	*1.19*	1.09	1.10	**1.08**	**1.32**	1614
Service	1.11	1.13	*1.11*	*1.19*	1.11	1.11	**1.11**	**1.29**	1613
Restaurant	1.11	1.15	1.12	1.20	1.10	1.13	1.15	1.25	1607
Shop	1.15	1.20	**1.16**	**1.29**	1.13	1.18	1.25	1.35	1609
Exercise place	1.07	1.08	1.07	1.08	1.07	1.08	1.07	1.09	1608
No particular destination	1.08	1.12	1.10	1.12	1.08	1.11	1.08	1.17	1604
Number of cars	**1.79**	**1.64**	**1.76**	**1.40**	1.87	1.67	1.39	1.42	1639
Residential Preference Factor Scores									
Accessibility	-0.04	0.03	**-0.05**	**0.25**	-0.08	-0.02	0.17	0.35	1624
Physical activity options	-0.02	0.01	-0.01	0.02	-0.01	-0.01	-0.08	0.13	1624
Safety	**0.25**	**-0.22**	**-0.06**	**0.31**	0.22	-0.27	**0.41**	**0.18**	1624
Socializing	*-0.05*	*0.04*	**-0.03**	**0.15**	-0.08	0.02	0.09	0.21	1624
Outdoor spaciousness	**0.06**	**-0.06**	*0.01*	*-0.10*	0.11	-0.06	-0.18	-0.02	1624
Attractiveness	**-0.06**	**0.04**	**-0.03**	**0.16**	-0.08	0.01	**0.04**	**0.29**	1624

Notes: [a] We also used two-way ANOVA to identify the main effects and interaction effects of age group and neighborhood type. However, our data are not balanced in terms of these two variables. For an unbalanced design, a two-way ANOVA is most appropriately represented as a linear regression with a constant term, two dummy variables (one for age and one for neighborhood type), and their interaction (product). However, the interpretation of such a model is somewhat tedious. For example, finding the age variable to be significant does not necessarily mean a significant main effect for age, since the other variable and the interaction term are simultaneously being controlled for; rather, it simply shows that the mean when age = 1 and neighborhood type = 0 is significantly different from the mean when both variables are 0. To more straightforwardly display and analyze the means by each group of interest, therefore, we chose here to present t-tests instead.

[b] S = suburban neighborhood, T = Traditional neighborhood, Y = the younger, E = the elderly. All interaction means are presented to allow for informal comparisons, but statistical tests with respect to the interactions are performed only on the difference between the elderly in suburban and traditional neighborhoods.

[c] For full sample; sizes will differ somewhat by variable due to missing data on that variable.

[d] For bolded entries, the difference between group means is significant at the 0.05 level.

[e] For italicized entries, the difference between group means is significant at the 0.1 level.

In addition to age, those observed differences are probably partly due to the lower auto ownership of the elderly (Table 3). Further, an unbalanced distribution of mobility constraints (such as physical or psychological limitations on driving and walking) between older and younger respondents may help explain their differences in driving and walking behavior. In particular (not shown in table), 7.4% of older respondents had driving limitations, compared to only 1.2% of younger respondents; 12.7% of older respondents had limitations on walking, compared to 3.1% of younger respondents. Differences in residential preferences are also notable (Table 3). Generally, the residential preferences of older people are consistent with their travel patterns – i.e., favoring lower levels of car use. Specifically, average scores are significantly different between older and younger respondents for five of the six factors. Interestingly, there is no age-based difference in the preference for physical activity options in the neighborhood. Older respondents give higher preference scores on average to accessibility, safety, socializing, and attractiveness; whereas, younger respondents give higher scores on average to outdoor spaciousness (difference significant at the 0.1 level). It is worth noting that the age-related difference in preferred outdoor spaciousness mainly comes from the distinction in preferences of residents in suburban neighborhoods: the suburban elderly have a far lower preference for outdoor spaciousness than does the suburban younger group. A possible interpretation is that the outdoor spaciousness of suburban dwelling was important to those seniors when they were younger, but that they have continued to live in such an environment after the need for it (e.g., for raising children) has passed. This result is consistent with the trend that the elderly show interest in densely located homes (Myers and Gearin, 2001).

To further compare the neighborhood preferences and perceptions of the elderly and the younger, we examined some specific neighborhood attributes relating to transportation systems and land use patterns (Table 4). Compared to the younger ones, on average, older respondents are more likely to prefer a neighborhood with complete sidewalks, close shopping areas, and other amenities such as a pool nearby, but they are less likely to perceive that they live in a neighborhood with such attributes. Although there are no significant differences in preferences for easy access to the freeway and downtown between the older and younger respondents, the former perceive these two attributes to be less true of their current neighborhood than do the latter. Further, the elderly prefer easy access to a regional shopping mall and public transit more than do younger respondents, although their perceptions of these two attributes being true of their current neighborhood do not significantly differ from those of the younger. Among the neighborhood attributes examined, a good bicycle route is the only one for which younger respondents have a stronger preference, a natural result of the difference in physical limitations between the older and the younger.

Overall, compared to younger people, the elderly have stronger preferences for most neighborhood attributes, especially ones that make it easier to drive less. However, the elderly are less likely to live in a place that meets their desires regarding land use patterns and transportation systems. On the one hand, this may suggest that the elderly have a different perspective on neighborhood characteristics than do younger people. In other words, given the same neighborhood traits, older people may be more likely to give lower perceptions because of their physical and psychological constraints. On the other hand, this pattern may indicate that the design of neighborhoods in which older people reside does not meet their preferences.

Table 4 Neighborhood Preference and Perception Means by Neighborhood Type and Age (t-tests)

	Neighborhood		Age		Interaction				N
	S[a]	T	Y	E	Y&S	Y&T	E&S	E&T	
Preferences									
Sidewalks throughout the neighborhood	3.08	3.01	**3.01**[b]	**3.25**	3.05	2.97	3.19	3.32	1625
Good bicycle routes beyond the neighborhood	**2.53**	**2.65**	**2.62**	**2.40**	2.58	2.66	*2.28*	*2.54*	1622
Easy access to the freeway	**2.95**	**2.73**	2.84	2.83	2.99	2.71	2.79	2.88	1627
Good public transit service (bus or rail)	**2.36**	**2.48**	**2.35**	**2.86**	2.28	2.41	2.76	2.98	1622
Parks and open spaces nearby	3.05	3.07	3.07	3.02	3.07	3.06	2.95	3.11	1627
Shopping areas within walking distance	**2.57**	**2.81**	**2.68**	**2.83**	2.54	2.79	*2.72*	*2.96*	1626
Other amenities such as a pool or a community center available nearby	2.19	2.15	**2.15**	**2.30**	2.18	2.12	2.26	2.34	1618
Easy access to a regional shopping mall	**2.46**	**2.21**	**2.26**	**2.71**	2.42	2.13	2.68	2.74	1625
Easy access to downtown	**2.50**	**2.93**	2.73	2.77	2.47[c]	2.94	**2.66**	**2.90**	1619
Perceptions									
Sidewalks throughout the neighborhood	3.59	3.57	**3.60**	**3.46**	3.60	3.61	*3.56*	*3.34*	1619
Good bicycle routes beyond the neighborhood	3.09	3.13	3.11	3.13	3.09	3.13	3.11	3.16	1499
Easy access to the freeway	**3.33**	**3.49**	**3.44**	**3.26**	3.36	3.50	*3.16*	*3.39*	1618
Good public transit service (bus or rail)	**2.95**	**3.23**	3.10	3.15	2.92	3.23	3.06	3.25	1436
Parks and open spaces nearby	3.46	3.49	3.47	3.48	3.45	3.49	3.50	3.45	1619
Shopping areas within walking distance	**3.09**	**3.24**	**3.20**	**3.01**	3.11	3.27	2.98	3.05	1619
Other amenities such as a pool or a community center available nearby	**2.72**	**2.89**	**2.84**	**2.64**	2.73	2.93	2.69	2.59	1544
Easy access to a regional shopping mall	3.08	3.04	3.07	3.00	3.09	3.05	3.01	2.98	1612
Easy access to downtown	**3.01**	**3.70**	**3.42**	**3.18**	3.03	3.73	**2.92**	**3.49**	1616

Notes: Responses fell on a four-point scale, with 1 being least important (preferences) or true (perceptions) and 4 being most important/true.

[a] S = suburban neighborhood, T = Traditional neighborhood, Y = the younger, E = the elderly.

[b] For bolded entries, the difference between group means is significant at the 0.05 level.

[c] For italicized entries, the difference between group means is significant at the 0.1 level.

4.2 Comparison of Travel and Residential Choices of the Elderly, by Neighborhood Type

The type of neighborhood in which older respondents live also shows a strong correlation with their travel behavior. The elderly in traditional neighborhoods reported an average of 81.7 miles of driving, versus 128.2 miles for older respondents in suburban neighborhoods (Table 3); that is, older suburbanites drive more than 50% longer distances on average. However, the mean auto trip frequencies are similar for the elderly in both types of neighborhoods. These results suggest that the spatially-segregated land use patterns of suburban neighborhoods increase trip lengths and hence lead to extra distances driven by older suburbanites. By contrast, the elderly in traditional neighborhoods on average use alternative modes more. These findings are not surprising since these older people are more likely to favor alternative modes, and are less likely to think themselves car dependent, than are their suburban counterparts (data not shown). On the other hand, the elderly in traditional and suburban neighborhoods show fewer differences in residential preferences and perceptions (Table 4) than we saw between older and younger respondents. The elderly in traditional neighborhoods were more likely than their suburban counterparts to prefer access to downtown and give a higher score on its perception – natural results. The former also tend to prefer shopping areas within walking distance as well as bicycle routes, despite there being no differences in their perceptions. Further, older suburbanites tend to give a higher score on the perception of complete sidewalks but a lower score on perceived access to the freeway.

4.3 Multivariate Analyses of Travel Behavior

Neighborhood type is a coarse measure of the built environment. To explore influential elements of the built environment and to test how they impact the travel behavior of the elderly in a way distinct from that of the younger residents, multivariate analyses incorporating various measurements of the built environment are in order. It is also important to control for socio-demographic and other variables, since some of the differences observed in the previous subsections may be due to differences in those variables by age category, rather than age itself. For example, the elderly have lower incomes on average, which contributes to mobility declines. We developed linear regression models for weekly vehicle-miles driven and transit trip frequency since the former is a continuous variable, and the latter can be treated as a continuous variable. Because the frequencies of walking to the store and strolling constitute count data with overdispersion, we estimated negative binomial regression models for them (Greene, 2002). When developing these models, we first created two dummy variables marking the elderly and the younger, respectively, and then interacted them with each potential explanatory variable (including the constant term). If both interaction terms for a given variable were significant in the model, a formal statistical test was conducted to ensure that the parameter estimates of the two variables were significantly different; otherwise, they were constrained to be equal. Specifically, an F-test was applied to the linear regression models, and a likelihood ratio test was used for the negative binomial models. Note that age-specific constants were not statistically different in all the models presented below.

4.3.1 Weekly Vehicle Miles Driven (VMD)

First, age plays an important role in driving behavior through its interactions with other variables (Table 5). For the elderly, those having limitations on driving tend to drive less (naturally enough), but those who are affluent tend to drive longer distances in a week. For the younger group, workers and those having children in the household tend to drive more; whereas, these factors are unimportant to the older group. The younger respondents, who value the safe nature of cars and who highly rate access to freeways, are likely to drive more, while those who think sidewalks are important tend to drive less.

Table 5 Regression Model for Ln (VMD+1)[a]

Variables	Elderly		Younger	
	Coefficient	p-value	Coefficient	p-value
Constant	2.243	0.000	2.243	0.000
Socio-demographics				
Limitations on driving	-1.739	0.000		
Children (<18) in the household			0.137	0.027
# cars per driving-age household member	0.284	0.000	0.284	0.000
Income ($k)	0.00432	0.017		
Worker			0.367	0.000
Female	-0.209	0.000	-0.209	0.000
Driver's license	1.850	0.000	1.850	0.000
Travel Attitudes				
Safety of car			0.0561	0.049
Car dependent	0.291	0.000	0.291	0.000
Neighborhood preferences				
Shopping areas within walking distance	-0.0822	0.004	-0.0822	0.004
Easy access to the freeway			0.200	0.000
Sidewalks throughout the neighborhood			-0.0685	0.026
Neighborhood characteristics				
Socializing			-0.0692	0.044
# maintenance businesses within 400m	-0.0831	0.004	-0.0831	0.004
N	174		1236	
R-square	0.268			
Adj. R-square	0.261			

[a] The weekly vehicle-miles driven variable was log-transformed to bring its distribution closer to normality. One mile was added to each total beforehand to prevent taking the log of zero, which is negative infinity.

Further, some variables influence the driving behavior of both older and younger respondents at the same magnitudes. Car ownership and driver's license possession are positively associated with VMD for both groups, while women in both groups have a tendency to drive less. Individuals who think themselves car dependent tend to drive more, but those who prefer shopping areas within walking distance tend to drive less. The number of maintenance establishments within 400 meters from the residence negatively influences the VMD of both older and younger people alike. In this aspect, although traditional neighborhood design tends to reduce driving, we did not find an extra effect on seniors' driving behavior. By contrast, younger people who perceive their neighborhood to have a higher socializing environment have a tendency to drive less, while the behavior of older individuals is not influenced by this variable.

4.3.2 Transit Trip Frequency

The model for transit trip frequency also shows significant differences for older and younger individuals (Table 6). The elderly who own fewer vehicles tend to use transit more often, but auto ownership does not have a significant influence on transit-taking behavior of the younger. On the other hand, younger individuals having limitations on driving on the freeway use transit more often, whereas this condition does not influence seniors' behavior. The younger who think themselves car dependent tend to use transit less often, but those who consider good transit service important tend to use it more often (note that causality could work in both directions in these cases). We also found that two neighborhood characteristics are positively associated with the transit-taking frequency of the elderly. In particular, the significance of the good public transit service perception suggests that providing a high level of public transit service in the neighborhood may enhance the mobility of older people.

Table 6 Regression Model for Transit Trip Frequency[a]

Variables	Elderly		Younger	
	Coefficient	p-value	Coefficient	p-value
Constant	4.839	0.000	4.839	0.000
Socio-demographics				
# cars per driving-age household member	-0.504	0.010		
Renter	0.295	0.097	0.295	0.097
Driver's license	-4.196	0.000	-4.196	0.000
Limitations on freeway driving			3.022	0.000
Travel Attitudes				
Pro-bike/walk	0.532	0.031	-0.269	0.004
Car dependent			-0.223	0.016
Pro-transit	0.312	0.001	0.312	0.001
Neighborhood preferences				
Good public transit service			0.265	0.004
Living on cul-de-sac	-0.154	0.057	-0.154	0.057
Neighborhood characteristics				
Good public transit service	0.239	0.034		
# maintenance businesses within 400m	1.030	0.001		
N	167		1112	
R-square	0.152			
Adj. R-square	0.144			

[a] As presented in Table 3, transit frequency for each of the six purposes was measured on a six-point ordinal scale. The frequency used here is a summation of the scales for the six purposes, which ranges from 6 to 36.

Interestingly, the pro-bike/walk attitude is associated with transit trip frequencies of older and younger individuals in opposite ways: positively for the elderly and negatively for the younger. In a previous study of the sample as a whole, we found that a pro-bike/walk attitude tends to reduce transit trip frequency (Cao et al., 2005). The finding here shows that the previous result is not true for the elderly: seniors who like biking/walking may also treat transit as a viable mode. On the other hand, some variables influence transit-taking behavior of older and younger people in the same way. Individuals without a driver's license and renters tend to take transit more often. Individuals who like transit have a tendency to use it more often, while those who prefer living on a cul-de-sac tend to use it less often.

4.3.3 Monthly Walking to the Store Frequency

Many variables equally affect the frequencies of walking to the store for older and younger individuals (Table 7). As expected, driver's license, age, a safety of car attitude, and a preference for neighborhood safety are negatively associated with walking to the store frequency, while a pro-bike/walk attitude, a preference for physical activity options, and a preference for and perception of shopping areas within walking distance have positive associations with walking frequency.

Table 7 Negative Binomial Regression for Walking to the Store Frequency

Variables	**Elderly**		**Younger**	
	Coefficient	p-value	Coefficient	p-value
Constant	0.742	0.029	0.742	0.029
Socio-demographics				
Driver's license	-0.629	0.013	-0.629	0.013
Age	-0.00854	0.004	-0.00854	0.004
Limitations on walking	-0.895	0.008		
Income ($k)	0.00871	0.002		
Worker			-0.294	0.006
Travel Attitudes				
Pro-bike/walk	0.326	0.000	0.326	0.000
Safety of car	-0.119	0.002	-0.119	0.002
Pro-transit			0.233	0.000
Neighborhood preferences				
Living on cul-de-sacs			-0.0853	0.023
Shopping areas within walking distance	0.166	0.000	0.166	0.000
Safety	-0.117	0.007	-0.117	0.007
Physical activity options	0.113	0.005	0.113	0.005
Accessibility	0.209	0.076		
Neighborhood characteristics				
Shopping areas within walking distance	0.290	0.000	0.290	0.000
Safety	-0.327	0.000		
# business types within 800m			0.0460	0.001
# maintenance businesses within 800m			0.03869	0.090
Distance to the closest grocery store (km)	-0.604	0.000	-0.129	0.025
N	182		1290	
Dispersion parameter	1.188	0.000		
Deviance R-square	0.326			

The model results also show some significant differences between older and younger individuals. First, the elderly having walking constraints walk to the store less often; affluent older individuals have a tendency to walk more often; and the younger people who are working tend to walk less often. With respect to attitudes, the younger people who like transit tend to walk to the store more often, while those valuing cul-de-sacs tend to do so less often; older individuals who prefer living in a high-accessible area have a tendency to walk more often. After controlling for all these factors, a few neighborhood characteristics are significant in the model. The distance to the nearest grocery store negatively influences walking frequencies of both the elderly and the younger. However, the magnitudes of those effects are different. In particular (from an overall average of 2.43 utilitarian walking trips per month), a 400-meter (quarter-mile) increase in the distance reduces walking frequency by about 0.90 trips per month for an older individual whose characteristics are taken at the overall sample mean, but (from a higher average of 3.63 trips per month) only reduces walking frequency by about 0.20 trips per month for a younger individual whose characteristics are also taken at the overall sample mean. Therefore, this accessibility plays a much more important role in influencing the walking behavior of older people although they walk less than the younger group. Further, the elderly who perceive a safe neighborhood (probably acting as a proxy for suburban neighborhood) walk to the store less often, whereas younger people living in high-accessible areas (more businesses and more business types) tend to walk more often.

4.3.4 Strolling Frequency

As shown in Table 8, income and the pro-bike/walk attitude are positively associated with strolling frequency, while workers tend to stroll less often. Women tend to stroll more often. It is interesting that older women do so even *more* often than younger women. As presented above, people walk to the store less often as they age. However, they tend to stroll more often. This finding is consistent with a study of Cao et al. (2006) using a different data set. In addition, age plays an important role in influencing strolling behavior through its interactions with other variables. The elderly who have limitations on walking tend (not surprisingly) to stroll less often. For younger people, one additional travel attitude (pro-transit) and three neighborhood preferences (accessibility, socializing, and physical activity options) have associations with strolling frequency, generally in expected ways. The negative association with accessibility preference may at first be surprising, but it may be that those who value accessibility are more destination-oriented and less inclined to walk just for exercise.

After accounting for the influences of socio-demographic and attitudinal factors, we found that four neighborhood characteristics are associated with strolling frequency. However, the frequencies of strolling for older and younger individuals are influenced by different dimensions of the residential neighborhood. For the younger, the social and aesthetic qualities of the environment are positively associated with their strolling behavior; the number of leisure businesses within a mile of the residence has a positive association with strolling frequency. For the elderly, having shopping areas within walking distance encourages strolling. The last two findings suggest that although a destination is secondary in strolling trips (and notwithstanding the negative association with accessibility *preferences* for the younger), potential destinations do contribute to generating strolling trips.

Table 8 Negative Binomial Regression for Strolling Frequency

Variables	**Elderly**		**Younger**	
	Coefficient	p-value	Coefficient	p-value
Constant	1.588	0.000	1.588	0.000
Socio-demographics				
Age	0.00647	0.023	0.00647	0.023
Limitations on walking	-1.319	0.000		
Worker	-0.498	0.000	-0.498	0.000
Female	0.339	0.066	0.222	0.001
Income ($k)	0.00355	0.000	0.00355	0.000
Travel Attitudes				
Pro-bike/walk	0.218	0.000	0.218	0.000
Pro-transit			0.135	0.000
Neighborhood preferences				
Accessibility			-0.146	0.001
Socializing			0.0744	0.065
Physical activity options			0.106	0.007
Neighborhood characteristics				
Shopping areas within walking distance	0.0811	0.085		
Socializing			0.140	0.001
Attractiveness			0.0846	0.015
# leisure businesses within 1600m			0.0129	0.001
N	181		1282	
Dispersion parameter	1.198	0.000		
Deviance R-square	0.127			

5. CONCLUSIONS

Altering land use patterns to make it possible to drive less appears to be a potentially useful policy to reduce driving while sustaining accessibility. However, little attention has been paid to the implications of this policy for older people, who often face physical and/or financial limitations on driving. This study compares the residential preferences and choices of older and younger people, and the influence of those factors on their travel behavior.

With respect to residential choice, the results showed that the elderly have stronger preferences for driving-reducing neighborhood characteristics, but they are less likely than younger people to live in a place that meets their preferences. The underlying reason is not clear, however, and merits further investigation. Moreover, older people are not a homogeneous group. The t-tests showed that older residents of traditional and suburban neighborhoods have distinct travel attitudes, with suburbanites favoring driving. For the elderly, travel attitudes are important determinants of their residential and travel choices. These findings lend some credibility to the argument that older people self-select their residential neighborhoods to meet their travel preferences.

Consistent with previous studies, older people generally drive less and use alternative modes more than younger people. The elderly in traditional neighborhoods also drive less and take alternative modes more than their suburban counterparts. Further, the multivariate analyses showed that these differences are reasonably well explained by individuals' residential preferences, travel attitudes, and socio-demographic characteristics. After accounting for these influences, various elements of neighborhood design have associations with travel behavior, especially walking. Overall, neighborhood accessibility significantly and negatively influences the driving distance of individuals, whether they are older or younger. Compared to the effect of socio-demographic characteristics, however, this influence is rather small. The model results also showed that the elderly who perceive good public transit service in their neighborhood tend to use it more often. However, transit is not likely to be a preferred mode for the seniors having cars and a driver's license. On the other hand, enhancing accessibility seems to be a promising strategy for promoting walking trips for both utilitarian and recreational purposes. In particular, if residents are closer to grocery stores (i.e. the distance to the closest grocery store becomes shorter), they tend to walk to stores more often. More importantly, this enhanced accessibility tends to have a much larger effect on the elderly than on the younger.

According to these results, it seems that neighborhood design offers more benefits from the standpoint of health and quality of life than from the standpoint of the environment. Although the car is the dominant mode for seniors, walking becomes an attractive alternative mode with advancing age, especially for those 85 and over (Rosenbloom, 2004). Further, an examination of the models presented here shows that auto ownership, driver's license possession, and physical limitations of the elderly have a pervasive and consistently important influence on their travel behavior. Seniors who have limitations on driving or do not have cars and a driver's license count on transit and walking to travel independently. In particular, they take transit about 10 times per month more often (3.96 vs. 0.39) than seniors without such constraints, and the former walk to the store more frequently than the latter although this difference is statistically insignificant.

According to the US Census Bureau, the number of elderly is projected to reach 70 million (20% of the population) in 2030, as a result of the increase in lifespan and baby boomers aging. Although some of the elderly will continue to drive, most will have to cease driving at some point. More importantly, the elderly of 20 years from now are already accustomed to an auto-oriented lifestyle and have little experience with alternative modes (Rosenbloom, 2001). If auto-oriented development patterns continue, more and more

seniors will experience a decline in mobility by necessity rather than choice. To promote mobility and preserve accessibility for the elderly (as well as other transportation-disadvantaged people), both land use policies and investments in transit and pedestrian infrastructure are important. To support aging-in-place, zoning changes and tax exemptions can be used to bring local stores and services back to residential neighborhoods. Pedestrian-friendly neighborhood design can provide the elderly a safe, comfortable, and convenient environment in which to walk to local businesses. In addition, providing or expanding transit service in residential neighborhoods (as well as improving its comfort and ease of use) will allow some senior residents to use public transportation to reach more distant destinations. To provide for those wanting to move, incentives can be offered to motivate developers to build affordable senior housing close to public transit stops and major destinations, as is the case for downtown Pasadena, California, and activity corridors in Irvine, California (Giuliano, 2004). Neighborhood design on its own cannot ensure continued accessibility for the elderly as their ability to drive declines, but it is an important element of a comprehensive strategy for meeting this goal.

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