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Healthy Aging and Where You Live: Community Design Relationships With Physical Activity and Body Weight in Older Americans

Lawrence Frank, Jacqueline Kerr, Dori Rosenberg, and Abby King

Background: Suburban development patterns may impede physical activity (PA) and mobility and affect healthy aging. This paper investigates the relationships between neighborhood design and walking, driving, PA, and obesity in adults over age 65 years. ***Methods:*** Data from the SMARTRAQ (Atlanta region) survey provided measures of PA, BMI, SES, and travel patterns. Neighborhood design was measured using a walkability index (residential density, street connectivity, retail density, and land use mix). Chi square and regression was used to evaluate relationships. ***Results:*** Increased walkability was related with more walking (OR 2.02), less time spent traveling in a car (OR .53), and lower odds of being overweight (OR .68). Those with 1 or no cars were more likely to walk (OR 2.9) and spend less time in cars (OR .53); but also less likely to get recommended levels of PA (OR .55). Visiting a fast food outlet was associated with increased odds of obesity (OR 1.81). ***Conclusions:*** Policies are needed to bring older Americans closer to shops and services and healthy food outlets as a means of encouraging regular walking and healthy body weight. Incentives to encourage neighborhood grocery stores and affordable housing in central areas along with regulatory reform through zoning can encourage PA and healthy body weight in the elderly.

Keywords: built environment, suburban sprawl, elderly, aging

An aging population is a major demographic trend that will shape the U.S. in the 21st century. The first baby boomers begin to turn 65 in 2011, ushering in an era of rapid growth in the elderly population.[1] Between 2012 and 2025 alone, the population of those over age 65 is set to double.[2] This trend has major implications on urban planning and development. The majority of the country's population currently lives in suburbs[2] where housing is separated from destinations and with few provisions for walking and public transport.[3] Studies indicate that the design of the suburban built environment encourages car dependence[4] and that older adults are spending more time driving than ever before.[5] As driving becomes more difficult, elderly located in sprawling suburbs will have limited access to social services, medical care, and shopping. Providing access to services for elderly aging in sprawl is likely to be time consuming and expensive, with significant implications for local governments, transit providers, and other levels of government. Whether a family member, public agency, or caregiver is filling the transportation gap, having to depend on others to get around likely contributes to a sense of isolation and lack of self-esteem. Large numbers of older adults are afflicted by chronic disease related to obesity, including heart disease, hypertension, cancer, diabetes, COPD, and arthritis.[6] Another health burden is late-life depression;[7] in cross-sectional surveys, depression rates have been reported to increase from 13% between ages 65 to 74 to 19% for those above age 85.[6]

Research indicates that physical activity may help to address some of these challenges. Regular physical activity has a plethora of health benefits, including preventing and treating chronic conditions such as cardiovascular disease, stroke, hypertension, type 2 diabetes, osteoporosis, dementia, pain, some cancers constipation, chronic obstructive pulmonary disease, high cholesterol, high blood pressure, and obesity.[8] Physical activity helps keep healthy older adults living independently, is associated with recovery from functional limitations in older age, and reduces the risk of falls.[9] Physical activity also is associated with improved quality of life and reduced risk of many mental health conditions, including depression and anxiety, among older adults.[8,10] In 2005, however, only 45% of U.S. men and 36% of women over age 65 met national physical activity recommendations.[11] About 30% of men over age 70 are inactive while nearly 40%

Frank is with the Schools of Environmental Health and Community and Regional Planning, the University of British Columbia, Vancouver, British Columbia.Kerr is with the Dept of Psychology, Active Living Research, San Diego State University, San Diego, CA. Rosenberg is with the Dept of Clinical Psychology, San Diego State University, San Diego, CA. King is with the School of Medicine, Stanford University, Palo Alto, CA.

of women over age 70 are inactive.[12] Recent objective monitoring of physical activity levels found only 2.5% of U.S. adults over age 60 meet physical activity recommendations,[13] suggesting that self-reported rates of physical activity may be grossly inflated. For older adults, walking is the most commonly available means to obtain physical activity and meet physical activity guidelines. While research is limited, it is logical that older adults who drive less, likely prefer being able to walk for leisure, and to access destinations to accomplish daily activities on foot. Walkable environments where older Americans live can facilitate the ability to meet physical activity guidelines.

Because of the barriers to physical activity in all populations, researchers are investigating ways to engineer physical activity back into our daily lives. Changes to the design of communities and living spaces are essentially permanent and thus can have a long term impact and reach large groups of people. Several reviews of built environment characteristics that are associated with physical activity include studies on older adults.[14–16] The evidence suggests that streets with short block lengths, multiple route choices, and many destinations encourage walking for transportation. Presence of parks and recreation facilities, sidewalks, and pleasant landscaping were found to promote walking for leisure. Few studies have assessed the relationship between urban form and weight status in older adults[17–19] and few have evaluated sedentary behavior in older adults.[4,20]

Thus, a walkable built environment can potentially allow older adults to maintain some degree of independence and interaction with the broader community, as well as providing an opportunity for regular physical activity. This study aimed to assess the relationship between urban form and walking, driving, physical activity, food access, and weight status in a large sample of older adults responding to a travel survey. It provides direct policy implications on how community design relates with physical activity and healthy body weight for older Americans.

Methods

The analyses presented here used cross sectional travel survey data from the Atlanta based SMARTRAQ study conducted in 2001 to 2002. The current analyses focus on adults aged 65 years or older (n = 1970). Study design, sample, and data collection methods have been reported previously.[21,22] Travel survey participants recorded destinations visited, travel mode, trip purpose, and time of day for 2 consecutive days. Data were collected for each day of the week. In addition to the travel diary, participants provided information on household demographics, their height and weight, and their activity levels. General physical activity levels were self reported as part of the travel survey.

County level Tax Assessor's data, regional land use data, street network data, and census data were used to determine the urban form characteristics within a 1 kilometer street network distance from each participant's household. Measures of land use mix, residential density, and street connectivity were calculated within a 1 kilometer distance from each participant's home. These 3 urban form characteristics were used to calculate a walkability index as used in Frank et al.[22] For the current analyses, the walkability index for the whole sample was split into tertiles: low, medium and high.

Five different outcome variables were assessed. The dichotomous dependent variables "walked at least once over the last 2 days" vs. "did not record walking at all" and "traveled in a car at least 1 hour a day" vs. "did not travel in a car for more than 1 hour a day" were derived from the travel survey data. The walking variable is likely to represent walking for transportation and extended car travel reflects increased time spent sitting. Minutes of physical activity were categorized into "meeting the 150 minute per week moderate-vigorous physical activity public health guidelines" or not meeting the guidelines. BMI scores were also calculated; those with a BMI of 25 or above were coded as overweight or obese, and those with a score of 30 or above as obese.

Chi square analyses were first performed to investigate the univariate relationships between the independent and dependent variables. Then a multi level logistic regression model was conducted for each outcome. The following demographic variables were entered into each logistic regression model as the first step: age (65–74, 75–84, 85+ years (referent)), living alone (referent) vs. not, household income (<$50,000 (referent), $50 to 74,000, $75,000+), 1 car or less vs. 2 or more cars in the household (referent), ethnicity (white (referent) vs. non white), education (university degree vs. no degree (referent)) and gender (male (referent) vs. female). For all models the 3 category walkability variable (low (referent) vs. medium or high) was entered in step 2. For the weight status models (overweight vs. not and obese vs. not), step 3 adjusted for other behaviors related to energy expenditure: walking trip over the 2 day diary period vs. not (referent), less than 1 hour in car (referent) vs. 1 hour or more per day, and less than 150 minutes moderate-vigorous physical activity (referent) vs. 150 minutes or more per week. For the weight status models the final step included behaviors related to energy intake. In the travel diary participants indicated whether they visited a food location for purchasing or eating foods and the locations' name and address. From this information we derived whether a participant had visited a grocery store (considered a healthier food option) or a fast food restaurant (considered a less healthy option) over the 2-day travel diary period. For each of these food visit variables, "no visit" was considered the referent category.

Results

Table 1 shows the sample demographics. Almost two thirds of the sample were 65 to 74 years old, a quarter lived alone, over half had an annual household income

Table 1 Sample Demographics and Results of Univariate Analyses With Walking, Driving, and Physical Activity Outcomes

	N	Total %	% walk at least once in 2 days		% travel in car over an hour		% meet MVPA 150 min/week guidelines	
65–74 years old	1198	60.8	4.4	***	21.2	***	42.7	
75–84 years old	622	31.6	5.3		10.5		38.0	
85+ years	150	7.6	2.7		1.3		28.8	
Living alone	495	25.1	7.7		9.7	***	32.6	*
Living with others	1475	74.9	3.5		18.5		46.1	
<$50,000 income	1089	55.3	5.2		11.5	***	33.9	*
$50,000–74,000 income	578	29.3	4.7		20.4		49.6	
75,000+ income	303	15.4	2.0		25.7		53.9	
0–1 car	761	38.6	7.8	***	8.8	***	30.6	*
2+ cars	1209	61.4	2.6		21.0		50.0	
Non white	467	23.8	6.6	*	9.2	***	31.4	*
White	1496	76.2	3.9		18.5		43.4	
No degree	1205	62.4	3.9		13.2	***	33.3	*
Degree	726	37.6	5.8		22.2		51.4	
Male	861	43.7	4.2		22.0	***	49.1	*
Female	1109	56.3	4.9		11.9		34.6	
Low walkability	659	33.5	2.7	***	23.2	***	42.7	
Medium walkability	654	33.2	3.7		15.4		42.9	
High walkability	657	33.4	7.3		10.2		36.6	

* $P < .05$, ** $P < .01$, *** $P < .001$.

less than $50,000, the majority had 2 or more cars in the household, almost a quarter of the sample was not white, just over a third had a university degree and about 56% of the sample was female.

Univariate analyses indicated that age, number of cars, ethnicity, and walkability were significantly related to walking at least once during the 2-day diary period. Only 4% of the sample reported walking in this time. Table 2 shows the univariate relationships for weight status. Fifty seven percent of the sample was overweight and 20 percent were obese.

Table 3 shows results from logistical regression analyses on the odds of walking, time spent in cars, and meeting physical activity recommendations. In the multivariate model (Table 3), those with 1 or fewer cars were almost 3 times more likely to walk, those with a degree were almost twice as likely to walk, and those living in a highly walkable neighborhood were 2 times more likely to walk than those in a low-walkable neighborhood. For the outcome concerning traveling in a car more than an hour a day (17% of the sample), all of the demographic variables and walkability showed significant univariate associations. In the logistic regression model, the youngest group (65–74), and those with a higher household income and a degree were more likely to travel in a car for an hour a day. Those with 1 car or fewer, nonwhites, and women were significantly less likely to spend an hour a day in a car. Those living in neighborhoods with medium walkability were 35% less likely, and those in high-walkable neighborhoods were 47% less likely, to travel more than an hour a day by car.

Forty two percent of the sample reported meeting the 150-minute-per-week physical activity recommendations, which was related to all the demographic variables except age. However, in the multivariate model, only those with a car were significantly more likely to meet recommended activity levels. This was the case after adjusting for sociodemographic factors. Increased walkability was related with more walking (OR 2.02) and less time spent traveling in a car (OR .53). Those with 1 car or without

Table 2 Results of Univariate Analyses With Overweight and Obesity Outcomes

	% overweight (BMI 25+)		% obese (BMI 30+)	
65–74 years old	59.8	***	20.7	**
75–84 years old	51.9		16.5	
85+ years	42.7		8.9	
Living alone	57.6		22.9	**
Living with others	55.5		17.0	
<$50,000 income	55.2		20.0	
$50,000–74,000 income	57.9		17.6	
$75,000+ income	55.8		14.6	
0–1 car	54.4		21.1	*
2+ cars	57.0		16.9	
Non white	63.4		27.8	***
White	53.6		15.7	
No degree	58.3		21.4	***
Degree	52.3		13.2	
Male	64.3		18.5	
Female	49.3		18.5	
Low walkability	57.5		15.5	
Medium walkability	54.1		19.7	
High walkability	56.5		20.3	
No walking trip	56.4		18.7	
Walking trip	48.8		15.1	
<1hr in car	55.4		19.3	
1+ hr in car	59.3		14.5	
<150 min MVPA	62.5	*	24.7	***
150+ min MVPA	56.1		14.2	
No grocery store trip	56.0		18.8	
Grocery store trip	56.1		17.7	
No fast food trip	55.7		18.1	
Fast food trip	59.2		22.3	

* $P < .05$, ** $P < .01$, *** $P < .001$.

a car were more likely to walk (OR 2.9) and spend less time in cars (OR .53), but also less likely to achieve the total recommended levels of physical activity (OR .55). As would be expected, those 65–74 year olds were much more likely to spend an hour in a car per day (OR 13.90) than those 85 and older.

Table 4 reports on the odds of being overweight or obese. Increased walkability was related with lower odds of being overweight (OR .68). Residents of medium vs. low walkable neighborhoods were 32% less likely to be overweight, and those who walked were significantly less likely (OR.51) to be overweight. Women and those

Table 3 Results of Logistic Regression Analyses With Walking, Driving, and Physical Activity Outcomes

	Walked at least once in 2 days			Traveled in car over an hour/day			Met MVPA 150 min/ week guidelines		
	OR	CI		OR	CI		OR	CI	
Step 1									
65–74 years old	2.31	0.81–6.64		13.90	3.40–56.92	***	1.15	0.62–2.12	
75–84 years old	2.07	0.71–6.03		7.33	1.76–30.48	**	1.15	0.61–2.14	
85+ years	Ref			Ref			Ref		
Living alone	Ref			Ref			Ref		
Living with others	0.90	0.52–1.55		1.02	0.67–1.57		0.58	0.64–1.29	
<$50,000 income	Ref			Ref			Ref		
$50,000–74,000 income	1.31	0.77–2.25		1.35	1.00–1.83		1.29	0.94–1.77	
$75,000+ income	0.51	0.21–1.27		1.62	1.14–2.31	*	1.29	0.86–1.93	
0–1 car	2.9	1.64–2.94	***	0.63	0.43–0.93	*	0.55	0.39–0.78	***
2+ cars	Ref			Ref			Ref		
Non white	1.53	0.95–2.46		0.60	0.42–0.85	**	0.81	0.59–1.09	
White	Ref			Ref			Ref		
No degree	Ref			Ref			Ref		
Degree	1.85	1.16–2.94	**	1.32	1.01–1.72	*	1.67	1.28–2.19	
Male	Ref			Ref			Ref		
Female	0.99	0.62–1.58		0.64	0.49–0.63	***	0.78	0.60–1.02	
Step 2									
Low walkability	Ref			Ref			Ref		
Medium walkability	1.10	0.59–2.07		0.65	0.48–0.86	**	1.13	0.82–1.54	
High walkability	2.02	1.13–3.64	*	0.53	0.38–0.74	***	1.08	0.78–1.48	

* $P < .05$, ** $P < .01$, *** $P < .001$ in final model.

with a degree were less likely to be overweight. Younger participates were more likely to be categorized as obese, as were non-whites and those with no college degree. Those who met the physical activity guidelines were 45% less likely to be obese, but those who visited a fast food outlet at least once in the 2-day survey period were 1.8 times more likely to be obese.

Discussion

After adjusting for key demographic variables, neighborhood design was related to walking, time spent traveling in a car, and overweight status in this study of older Atlantans. Only those living in the highest tertile of neighborhood walkability were significantly more likely to walk than those in the least walkable environments. Studies in adults under age 65 years tend to show a more linear relationship between neighborhood design and walking, where smaller increases in walkability were shown to be associated with increased walking.[14] Our results suggest that only high levels of walkability, where destinations are close by, were associated with walking in this elderly population. Overall walking levels were low (4% in this sample), and are similar to other national travel survey studies.[5] This study indicates that walking levels could increase 2-fold if older adults had access to multiple destinations within short distances by living in a more walkable neighborhood as currently defined. Other studies in older adults also found that living in

Table 4 Logistic Regression Analyses With Overweight and Obesity Outcomes

	Overweight (BMI 25+)			Obese (BMI 30+)		
Step 1						
65–74 years old	1.88	1.04–3.39	*	6.64	2.01–21.91	***
75–84 years old	1.32	0.73–2.41		3.42	1.02–11.47	*
85+ years	Ref			Ref		
Living alone	Ref			Ref		
Living with others	0.90	0.63–1.28		0.72	0.47–1.10	
<$50,000 income	Ref			Ref		
$50,000–74,000 income	1.10	0.79–1.52		1.08	0.71–1.62	
$75,000+ income	1.04	0.68–1.52		0.95	0.55–1.65	
0–1 car	0.97	0.68–1.38		1.00	0.65–1.56	
2+ cars	Ref			Ref		
Non white	Ref			1.67	1.18–2.38	**
White	1.32	0.97–1.80		Ref		
No degree	Ref			Ref		
Degree	0.67	0.51–0.89	*	0.55	0.38–0.78	**
Male	Ref			Ref		
Female	0.61	0.46–0.81	***	0.94	0.67–1.31	
Step 2						
Low walkability	Ref			Ref		
Medium walkability	0.68	0.49–0.93	*	1.23	0.82–1.83	
High walkability	0.83	0.60–1.15		1.23	0.82–1.84	
Step 3						
No walking trip	Ref			Ref		
Walking trip	0.51	0.30–0.87	**	0.55	025–1.21	
<1hr in car	Ref			Ref		
1+ hr in car	0.86	0.51–1.22		0.67	0.41–1.06	
<150 min MVPA	Ref			Ref		
150+ min MVPA	0.78	0.59–1.02		0.58	0.41–0.82	***
Step 4						
No grocery store trip	Ref			Ref		
Grocery store trip	1.15	0.87–1.53		0.89	0.24–1.27	
No fast food trip	Ref			Ref		
Fast food trip	1.00	0.66–1.53		1.81	1.12–2.93	*

* $P < .05$, ** $P < .01$, *** $P < .001$ in final model.

pedestrian-friendly, walkable, urban neighborhoods with nearby shops and services is associated with increased levels of walking, as well as pedometer steps.[4,16–18,23,24]

Medium and high levels of walkability were inversely related to time spent traveling in a car. Time spent in a car is not only time spent sitting, but is also time away from other activities such as hobbies and physical activity that could promote better health. People living in less walkable neighborhoods are more reliant on a car and consequently spend more time sitting in their car traveling longer distances. Those who did not have a car in this study were also more likely to walk for transportation, independent of education and income. Previous studies have shown that walking for transportation is inversely related to vehicular access.[37] Individuals in high walkable neighborhoods may be able to carry out daily activities without a car may choose not to own one. This study also found that older adults report greater moderate to vigorous activity when they have access to a car. Vehicle ownership was however correlated with activity levels and in univariate analysis and the 2 factors may be interdependent. In addition, in an auto oriented region like Atlanta, many destinations where physical activity can occur such as parks are too far to access on foot.

Walkability predicted the likelihood a respondent walked but did not predict meeting activity guidelines. Walkability is a construct expected to be related to walking for transportation more than other forms of physical activity that can take place outside of local neighborhoods. The relationship between car ownership and physical activity (independent of other demographics) indicates that older adults may have to drive to suitable physical activity locations such as recreation centers or gyms to access age appropriate physical activity opportunities. These journeys are likely to be less than an hour; the time spent driving investigated in this paper. Unlike, younger adults who are more likely to be able to participate in higher intensity activities like jogging in their local neighborhood, older adults may need more supervised settings for more intense activity. This finding further highlights the importance of having such facilities within walking distance of senior residences.

Significant policy implications extend from these results. Foremost, policies are needed to bring destinations such as shops and services closer to where elderly live—and to encourage elderly to be located in areas where shops and services are concentrated. In addition, direct and safe pedestrian connections are needed between where older Americans live and nearby commercial destinations. Comprehensive plan policies calling for increased concentrations of housing suitable to older Americans within a kilometer or less from retail hubs can be supported through changes in regulatory and fiscal policies. On the regulatory side, zoning codes which impacts land use density and mix and subdivision codes which impact street network characteristics need to be changed to mandate increased walkability. On the fiscal side, tax abatement can be applied to stimulate, incubate, and retain services near to where concentrations of elderly reside. Senior's specific housing strategies are needed in areas with direct access to nearby retail destinations. Location efficient mortgage lending is another approach that could be applied to allow seniors to borrow more money who choose to purchase homes in more walkable places where their transportation costs are lower.

Vehicle ownership and use is influenced through policies adopted at the state and local levels. Distance based vehicle insurance is one policy approach that could provide lower risk older American drivers with an incentive to walk more and drive less and save on car insurance. We observed that those with 1 or no cars compared with those with 2 or more cars were nearly 3 times more likely to walk (OR 2.9) and 37% less likely (OR .67) to spend more than an hour in a car per day. However, results also show that increased auto ownership is associated with increased overall self reported physical activity. Further investigation is needed employing objectively measured physical activity to confirm and better understand these results.

The provision of onsite parking in more compact areas is very expensive and can price many older Americans out of the most walkable areas where they may want to reside. Many jurisdictions have begun to allow developers to "unbundle" parking requirements from their projects for a certain number of housing units. This eliminates the provision of parking onsite and reduces the cost of dwellings by up to $30,000. This policy can make many walkable areas more affordable to older Americans on fixed incomes. Car sharing programs can also be encouraged through fiscal and regulatory policies and programs which can provide the access required by seniors to get to parks and other destinations where they are active. These strategies could also help to reduce sedentary time spent in cars and reduced risk of injury and accidents for older Americans. Most studies of older adults report a positive relationship between aspects of community design (density, mix, connectivity) and walking.[4,16,17,23,25] In the literature on adults under 65, objectively-defined walkability is more consistently related to walking for transportation than walking for leisure or physical activity.[14,15] One study in older adults found a relationship between neighborhood environment and physical activity[18] while another did not.[26] In our analyses there was no relationship between meeting the guidelines for self-reported physical activity and walkability (although, as noted above, car ownership was positively related to meeting the guidelines). As recent accelerometer data show,[13] self report measures of physical activity are inflated and this may interfere with analyses of urban form. Walkability within 1km of home may not be related to older Americans meeting physical activity levels in a study region with limited variation in urban form. Indeed, previous studies have shown that individuals travel up to 8km to recreation centers.[27]

In the current sample of older adults, medium levels of walkability were related to overweight status, even after adjusting for demographics, and behaviors related to energy expenditure and intake. There was no relationship

with obesity. One recent neighborhood study in adults 50 to 75 years found that land use mix was related to both overweight and obesity.[18] A study in 45 to 84 year olds also found a negative relationship between urban form and BMI but this relationship was attenuated by diet and physical activity.[19] Another study, however, found no significant relationship between walkability and BMI in adults over 65 years old.[17] The lack of relationship between higher levels of walkability and weight status has also been found in other studies.[2,28,29] Overall, this result is rare but may be detecting higher crime levels and increased proximity to poor food options. Ten percent of this sample of older adults ate or purchased food at a fast food outlet over the 2-day diary period and the analyses show that this behavior was related to obesity. This is a novel finding in this age group and warrants further investigation. It is, however, consistent with another recent study on food outlet visitation showing that 20 to 65 year old women had significantly higher BMI levels if they reported visiting a fast food outlet at least once over a 2-day period.[30] Policies that support neighborhood grocery stores that sell fresh produce in urban centers where elderly can live without being car dependent may support lower BMI in the study population. The city of Portland has recently unveiled the 20 minute neighborhood concept with this exact principal in mind, making the neighborhood grocery the hub of a community once again. Neighborhood grocery stores are being increasingly supported through tax and regulatory policies including tax abatement (fiscal) and changes to zoning codes (regulatory).

The present results should be considered in light of some study limitations. The study was cross sectional, there was some participation bias, and it was conducted in a region with limited variability in urban form. Self-reported BMI may underestimate obesity prevalence, travel diaries may not accurately assess all walking trips, and self-reported physical activity levels may be over reported and appear to be inconsistent with travel diary results on walking. Future studies should consider additional variables, such as neighborhood socioeconomic status, employment status, and perceptional factors such as crime, safety from traffic, and the presence of recreational facilities, crosswalks, and sidewalks.

Conclusions

Urban form was related to walking, time spent in a car, and overweight status in a large cohort of older adults living in Atlanta, GA. Previous studies have also found that urban form is related to depression, hypertension, and disability in older adult populations[31–35] and may be more important to older adults than younger populations.[36] Together these results suggest that the built environment may play a critical role in the health of older adults, and point to the need to carefully consider the built environment when locating senior centers, medical facilities, and other social services in a community. Vehicle ownership was an important correlate of walking, time spent in cars, and overall levels of physical activity. In addition, increasing the overall walkability of urban and suburban areas—with multiple destinations within short distances—can support more walking, less driving, and the healthier aging of older Americans. Financial and award-based incentives to build shops, services, recreation facilities and homes closer together may help the development of walkable communities for seniors and all age groups.

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