# Individual and neighborhood characteristics associated with neighborhood walking among US older adults

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## ARTICLE INFO

## ABSTRACT

*Background:* Neighborhood walking connotes physical activity and opportunities for social and cognitive engagement and improved mental health, factors previously associated with outcomes including mortality, cardiovascular disease, and dementia. Few studies have examined correlates of neighborhood-specific walking in older adults.
*Purpose:* We investigated the individual and neighborhood/regional correlates of neighborhood-based walking among US older adults.
*Methods:* We obtained cross-sectional data on $\geq$ 65 year olds from the population-based 2017 National Household Travel Survey (n = 73,523). Respondents completed diaries detailing trips during an assigned travel day. Adjusted logistic regression (using survey weights) tested associations between individual, neighborhood, and regional characteristics and $\geq$ 1 versus no neighborhood walk trips/day (from travel diary).
*Results:* Twelve percent had $\geq$ 1 neighborhood walk trip/day and 54% of the neighborhood walkers achieved $\geq$ 30 min of walking/day. African Americans/Blacks (versus non-Hispanic Whites) and working individuals (versus retired) had lower odds of neighborhood walking. Individuals without cars, bus/train users, and those with higher neighborhood housing density had greater odds of neighborhood walking. Utilitarian walking was less likely among African Americans/Blacks and Hispanics but more likely among Asians (versus non-Hispanic Whites). Social/recreational neighborhood walking was more likely for those without cars, bus/train users, and those with greater neighborhood housing density.
*Conclusion:* Few US older adults walked in their neighborhoods, suggesting a potentially fruitful target for health promotion efforts and community interventions to improve health and quality of life in older adults. Future work is needed to determine other neighborhood factors associated with greater neighborhood walking.

## 1. Introduction

Residential neighborhoods provide opportunities for physical activity among all ages by providing spaces for leisure-based exercise and walking/bicycling to destinations (Barnett et al., 2017; Marzi, Demetriou, & Reimers, 2018). The neighborhood environment is particularly important for older adults ($\geq$65 year olds), who experience shrinking life space (Huisingh et al., 2017). With increasing age, older adults may drive less frequently (or never), have greater frailty and disease, and have fewer friends and family living nearby (Collard, Boter, Schoevers, & Oude Voshaar, 2012; Fakoya, McCorry, & Donnelly, 2020; Shah et al., 2012). Approximately 28% of older Americans live alone

(Administration of Community Living, 2017). The US population of older adults is expected to rise from 56 million in 2020 to 88 million by 2050, which will be accompanied by a concurrent increase in prevalence of diseases disproportionately affecting older adults, including cardiovascular disease and Alzheimer's disease (Alzheimer's Association, 2020; Singh et al., 2019). Therefore, studies are increasingly aimed at determining supportive neighborhood environments that promote physical activity (U.S. Department of Health and Human Services, 2015, 2018) and other health behaviors for older adults. The majority (77%) of older Americans live in urban areas (US Census, 2019), and thus, interventions to improve neighborhood environments for older adults may have significant population-level benefits by improving quality of life,

increasing healthy behaviors that reduce disease burden, and allowing for aging in place.

Neighborhood characteristics such as greater social and walking destinations, adequate/safe walking infrastructure, and access to parks and public transportation have been associated with greater amounts of walking and physical activity in older adults (Barnett et al., 2017; Cerin et al., 2017). Walking is generally a safe and important source of physical activity for older adults, who often experience decreased cardiorespiratory fitness and lack of balance and strength with age (Iwasaki & Yamasoba, 2015; McPhee et al., 2016). In addition, neighborhood-based walking may offer other health-related benefits such as opportunities for social engagement, cognitive stimulation, and stress and anxiety reduction. In turn, social and cognitive engagement and improved mental health, in addition to higher physical activity levels, have been associated with multiple health outcomes, including reduced mortality, cardiovascular disease, and depression, and lower risk of cognitive impairment and dementia (Aldwin et al., 2011; Kivimäki and Steptoe, 2018; Krell-Roesch et al., 2017; Marioni et al., 2015; Min, Ailshire, & Crimmins, 2016; Ramsay et al., 2008).

One known study has investigated the associations between objectively-measured neighborhood characteristics and neighborhood-specific walking in older adults (Cerin et al., 2013b). The study found presence of community resources (e.g., health clinic) and destination density (retail, food/grocery stores, restaurants) associated with more self-reported neighborhood walking for transportation. In contrast, similar studies have typically focused on perceived neighborhood characteristics (Barnett et al., 2016; Cerin et al., 2013a; Gallagher et al., 2012), and/or total amount of physical activity or walking irrespective of location (Barnett et al., 2017; Carlson et al., 2012; Cerin et al., 2017; Frank, Kerr, Rosenberg, & King, 2010; Mooney et al., 2017). Perceived neighborhood characteristics may be biased and although they may be useful for certain purposes, often do not reflect the objective built environments that would be targeted by future interventions and policies (Orstad, McDonough, Stapleton, Altincekic, & Troped, 2017). The use of a total physical activity measure may reflect physical activity obtained in large part outside the residential neighborhood. In addition, studies focused on physical activity regardless of place fail to account for the other possible health benefits of walking in one's neighborhood (mentioned above).

We aimed to quantify the percentage of older Americans who participate in neighborhood-based walking, describe the neighborhood-based walking trips, and investigate the association between individual characteristics and neighborhood/regional characteristics and neighborhood walking. We hypothesized that individuals who participate in neighborhood walking live in neighborhoods with greater densities of housing, workers, and renter-occupied units. We also hypothesized that neighborhood walking would be associated with US Census region (Northeast, Midwest, South, West), a proxy for differences in cultural preferences, development patterns, and climate, which may affect neighborhood walking. Altogether, we posited that denser areas, which offer more community-based opportunities for social and physical activities, would be associated with neighborhood walking in older adults.

## 2. Methods

Data were obtained from the publicly available 2017 National Household Travel Survey (NHTS) (Federal Highway, 2017). No consents or institutional board approvals were required as this study involved secondary data analysis of de-identified data. The NHTS, a national survey of the personal and household travel patterns of Americans, collected data at the household, household member, trip, and vehicle level. The primary sampling unit was based on four categories of the household's metropolitan statistical area (MSA) size and rail availability: 1) MSA with heavy rail and $> 1$ million people; 2) MSA with no heavy rail and $> 1$ million people; 3) MSA with $< 1$ million people; and 4) not an MSA (rural/small town). Households were randomly sampled

from these four MSA-rail categories and were invited to participate via mail. Respondents were allowed to complete their surveys by phone or online and were randomly assigned a travel diary day (Monday through Sunday) to record all trip details, including travel time, mode, and purpose. The overall response rate was 30.4%, with 129,696 households and 264,234 household members completing the survey.

Using the travel diary data, we created a dichotomous measure of $\geq 1$ neighborhood walk trip (versus none) during the assigned travel day. Trips designated as home-based (as origin and/or destination) were used to derive this measure and included loop trips starting and ending from home. The outcome was dichotomized instead of quantified because we hypothesize that any time spent outside of the home and in the neighborhood can be beneficial to the mental and physical health of older adults.

Demographics, neighborhood/regional characteristics, health characteristics, and trip characteristics were described for the participants (total and stratified by $\geq 1$ neighborhood walk trip/day versus none). Individual-level sociodemographics included age, sex, race/ethnicity, education, income, employment status, car and home ownership, and household size. Race and Hispanic ethnicity were combined into a single race/ethnicity variable as follows: non-Hispanic White, African American/Black (regardless of Hispanic ethnicity), Hispanic (all races but African American/Black), non-Hispanic Asian, and non-Hispanic other race. Neighborhood and regional characteristics included US Census block group measures of population density (people/mi$^2$), housing unit density (units/mi$^2$), and percent renter-occupied housing; a US Census tract measure of worker density (per mi$^2$); urbanicity (urban, suburban, rural); and US Census Region (states listed in Supplemental Table 1). Health and transportation-related characteristics included health status (e.g., excellent, good), physical activity frequency, medical condition affecting driving, medical device for walking (i.e., cane, crutch, wheelchair/scooter, service dog), and bus and train travel frequency. Travel day characteristics included season (fall, winter, spring, summer), day (weekday or weekend), trip purpose, public transportation use (yes/no), and total minutes walking in neighborhood.

Unadjusted logistic regression tested associations between all characteristics and odds of $\geq 1$ neighborhood walk trip/day (versus none). For each ordinal variable, we tested for linear trend. Age, income, education, sex, race/ethnicity were included in the adjusted models a priori as they are common risk factors for health outcomes. Certain characteristics were included in the study for descriptive purposes only and thus were excluded from the adjusted analyses (i.e., population density, urbanicity, health status, physical activity/walking/bike frequency, public transportation use due to financial burden, walk trip purpose, total neighborhood walking minutes). Variables with unadjusted associations at $p < 0.10$ were included in a single adjusted logistic regression model. Unadjusted and adjusted models included person-level survey weights and replicate weights (constructed using Jackknife method) provided by NHTS to produce unbiased estimates accounting for survey sampling methods. The same adjusted model was stratified to determine if neighborhood walking predictors varied by trip purpose (work, school, or errand versus social/recreational). Models accounted for data clustering at the state and household level. Descriptive statistics were produced in R version 4.0.2 and SAS version 9.4, and all regression analyses were conducted using the "survey" package in R. Reported percentages and regression estimates were weighted to provide national estimates.

## 3. Results

The sample consisted of 73,523 survey respondents who were 65 years and older (Fig. 1). An estimated 12% of American older adults participate in $\geq 1$ neighborhood walk trip/day (Table 1). Tables 1-3 displays the participant characteristics, neighborhood/regional characteristics, and health and transportation characteristics stratified by those who achieved $\geq 1$ versus no neighborhood walk trips/day (95% CIs for
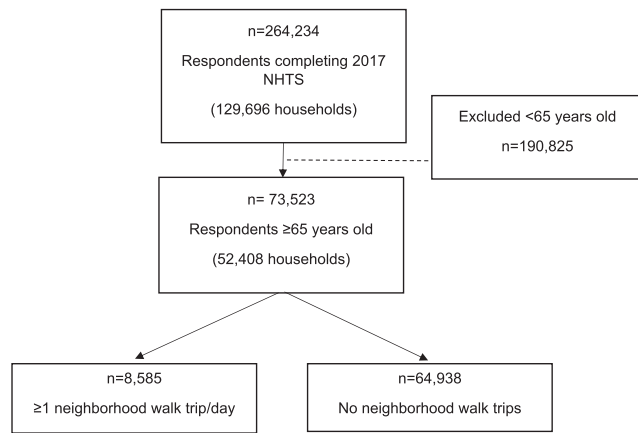
**Fig. 1.** Flow diagram for obtaining final sample Abbreviation: NHTS = National Household Travel Survey.

weighted percentages in Supplemental Table 2). Based on the unweighted sample, 63% of survey respondents were < 74 years old, 53% were female, 70% had at least some college education, and 31% had a family income ≥$75,000/year. Eight-five percent were non-Hispanic White, 5% Black/African American, 4% Hispanic, 2% Asian, and 2% other race/ethnicity. Tables 1-3 also present p-values from the unadjusted logistic regression models clustered on state and household. From these unadjusted models, age, education, income, race/ethnicity, home ownership, employment status, car ownership, and household size were associated with ≥ 1 neighborhood walk trip/day (Table 1). Individuals were more likely to participate in neighborhood walking if they were of younger ages (trend p < 0.001) and greater education (trend p < 0.001) and income (trend p = 0.02).

In unadjusted logistic regression analyses, older adults living in denser neighborhood environments (i.e., higher population, housing, renter, and worker density [trend p-value < 0.001], urban versus rural) were more likely to have ≥ 1 neighborhood walk trip/day (Table 2). Individuals with ≥ 1 neighborhood walk trip/day were more likely to report better health (trend p-value < 0.001), more frequent walking/bicycling for travel (trend p-values < 0.001), more frequent use of the bus/train for travel (trend p-values < 0.001) and use public transportation due to financial burden, and were less likely to report lower physical activity levels (trend p-value < 0.001) (Table 3).

The assigned travel diary days were approximately equally distributed across seasons and most (~70%) were on weekdays versus weekends (Supplemental Table 2). Walking trip purposes included work (10% of neighborhood walkers), shopping/errands (60%), social/recreational (45%), meals (25%), and other purposes (i.e., school/religious, transport someone, medical) (32%) (Supplemental Table 3). Among neighborhood walkers, 54% achieved at least 30 min/day walking in the neighborhood.

Fig. 2 and Supplemental Table 4 provide the geographic distribution of neighborhood walking among US older adults by US Census Division. On average, the percentage of older Americans participating in any neighborhood walking was lowest in East South Central States (5.6% in Alabama, Kentucky, Mississippi, and Tennessee) and highest in Mountain states (17.2% in Arizona, Colorado, Idaho, Montana, New Mexico, Nevada, Utah, and Wyoming).

In adjusted analyses, those with high school degrees or some college/an associate's degrees, African Americans/Blacks, workers (versus retired), and those using a medical device to walk had lower odds of neighborhood walking (Table 4). Individuals who did not own a car, lived in neighborhoods with greater housing density, and used the bus/train at least a few times/month had greater odds of neighborhood walking. Age, sex, income, home ownership, household size,

**Table 1**
Participant characteristics.

| Characteristic [a] | Unweighted Total, n = 73,523 | n (weighted col %[b]) | | Unadjusted logistic regression p-value[b] |
|---|---|---|---|---|
| | | No neigh. walk trip, n = 64,938 (87.7%) | ≥1 neigh. walk trip, n = 8,585 (12.3%) | |
| **Age** | | | | |
| 65–69 years old | 26,880 | 23,430 (37.4%) | 3,450 (41.6%) | Ref. |
| 70–74 years old | 19,506 | 17,178 (25.6%) | 2,328 (26.8%) | 0.29 |
| 75–79 years old | 12,646 | 11,231 (16.3%) | 1,415 (16.2%) | 0.29 |
| 80 and older | 14,491 | 13,099 (20.8%) | 1,392 (15.4%) | <0.0001 |
| Female, n (%) | 39,257 | 34,802 (56.1%) | 4,455 (54.7%) | 0.35 |
| **Education level (degree)** | | | | |
| <HS degree | 4,090 | 3,776 (10.2%) | 314 (8.4%) | <0.0001 |
| High school degree/equiv. | 17,978 | 16,533 (28.8%) | 1,445 (22.2%) | <0.0001 |
| Some college/ associate's | 21,605 | 19,358 (28.9%) | 2,247 (26.2%) | <0.0001 |
| Bachelor's degree | 14,011 | 11,998 (15.1%) | 2,013 (19.0%) | 0.27 |
| Graduate/ professional | 15,734 | 13,180 (17.0%) | 2,554 (24.1%) | Ref |
| **Annual household income** | | | | |
| 0–34,999 | 22,593 | 19,988 (38.9%) | 2,605 (40.9%) | Ref. |
| 35,000–74,999 | 23,993 | 21,384 (33.5%) | 2,609 (28.3%) | 0.001 |
| 75,000–125,000 | 14,926 | 13,096 (17.9%) | 1,830 (18.6%) | 0.84 |
| >125,000 | 7,992 | 6,853 (9.7%) | 1,139 (12.2%) | 0.10 |
| **Race/ethnicity** | | | | |
| NH White | 62,739 | 55,359 (72.6%) | 7,380 (70.6%) | Ref. |
| Black/African American[c] | 4,019 | 3,662 (11.6%) | 357 (9.5%) | 0.16 |
| Hispanic[d] | 3,174 | 2,832 (10.4%) | 342 (12.6%) | 0.11 |
| NH Asian | 1751 | 1,458 (3.2%) | 293 (5.3%) | 0.02 |
| NH Other | 1554 | 1,378 (2.2%) | 176 (2.0%) | 0.69 |
| **Home ownership** | | | | |
| Own | 64,410 | 57,330 (78.1%) | 7,080 (69.3%) | Ref. |
| Rent | 8,570 | 7,128 (20.5%) | 1,442 (29.2%) | <0.0001 |
| Other | 529 | 469 (1.4%) | 60 (1.6%) | 0.38 |
| **Employment status** | | | | |
| Retired | 57,667 | 50,745 (74.4%) | 6,922 (76.4%) | Ref. |
| Working | 9,023 | 8,018 (14.0%) | 1,005 (14.3%) | 0.96 |
| Other | 6,817 | 6,161 (11.6%) | 656 (9.4%) | 0.01 |
| **Household vehicles** | | | | |
| None | 2,761 | 2,076 (7.3%) | 685 (17.5%) | <0.0001 |
| 1 or more | 70,762 | 62,862 (92.7%) | 7,900 (82.5%) | Ref. |
| **Household size** | | | | |
| 1 | 19,548 | 16,682 (25.6%) | 2,866 (35.3%) | Ref. |
| 2 | 46,785 | 41,663 (54.6%) | 5,122 (49.1%) | <0.0001 |

(*continued on next page*)

**Table 1** (*continued*)

| Characteristic [a] | Unweighted Total, n = 73,523 | n (weighted col %[b]) | | Unadjusted logistic regression p-value[b] |
|---|---|---|---|---|
| | | No neigh. walk trip, n = 64,938 (87.7%) | ≥1 neigh. walk trip, n = 8,585 (12.3%) | |
| 3 or more | 7190 | 5,698 (19.8%) | 514 (15.7%) | <0.0001 |

Source: 2017 National Household Travel Survey
Equiv = Equivalent, Neigh = neighborhood, Ref = reference/comparison group, NH = Non-Hispanic
[a] Missing data: income, n = 4,019; education, n = 105; race, n = 316; Hispanic, n = 116; home ownership, n = 19; employment, n = 16; [b] Reported percentages and regression estimates were weighted to provide national estimates; [c] includes Hispanic; [d] Excludes African American/Black; 95% confidence limits for percentages provided in Supplemental Table 2.

neighborhood renter-occupied housing density, neighborhood workers/mi$^2$, US Census region, and the season and day of week of the assigned travel diary day were not associated with neighborhood walking in the adjusted model ($p < 0.05$).

When stratifying the adjusted model, the predictors differed by trip purpose (Supplemental Table 5). Individuals were less likely to have ≥ 1 neighborhood walk trip for work, school, or errands (i.e., utilitarian walking) if they were Black/African American or Hispanic (versus non-Hispanic White), working (versus retired), or used a medical device for walking, and were more likely to have utilitarian walking if they were Asian or had households of ≥ 3 people. Individuals were less likely to have ≥ 1 neighborhood walk trip for social/recreational purposes if they used a medical device for walking and were more likely to participate in social/recreational neighborhood walking if they had no car, lived in households of ≥ 3 people, lived in higher housing density neighborhoods, or were bus/train users.

## 4. Discussion

A small percentage (12%) of US older adults took at least one neighborhood walk trip/day. Approximately half of the neighborhood walkers walked for shopping and meals, and 54% of those who had neighborhood walk trips achieved at least 30 min of walking/day. The percentage of older Americans who had ≥ 1 neighborhood walk trip/day varied by US region, from an average of 6% in the East South Central States (e.g., Alabama, Tennessee) to 17% in the Mountain states (e.g., Arizona, Utah). Multiple individual level characteristics (education, race/ethnicity, employment status, medical device for walking, car ownership, public transportation use) and neighborhood housing density were associated with neighborhood walking in older adults. In addition, the predictors of neighborhood walking depended on trip purpose. Neighborhood walking for work, school or errands was less likely among African Americans/Blacks and Hispanics but more likely among Asians (versus non-Hispanic Whites). In contrast, neighborhood walking for social/recreational purposes was more likely in those with higher neighborhood housing density, with no car, and for bus/train users.

Unlike the neighborhood built environments (e.g., housing density), individual characteristics that predict neighborhood walking are not readily modifiable. However, understanding these characteristics remains useful for informing future research studies and health promotion strategies and interventions. Workers were less likely to participate in neighborhood walking, which may reflect lack of time. Neighborhood walking was more prevalent among individuals without household cars and bus/train users, likely due to necessity or cost savings. Older adults with household cars were less likely to walk in the neighborhood, indicating that they may choose to drive to destinations instead. We included race/ethnicity in our analyses because this social construct is frequently associated with health outcomes in older adults (e.g.,

**Table 2**
Neighborhood and regional characteristics.

| Characteristic[a] | Unweighted n (weighted col %[b]) | | | Unadjusted logistic regression p-value[b] |
|---|---|---|---|---|
| | Total, n = 73,523 | No neigh. walk trip n = 64,938 (87.7%) | ≥1 neigh. walk trip n = 8,585 (12.3%) | |
| *Population density (people/mi$^2$) (US Census block group)* | | | | |
| 0–499 | 25,079 | 22,823 (28.1%) | 2,256 (17.1%) | Ref. |
| 500–999 | 7,512 | 6,407 (8.7%) | 745 (5.5%) | 0.70 |
| 1,000–3,999 | 23,160 | 20,419 (31.8%) | 2,741 (29.8%) | <0.0001 |
| 4,000–9,999 | 14,389 | 12,417 (21.9%) | 1,972 (24.1%) | <0.0001 |
| ≥10,000 | 3,679 | 2,815 (9.6%) | 864 (23.7%) | <0.0001 |
| *Housing units/mi$^2$ (US Census block group)* | | | | |
| 0–499 | 33,792 | 30,690 (38.8%) | 3,102 (24.1%) | Ref. |
| 500–999 | 10,475 | 9,251 (14.6%) | 1,224 (11.7%) | 0.01 |
| 1,000–3,999 | 24,898 | 21,675 (36.3%) | 3,223 (38.4%) | <0.0001 |
| 4,000–9,999 | 3,201 | 2,554 (6.6%) | 647 (12.0%) | <0.0001 |
| ≥10,000 | 1,093 | 711 (3.7%) | 382 (13.8%) | <0.0001 |
| *Urbanicity* | | | | |
| Urban/second city | 19,570 | 16,636 (33.5%) | 2,934 (48.3%) | <0.0001 |
| Suburban | 15,424 | 13,541 (44.6%) | 1,883 (30.6%) | Ref. |
| Small town/rural | 38,465 | 34,704 (21.8%) | 3,761 (21.1%) | <0.0001 |
| *Renter-occupied housing (US Census block group)* | | | | |
| 0–14% | 26,862 | 24,113 (36.0%) | 2,749 (27.6%) | Ref. |
| 15–24% | 18,399 | 16,477 (22.2%) | 1,922 (19.0%) | 0.47 |
| 25–34% | 10,488 | 9,295 (13.5%) | 1,193 (12.1%) | 0.25 |
| 35–44% | 7,146 | 6,200 (9.5%) | 946 (10.3%) | <0.0001 |
| 45–64% | 7,438 | 6,318 (12.1%) | 1,120 (16.5%) | <0.0001 |
| 65–100% | 3,126 | 2,478 (6.8%) | 648 (14.4%) | <0.0001 |
| *Workers/mi$^2$ (US Census tract)* | | | | |
| 0–49 | 14,760 | 13,412 (16.7%) | 1,348 (9.6%) | Ref. |
| 50–249 | 14,075 | 12,690 (15.9%) | 1,385 (11.5%) | 0.12 |
| 250–999 | 17,547 | 15,530 (22.8%) | 2,017 (20.8%) | 0.0001 |
| 1,000–1,999 | 12,579 | 11,162 (19.1%) | 1,417 (16.5%) | 0.0012 |
| 2,000–999,999 | 14,498 | 12,087 (25.4%) | 2,411 (41.6%) | <0.0001 |
| *Census region* | | | | |
| Northeast | 12,005 | 10,476 (17.6%) | 1,529 (25.1%) | <0.0001 |
| Midwest | 10,959 | 9,833 (22.3%) | 1,126 (16.7%) | <0.0001 |
| South | 31,022 | 28,025 (38.6%) | 2,997 (30.6%) | Ref. |
| West | 19,537 | 16,604 (21.5%) | 2,933 (27.6%) | 0.08 |

Source: 2017 National Household Travel Survey
Abbreviations: neigh = neighborhood; mi = mile; Ref = reference/comparison group
[a] Missing data: population density, housing units, urbanicity, renter-occupied units, and workers, n = 64; [b] Reported percentages and regression estimates were weighted to provide national estimates; 95% confidence limits for percentages provided in Supplemental Table 2.

cardiovascular disease), but also may be an important determinant of neighborhood walking due differences by race/ethnicity in culture, physical activity preferences, and neighborhood characteristics conducive to walking. Compared to non-Hispanic Whites, African Americans/

**Table 3**
Health and transportation characteristics.

| Characteristic[a] | Unweighted n (weighted col %[b]) | | | Unadjusted logistic regression p-value[b] |
|---|---|---|---|---|
| | Total n = 73,523 | No neigh. walk trip n = 64,938 (87.7%) | ≥1 neigh. walk trip n = 8,585 (12.3%) | |
| *Health status* | | | | |
| Excellent/very good | 36,856 | 31,576 (43.1%) | 5,280 (53.1%) | Ref. |
| Good | 23,458 | 21,053 (33.6%) | 2,405 (32.2%) | <0.0001 |
| Fair | 9,987 | 9,228 (17.0%) | 759 (12.1%) | <0.0001 |
| Poor | 3,139 | 3,004 (6.4%) | 135 (2.6%) | <0.0001 |
| Medical condition resulted in giving up driving | 4,791 | 4,429 (10.0%) | 362 (4.9%) | <0.0001 |
| Medical device used for walking | 9,413 | 8,856 (17.2%) | 557 (7.9%) | <0.0001 |
| *Physical activity level* | | | | |
| Rarely/never | 8,424 | 8,162 (16.0%) | 262 (4.0%) | Ref. |
| Some light/ moderate | 50,673 | 44,693 (68.0%) | 5,980 (73.2%) | <0.0001 |
| Some vigorous | 14,251 | 11,923 (15.9%) | 2,328 (22.8%) | <0.0001 |
| *Walking frequency for travel* | | | | |
| Daily | 12,668 | 9,425 (18.1%) | 3,243 (44.6%) | <0.0001 |
| Few times/week | 12,077 | 10,357 (18.5%) | 1,720 (21.9%) | <0.0001 |
| Few times/month | 8,559 | 7,645 (14.0%) | 914 (11.4%) | <0.0001 |
| Few times/year or never | 31,326 | 29,246 (49.4%) | 2,080 (22.1%) | Ref. |
| *Bicycling frequency for travel* | | | | |
| Daily | 624 | 499 (1.1%) | 125 (1.5%) | 0.005 |
| Few times/week | 2,227 | 1,828 (3.7%) | 399 (5.9%) | 0.001 |
| Few times/month | 2,789 | 2,301 (3.9%) | 488 (6.9%) | 0.002 |
| Few times/year or never | 56,575 | 50,141 (91.3%) | 6,434 (85.7%) | Ref. |
| *Bus frequency for travel* | | | | |
| Daily | 540 | 397 (1.8%) | 143 (4.8%) | <0.0001 |
| Few times/week | 919 | 636 (2.8%) | 283 (9.1%) | <0.0001 |
| Few times/month | 1,326 | 962 (3.5%) | 364 (8.3%) | <0.0001 |
| Few times/year or never | 60,577 | 53,695 (92.0%) | 6,882 (77.8%) | Ref. |
| *Train frequency for travel* | | | | |
| Daily | 287 | 215 (1.1%) | 72 (2.7%) | <0.0001 |
| Few times/week | 461 | 306 (1.4%) | 155 (5.1%) | <0.0001 |
| Few times/month | 970 | 704 (2.3%) | 266 (8.2%) | <0.0001 |
| Few times/year or never | 61,405 | 54,285 (95.1%) | 7,120 (84.0%) | Ref. |
| Use public transportation due to financial burden | 5,288 | 4,180 (11.7%) | 1,108 (23.7%) | <0.0001 |

Source: 2017 National Household Travel Survey
Abbreviation: neigh = neighborhood; Ref = reference/comparison group
[a] Missing data: health status, n = 83; medical condition, n = 15; physical activity, n = 175; walking frequency, n = 8893; bicycling frequency, n = 11308; bus frequency, n = 10161; train frequency, n = 10400; financial burden, n = 5085; [b] Reported percentages and regression estimates were weighted to provide national estimates; 95% confidence limits for percentages provided in Supplemental Table 2.

Blacks and Hispanics were less likely and Asians were more likely to take ≥ 1 neighborhood walk trip/day. Racial differences in physical activity engagement (August & Sorkin, 2011), as well as preferences for physical and social activities and neighborhood psychosocial context (e. g., crime, neighborhood walkability) may help explain these

associations. For instance, studies have found different preferences for neighborhood park spaces depending on race/ethnicity (Derose, Han, Williamson, Cohen, & Corporation, 2015) and that neighborhood crime affects physical activity levels (Suglia et al., 2016). These findings suggest potential strategies to increasing physical activity among racial/ethnic groups by increasing neighborhood walking through safe interventions or policies specifically targeting individuals or their neighborhoods.

Four studies of older adults (all cross-sectional, none population-based) are most relevant to our findings because they studied correlates of neighborhood walking (most studies focus on total walking or total physical activity irrespective of place). Three of the studies were conducted in Hong Kong, China. The first found that community resources (places of worship, health clinic) and destination accessibility (retail, grocery, restaurants), assessed via an environmental audit of the residential neighborhoods, were associated with greater self-reported minutes of neighborhood transport walking (Cerin et al., 2013b). The second found multiple perceived neighborhood characteristics including diversity of land uses (e.g., commercial and residential), street connectivity (proxy for destination access), proximity to recreational facilities and public transportation, pedestrian infrastructure (e.g., sidewalks), housing and population density, crime, aesthetics, and places to rest were associated with self-reported frequency/minutes of neighborhood walking for transport or leisure (A. Barnett et al., 2016). The third observed that access to services/destinations, places to rest, aesthetics, and low traffic were associated with accelerometer-based measures of minutes of neighborhood walking for transport or recreation (Cerin et al., 2013a). The fourth study, based in Michigan, US, found that neighborhood destinations (e.g., stores and services) and neighborhood design (e.g., street connectivity, aesthetics) were associated with greater self-reported minutes of neighborhood walking for transport or recreation (Gallagher et al., 2012).

These previous studies suggest that "the 5Ds" (density, diversity of destinations, design, destination accessibility, and distance to public transportation) (Kang, 2018) are associated with neighborhood-based walking in older adults. Our study found that density (i.e., housing units/mi$^2$) was a strong correlate of neighborhood walking in a nationally representative sample of US older adults. Neighborhood measures of renter-occupied housing and workers/mi$^2$ were not associated with overall neighborhood walking. Although our neighborhood measures may capture similar constructs from the previous four studies mentioned above, they may differ enough to yield different associations. Additionally, the outcome measure of ≥ 1 neighborhood walk trip/day (i.e., presence/absence of neighborhood walking) is unique to this study and may help explain different findings compared to the past studies, which primarily focused on total minutes of walking.

Considering this study together with the noted prior studies, gaps in the research become clear. Studies to date tend to focus more on neighborhood measures that would encourage walking for utilitarian purposes (e.g, public transport access and destinations) and not necessarily on recreational walking (Barnett et al., 2017). For instance, quality of neighborhood parks or density and types of recreational walking destinations (e.g., landmarks) may be important predictors of neighborhood recreational walking. In addition, the social context of the neighborhood (e.g., age and racial composition), amount of shade, and overall level of neighborhood greenness may be associated with neighborhood walking. Our finding that only a small percentage of older adults participate in at least one neighborhood walk trip/day suggests that studies cannot presume that living in a neighborhood with certain environmental characteristics equates to actual exposure to those neighborhood characteristics. Instead, studies focused on neighborhood environments (e.g., walkability) and health will need to incorporate measures of time spent in the neighborhood, such as measures that can be obtained from devices like Global Positioning System (GPS) trackers. Our findings suggest differences in neighborhood walking by US region, although much if not all of the regional variation was explained by

**Fig. 2.** Percentage of American older adults with ≥ 1 neighborhood walk trip/day by US Census Division In 2017, fewer older adults had ≥ 1 neighborhood walk trip/day in the East South Central (5.6%), West North Central (8.4%), and West South Central (8.5%) states, compared to the New England (15.4%), Middle Atlantic (17.1%) and Mountain states (17.2%) (weighted unadjusted percentages). See Supplemental Table 4 for additional data. Source: 2017 National Household Travel Survey.

individual and neighborhood characteristics. Nonetheless, research on neighborhood environments and walking should carefully consider regional differences, as differences in cultural preferences, climate, development patterns, and transportation infrastructure that may affect neighborhood walking may be strongly associated with certain places/ regions. In addition, further study is needed on how neighborhood environment-neighborhood walking associations among older adults vary depending on individual characteristics, including but not limited to age, sex, socioeconomic status, and race/ethnicity.

This study has limitations. The response rate may limit the generalizability of this study, although the sample size was large. While the survey and replicate weights aid in producing unbiased estimates, the results may be biased by other factors such as residual confounding by neighborhood SES or misclassification bias (e.g., incorrectly reporting trip details). Data were cross-sectional and thus provide correlations. Conclusions cannot be made about causal associations between neighborhood and regional characteristics and walking behavior, and future longitudinal studies are needed to help support causal assertions. The trip diaries captured a day's worth of travel and therefore may not represent the respondents' typical behaviors. Since a small proportion of older adults walked during their travel diary day, we dichotomized the outcome into any versus no neighborhood walking (alternative was a continuous measure that would be highly skewed toward 0 min of neighborhood walking). While the derivation of neighborhood walking from travel diaries is an improvement upon the use of physical activity questionnaires, which are affected by recall bias and social desirability bias (Adams et al., 2005; Fransson, Knutsson, Westerholm, & Alfredsson, 2008), GPS and accelerometer data would provide improved measures. Other neighborhood and regional characteristics are likely important in predicting older adult walking behavior but were not available in the NHTS, including but not limited to neighborhood crime, traffic, and

parks and recreational spaces. Lastly, African Americans/Blacks reporting Hispanic ethnicity were categorized as African American/ Black. We recognize that participants' primary identification (race or ethnicity) may be associated with their residential location or neighborhood walking behavior, but we lacked the data to examine this. For this study, only 1% of the African American/Black sample identified as Hispanic; thus, results were unlikely to be significantly influenced by this categorization. However, future studies would benefit from a more nuanced analysis of the predictors of neighborhood walking among older adults by race and ethnicity.

Despite the study limitations, the NHTS provided comprehensive data with which to examine neighborhood walking at the US national level. The use of travel diary data to assess neighborhood walking is an improvement upon studies relying on self-reported physical activity questionnaires. Study strengths also include the diverse sample representing the diversity of US older adults and the objective measures of neighborhood characteristics. This is one of the first studies specifically targeting associations between neighborhood/regional characteristics and neighborhood-based walking in older adults. Neighborhood walking is an important outcome for older adults, not only because it indicates physical activity but also because it captures neighborhood opportunities for social and cognitive engagement and improved mental health. Spending time outside the home and in the neighborhood may help reduce loneliness, social isolation and depression in older adults, conditions that increase with age and that have been associated with mortality and morbidity (Courtin & Knapp, 2017; Leigh-Hunt et al., 2017). Findings from this study may help inform health promotion efforts and interventions and future studies focused on community characteristics that promote neighborhood walking among older adults.

**Table 4**
Adjusted associations with ≥ 1 neighborhood walk trip/day.

| Characteristic | Adjusted OR (95% CI)[a] | p-value |
|---|---|---|
| Age (years) | 0.99 (0.98, 1.00) | 0.11 |
| Female (vs male) | 1.00 (0.84, 1.18) | 0.99 |
| *Education level (vs graduate/professional)* | | |
| <High school degree | 0.92 (0.77, 1.11) | 0.43 |
| High school degree/equivalent | 0.68 (0.55, 0.83) | <0.0001 |
| Some college/associate's degree | 0.71 (0.63, 0.80) | 0.0005 |
| Bachelor's degree | 0.91 (0.73, 1.15) | 0.41 |
| *Race/ethnicity (vs NH White)* | | |
| Black/African American[b] | 0.53 (0.38, 0.76) | 0.001 |
| Hispanic[c] | 1.33 (0.47, 3.74) | 0.60 |
| NH Asian | 1.39 (0.98, 1.99) | 0.07 |
| NH Other | 0.87 (0.48, 1.55) | 0.63 |
| *Annual household income (vs < 35,000)* | | |
| 35,000–75,000 | 0.91 (0.76, 1.08) | 0.27 |
| 75,000–125,000 | 1.03 (0.85, 1.24) | 0.77 |
| >125,000 | 1.11 (0.89, 1.40) | 0.35 |
| *Home ownership (vs own)* | | |
| Rent | 1.15 (0.86, 1.55) | 0.35 |
| Other | 1.49 (0.83, 2.66) | 0.19 |
| *Employment status (vs retired)* | | |
| Working | 0.66 (0.46, 0.96) | 0.04 |
| Other | 0.83 (0.62, 1.96) | 0.19 |
| No household vehicle(s) (vs any) | 2.81 (1.95, 4.07) | <0.0001 |
| *Household size (vs 1)* | | |
| 2 people | 0.87 (0.69, 1.09) | 0.23 |
| 3 or more people | 0.98 (0.78, 1.21) | 0.84 |
| Medical condition resulted in giving up driving | 0.79 (0.50, 1.23) | 0.30 |
| Medical device used to walk | 0.49 (0.37, 0.65) | <0.0001 |
| *Housing units/mi² (US Census block group) (vs 0–499)* | | |
| 500–999 | 1.28 (0.95, 1.73) | 0.10 |
| 1,000–3,999 | 1.74 (1.18, 2.58) | 0.007 |
| 4,000–9,999 | 2.68 (1.73, 4.17) | <0.0001 |
| ≥10,000 | 4.72 (2.42, 9.21) | <0.0001 |
| *Renter-occupied housing (US Census block group) (vs 0–14%)* | | |
| 15–24% | 1.11 (0.76, 1.64) | 0.59 |
| 25–34% | 1.09 (0.79, 1.50) | 0.60 |
| 35–44% | 1.08 (0.88, 1.32) | 0.45 |
| 45–64% | 1.10 (0.87, 1.39) | 0.43 |
| 65–100% | 0.96 (0.73, 1.26) | 0.75 |
| *Workers/mi² (US Census tract) (vs 0–49)* | | |
| 50–249 | 1.06 (0.81, 1.38) | 0.68 |
| 250–999 | 0.98 (0.71, 1.37) | 0.92 |
| 1,000–1,999 | 0.78 (0.56, 1.09) | 0.15 |
| 2,000–999,999 | 0.76 (0.44, 1.29) | 0.31 |
| *Census region (vs South)* | | |
| Northeast | 1.14 (0.89, 1.46) | 0.32 |
| Midwest | 1.00 (0.81, 1.22) | 0.97 |
| West | 1.24 (1.00, 1.54) | 0.06 |
| Use bus or train at least a few times/month | 1.62 (1.22, 2.16) | 0.002 |
| *Season of travel diary day (vs Winter)* | | |
| Spring | 1.25 (0.94, 1.66) | 0.13 |
| Summer | 1.02 (0.68, 1.53) | 0.92 |
| Fall | 1.30 (0.98, 1.72) | 0.07 |
| Travel day on weekday (vs weekend) | 1.06 (0.94, 1.20) | 0.34 |

Source: 2017 National Household Travel Survey.
Abbreviations: HS = high school; OR = odds ratio; CI = confidence interval; vs = versus; NH = Non-Hispanic.
[a] Reported regression estimates were weighted to provide national estimates; [b] includes Hispanic; [c] Excludes African American/Black.

## Credit authorship contribution statement

**Lilah M. Besser:** Data curation, Conceptualization, Methodology, Writing - original draft, Supervision. **Lun-Ching Chang:** Methodology. **Jessica Kluttz:** Visualization, Writing - review & editing.

## Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

## Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.pmedr.2020.101291.

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