Original Contribution

Neighborhood Amenities and Mobility in Older Adults

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Diversity of neighborhood amenities may promote the mobility of older adults. A 2010 community-based sample of 510 adults aged ≥65 years in Philadelphia, Pennsylvania, and geospatial data from the Esri Business Analyst database (Esri, Inc., Redlands, California) were used to assess associations of neighborhood amenity diversity with mobility. Neighborhoods were defined by census tract, and diversity of amenities was derived by using the Leadership in Energy and Environmental Design’s neighborhood development index (US Green Building Council, Washington, DC). Generalized estimating equations adjusted for demographic, socioeconomic, and neighborhood characteristics were used to estimate differences in mobility score by tertile of amenity diversity. Analyses were stratified by participants’ routine travel habits (stayed at home, stayed in home zip code, or traveled beyond home zip code). We found that for those who spent most of their time in their home neighborhoods, mobility scores (from the Life-Space Assessment, which ranges from 0 to 104 points) were 8.3 points higher (95% confidence interval: 0.1, 16.6) among those who lived in neighborhoods with the most amenity diversity compared with those who lived in neighborhoods with the least amenity diversity. No significant associations between amenity diversity and mobility were observed for those who did not leave home or who regularly traveled outside their neighborhoods. Neighborhoods with a high diversity of amenities may be important promoters of mobility in older adults who do not routinely travel outside their neighborhoods.

aging; mobility limitation; residence characteristics

Abbreviations: LEED-ND, Leadership in Energy and Environmental Design Neighborhood Development; LSA, Life-Space Assessment.
community facilities (10). The system emphasizes diversity of amenities rather than the total number of establishments providing a single type of service.

Individuals who spend the most time in their home neighborhoods have the highest exposure to those neighborhoods and are most likely to be influenced by them. It is supposed that the home neighborhood plays a stronger role for older adults than it does for younger adults who spend time outside their home neighborhoods for work or school (11). However, the daily life patterns of older adults are not uniform, and the home neighborhood may not be of equal importance for all (11).

We used a community-based sample of 675 older adults living in 276 neighborhoods in Philadelphia, Pennsylvania, to assess the association between the diversity of amenities in the neighborhood (defined by census tract) and achieved mobility as measured by the Life-Space Assessment (LSA) (12). We also included spatially lagged independent neighborhood variables to account for effects from adjacent neighborhoods. We hypothesized that individuals living in neighborhoods with a greater diversity of amenities would have higher mobility scores, and that the strongest associations would be for those who do not regularly travel outside their home zip codes.

MATERIALS AND METHODS

This was a cross-sectional, multilevel analysis of associations of diversity of neighborhood amenities with mobility in older adults.

Study sample

The population-based Household Health Survey is conducted biennially in southeastern Pennsylvania by the Public Health Management Corporation (Philadelphia, Pennsylvania). Noninstitutionalized individuals are recruited by random digit telephone dialing stratified on 54 service areas to maintain geographic representativeness. The overall response rate for the 2010 survey was 24.5% (according to the American Association for Public Opinion Research’s response rate 3 method) (13); this was only marginally lower than those of other large population-based random digital dialing telephone surveys widely used in research (14). In 2010, participants aged ≥65 years in the city of Philadelphia were invited to participate in our Life-Space Mobility in Older Adults Substudy (n = 702). The participation proportion for the substudy was 74.1%.

All participants provided informed consent at administration of the survey. This substudy was approved by the institutional review board of Drexel University (Philadelphia, Pennsylvania).

Neighborhood definition

Census tract was the smallest geographical unit available to geocode participants and was used to define neighborhoods. The median area of a tract was 0.23 square miles (25th–75th percentile, 0.15–0.35 square miles) (1 square mile = 2.6 km²). All data used to characterize tract covariates were obtained from the 2010 US Census and the American Community Survey (15).

Amenity diversity

The “diverse uses” criterion from the LEED-ND was used to define amenity diversity (10). Amenities from 4 categories were included. The “food retail” category includes supermarkets, other food stores with produce, and farmers’ markets. The “community-serving retail” category includes clothing stores, convenience stores, hardware stores, pharmacies, and other retail. The “services” category includes banks, gyms or health clubs, hair care services, laundry or dry cleaning services, and restaurants or cafés. The “civic and community facilities” category includes senior care facilities, child care centers, community or recreation centers, cultural arts facilities, educational facilities, family entertainment venues (theaters or sports venues), government offices that serve the public on site, places of worship, medical clinics, police or fire stations, post offices, public libraries, public parks, and social services centers. Although not all amenities may be of direct relevance to older adults, they may capture abstract qualities of the neighborhood, such as the ability to meet one’s day-to-day needs and the sense of a complete neighborhood (16).

Point locations of all amenities except parks and farmers’ markets were obtained from the 2010 Esri Business Analyst database (Esri, Inc., Redlands, California), which compiles data from telephone directory listings, annual business reports, US Securities and Exchange Commission information, federal, state, and municipal government data, business magazines, newsletters and newspapers, and information from the US Postal Service (17). Previous research has estimated that the Esri database includes approximately 51% of all business types (18). The type of use was identified by using 9-digit North American Industry Classification System codes (19). Information on park locations was obtained from the City of Philadelphia’s 2012 park boundaries data file from Pennsylvania Spatial Data Access (20). Farmers’ markets were geocoded from a 2012 list of approved market sites from the City of Philadelphia. ArcMap, version 10, software (Esri, Inc.) was used for mapping and construction of neighborhood variables.

Diversity was calculated according to the LEED-ND algorithm by counting up to 2 occurrences of any particular amenity type in each neighborhood and then summing occurrences across the 27 types, resulting in a scale ranging from 0 to 54. Consistency of the amenity diversity score was adequate (Cronbach’s α = 0.79). Only parks were not positively correlated with the rest of the score (Pearson’s r = -0.03). However, removal of parks did not improve consistency (α = 0.80). Parks were therefore included in these analyses, but a sensitivity analysis excluding parks from the score was also conducted. The correlations of other amenity components with the total score ranged from 0.16 to 0.50. Various quantiles of amenity diversity based on the distribution for all tracts in Philadelphia were assessed; given the sample size and similar results with different cutoffs, we used tertiles of 2–17, 18–23, and 24–43.
Mobility

The LSA was used to measure mobility because it captures achieved function and incorporates aspects of mobility beyond the capacity to walk (12, 21). The LSA assesses the mobility of the respondent in the past month over 5 levels of distance: level 1, at home; level 2, in areas immediately outside the home such as yards or driveways; level 3, in the home neighborhood; level 4, in the home city beyond the home neighborhood; and level 5, beyond the home city. For each level of achieved mobility, respondents were asked how frequently they traveled to that area and whether they needed assistance from another person or from equipment (12). The LSA was modified for the current study by eliminating level 2 as described above because this level lacks relevance to many urban residents. Scores for distance traveled, frequency of travel, and the need for assistance were totaled to create an overall score for the current analyses; this method is the most highly correlated with physical performance (21). Total scores can range from 0 to 104, with higher scores indicating greater mobility. The validity and reliability of this assessment have been established in a population of older adults (12, 21). The internal consistency of the modified LSA was adequate ($\alpha = 0.77$).

Routine travel

Participants were asked, “What is the zip code of the place where you spend most of your time when you are not at home?” If a zip code was provided ($n = 309$), it was compared with the home zip code, or participants could indicate they did not regularly leave home ($n = 201$). Those who did not respond were considered missing. Routine travel was categorized as having stayed at home, stayed in the home zip code, or traveled outside the home zip code.

Statistical analysis

Neighborhood variables were either normally distributed or minimally skewed, and no differences were observed between parametric and nonparametric analyses; parametric statistics are reported. Associations of neighborhood and participant characteristics with tertiles of amenity diversity were calculated by using the analysis of variance test for continuous measures and the $\chi^2$ test for categorical measures. $P$ values are 2-sided.

Estimation of mean differences in mobility scores by neighborhood amenity diversity tertile used generalized estimating equations to account for nesting of individuals within tracts. The lowest tertile of amenity diversity was the reference for all analyses. Individual- and neighborhood-level covariates were chosen a priori and were included in all models. Neighborhood-level covariates were size (in square miles), population, percentage of adults over age 65 years, and median income. Individual-level covariates were age, sex, race, educational achievement, living arrangement, poverty status (above or below 200% of the poverty level), difficulty with housing costs, and home ownership. Effect modification of the association between amenity diversity and mobility was assessed for routine travel. We used SAS, version 9.2, software (SAS Institute, Inc., Cary, North Carolina) for all statistical analyses.

Analyses were performed to assess the interactions of amenity diversity with a spatially lagged independent variable that represented the average amenity diversity in adjacent tracts (22) (Web Appendix). GeoDa, version 1.2, software (GeoDa Center for Geospatial Analysis and Computation, Tempe, Arizona) was used to construct spatial lag variables (23).

To avoid collinearity in regression models, the Pearson correlations of neighborhood covariates with amenity diversity and between index neighborhood variables and lagged counterparts were assessed; no variables had correlations greater than 0.8, and all were retained.

Sensitivity analyses to assess the potential effects of length of residency in a neighborhood were conducted by removing individuals with less than 5 years of residency ($n = 65$) and those for whom mobility data were missing ($n = 124$). Because of missing data of the modifier, comparisons were made between those with missing data and those without, and analyses were conducted assuming these individuals were missing data either because of nonresponse from not leaving home routinely or from routinely traveling beyond their home zip codes but not knowing the zip code they visited. In addition, the final model was rerun with removal of parks from the amenity diversity score.

RESULTS

These analyses included 674 individuals for whom complete mobility and census tract data were available (96% of substudy participants; 27 with missing mobility data and 1 with missing census tract data). The included participants did not differ in age, race, poverty status, home ownership, or living arrangement compared with the total 2010 Philadelphia census population aged $\geq 65$ years ($P \geq 0.05$). Participants in this sample were more likely to be female ($P < 0.001$), less likely to be married ($P = 0.002$), and more likely to be better educated ($P < 0.001$) than were those in the older Philadelphia population. We were missing data on routine travel for an additional 136 individuals; therefore, 510 individuals were included in these analyses. Individuals for whom travel data were missing were not different in mobility, demographic, socioeconomic, or health variables compared with those in the sample for whom travel data were available (all $P \geq 0.1$).

Of the 373 residential tracts in Philadelphia, 276 were home to study participants and were included in these analyses. Included tracts did not differ from excluded tracts on amenity diversity ($P = 0.9$). However, included tracts were smaller in area and population size than were excluded ones ($P < 0.001$) and had lower median age and median income of residents than did excluded tracts ($P < 0.001$).

At the tract level, amenity diversity was associated with total population but not with area, median income, or median age (Table 1). Amenity diversity was associated with several individual-level characteristics (Table 2). Those living in neighborhoods in the middle tertile of amenity diversity had the lowest mobility. Participants of minority race or whose income was below 200% of the federal poverty
level were most likely to live in neighborhoods with low amenity diversity. Home ownership was highest in neighborhoods with low amenity diversity. Routine travel outside the home was associated with younger age, higher level of education, and lower likelihood of living in poverty (Table 3).

In adjusted analyses, no association was observed between amenity diversity and mobility (mean difference for the lowest tertile vs. the middle tertile = −2.2, 95% confidence interval: −6.5, 2.2; mean difference for the lowest tertile vs. the highest tertile = 3.2, 95% confidence interval: −1.5, 7.9). Effect modification was observed by routine travel habits (P for interaction = 0.05). Among individuals who spent most of their time within their home zip codes, the highest mobility was observed for those living in neighborhoods in the highest tertile of amenity diversity (mean difference = 8.3, 95% confidence interval: 0.1, 16.6) with approximately equal mobility for those in the middle tertile compared with the lowest tertile (mean difference = −1.7 for the middle tertile, 95% confidence interval: −10.0, 6.6). No association was observed for those who did not regularly leave home or for those who routinely spent time outside their home zip codes (Table 4).

There were no significant interactions between amenity diversity and the spatially lagged counterpart (all P ≥ 0.1). No difference in the association between amenity diversity and mobility was observed in any of the following sensitivity analyses: the inclusion of those with missing routine travel data as either those who stayed at home or as those who traveled beyond their home zip codes; the exclusion of those who had lived in the neighborhood fewer than 5 or 10 years; and the exclusion of parks from the amenity diversity score (data not shown).

**DISCUSSION**

In a community-based sample of older adults, associations between neighborhood amenity diversity and mobility differed by routine time spent in the home zip code. For older adults who spent a majority of time within their home zip codes, living in a neighborhood in the highest tertile of amenity diversity was associated with greater mobility. There was no association between amenity diversity and mobility for those who regularly traveled outside their home zip codes or for those who did not routinely leave home. The increased mobility seen in the highest tertile of amenity diversity among those who stayed within their home zip codes represented an 8% difference in total mobility. This was approximately equal to the association seen for each of the individual-level socioeconomic indicators (poverty status, home ownership, and difficulty with housing costs) in the multivariable analysis. Although no guidelines have been developed for interpretation of LSA score differences, previous studies demonstrated that a change as low as 3 points can be clinically meaningful (24).

Although neighborhood characteristics may become more important in determining health and well-being as we age (25), these results indicate that this association may not be uniform for all older individuals. The local neighborhood environment is likely most important in determining mobility for those who spend the most time there. It is recognized that definitions of “neighborhood” used in research do not always align with the places in which people spend the majority of their time or meet their daily needs (26, 27). For some individuals, the home neighborhood may not be the most relevant in determining their levels of mobility, and the neighborhoods in which people routinely spend time may be very different from their home neighborhoods (28). The measure of routine time in the home neighborhood that was collected as part of the Household Health Survey was based on zip codes, whereas our analysis defined neighborhood boundaries by census tracts. We found this crude measure of activity space to be an important modifier; future studies should incorporate versions of this question that are consistent with their definitions of neighborhood.
We observed an association between amenity diversity and mobility only at the highest tertile of amenity diversity (a score of ≥24). The LEED-ND guidelines provide cutoffs to define levels of diverse use and define the highest level as neighborhoods with scores of 19 or higher (10), which is approximately equivalent to our middle tertile, at which we saw no association. This may indicate that, at least for older urban populations, the currently suggested cutoffs may not be adequate. Our highest tertile of amenity diversity represents a high level of diverse use that may not be achieved in other geographic regions, particularly nonurban ones.

This is the first study of neighborhood amenities and mobility in the elderly that used a measure of amenity diversity such as the LEED-ND or a global measure of mobility such as the LSA. Previous studies have focused on walking with an emphasis on physical activity (8) and have suggested a positive association between neighborhood destinations and walking. Several studies have reported positive associations between destinations within a neighborhood and walking (29–34), physical activity (35, 36), or pedometer readings (37) in older adults. In contrast, studies have also reported no association or an association in the opposite of the expected direction (38–40). The specific destinations included in these analyses have varied greatly (Web Table 1). Two studies (39, 40) used the Neighborhood Environment Walkability Scale, which is comprehensive but uses self-reports, which may differ substantially from objective measures and are subject to individual-level differences.
in perception (27, 35). Other studies used proxies for amenities that were positively associated with neighborhood walking (41, 42). The LEED-ND amenity diversity measure provides a comprehensive list of destinations with an emphasis on diversity of amenities rather than total number; promoting diversity of amenities that allow individuals to meet daily needs within neighborhoods creates a sense of neighborhood completeness (10). Amenity diversity can be encouraged through zoning codes that guide land use and through tax abatements to stimulate and retain retail establishments (43). Given the lack of consistency in measures of the built environment, the use of a policy-relevant measure like the LEED-ND rather than total amenity counts should be considered in future research.

The LSA is a standardized measure of achieved mobility that assesses the spatial area traveled by individuals as part of their daily routines over specified periods of time (12, 21). It may be particularly useful in studying environmental determinants of mobility because it can capture mobility limitations and disabilities that include but are not limited to those that affect walking (12) and can capture any mode of transport. There is evidence that neighborhood destinations increase transit use among older adults (31).

Similar to many other studies in the field of neighborhood effects research (44, 45), this study used census tracts as proxies for the spatial boundaries of neighborhood influence. Philadelphia census tracts are fairly small and uniform in size. Census tracts are roughly equal in size to people’s perceptions of their neighborhoods but rarely match the boundaries of an individual’s self-defined neighborhood (46). We observed no significant interactions between amenity diversity of an individual’s home tract and the average amenity diversity of the surrounding tracts. This indicates that associations did not depend on the level of amenity diversity in nearby tracts. Spatially lagged independent variables take advantage of spatially complete exposure data even when outcome data are spatially incomplete, as occurs in many epidemiologic studies. Most commonly used spatial analysis methods rely on spatially continuous outcome data. Spatially lagged independent variables have been used primarily in econometrics and ecology (22); further work is needed to refine their use in epidemiologic analyses.

Because this was a cross-sectional study, we cannot account for neighborhood selection effects. Sensitivity analyses that excluded individuals who lived in their neighborhoods for fewer than 5 or 10 years did not result in qualitatively

### Table 3. Characteristics of 510 Adults Aged ≥65 Years in 276 Census Tract Neighborhoods by Routine Travel Habits, Philadelphia, Pennsylvania, 2010

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Stays at Home (n = 201)</th>
<th>Stays in Home Zip Code (n = 152)</th>
<th>Travels Beyond Home Zip Code (n = 157)</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean (SD) No. %</td>
<td>Mean (SD) No. %</td>
<td>Mean (SD) No. %</td>
<td></td>
</tr>
<tr>
<td><strong>Mobility score</strong></td>
<td>38.4 (24.7) 153 76.1</td>
<td>51.5 (24.8) 98 64.5</td>
<td>59.4 (21.5) 120 76.4</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td><strong>Age, years</strong></td>
<td>75.6 (7.4)</td>
<td>74.8 (6.7)</td>
<td>73.0 (6.7)</td>
<td>0.002</td>
</tr>
<tr>
<td><strong>Female sex</strong></td>
<td></td>
<td></td>
<td></td>
<td>0.02</td>
</tr>
<tr>
<td>White</td>
<td>90 45.7</td>
<td>84 55.3</td>
<td>85 55.6</td>
<td>0.3</td>
</tr>
<tr>
<td>Black</td>
<td>94 47.7</td>
<td>59 38.8</td>
<td>61 39.9</td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>13 6.6</td>
<td>9 5.9</td>
<td>7 4.6</td>
<td></td>
</tr>
<tr>
<td><strong>Race</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lives alone</td>
<td>96 48.0</td>
<td>85 56.3</td>
<td>82 52.6</td>
<td>0.3</td>
</tr>
<tr>
<td><strong>Lives alone</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt; High school</td>
<td>57 28.5</td>
<td>26 17.1</td>
<td>18 11.5</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>High school graduate</td>
<td>80 40.0</td>
<td>64 42.1</td>
<td>61 38.9</td>
<td></td>
</tr>
<tr>
<td>&gt; High school</td>
<td>63 31.5</td>
<td>62 40.8</td>
<td>78 49.7</td>
<td></td>
</tr>
<tr>
<td><strong>Below 200% poverty</strong></td>
<td>116 57.7</td>
<td>75 49.3</td>
<td>50 31.9</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Has difficulty with housing costs</td>
<td>80 41.0</td>
<td>57 38.3</td>
<td>56 36.1</td>
<td>0.6</td>
</tr>
<tr>
<td>Owns home</td>
<td>138 71.9</td>
<td>113 76.4</td>
<td>123 79.9</td>
<td>0.2</td>
</tr>
<tr>
<td>Car as primary transportation</td>
<td>134 66.7</td>
<td>106 69.7</td>
<td>103 65.6</td>
<td>0.7</td>
</tr>
<tr>
<td>Public transit as primary transportation</td>
<td>37 18.4</td>
<td>32 21.1</td>
<td>37 23.6</td>
<td>0.5</td>
</tr>
</tbody>
</table>

Abbreviation: SD, standard deviation.

- Mobility was assessed by the Life-Space Assessment (Peel C, et al. Phys Ther. 2005;85(10):1008–1119) (12), which uses a scale of 0–104 points. Higher scores indicate higher mobility.
- Poverty status was based on income and household size and was determined by using the US federal poverty guidelines.

different results, suggesting that results may not have been due to those with mobility limitations moving to neighborhoods with higher amenity diversity. The observed association could also be due to unmeasured confounders or error in our exposure measurement based on limitations of the Esri Business Analyst database (18). Similar to other databases, the Esri database has been shown to underestimate counts of amenities (18). Given that we were counting only 2 of the total occurrences of an amenity, we were unlikely to have misspecified the counts for common amenities, but our estimate of the total score may have been conservative from mispecification of less common amenities.

is unknown whether this would have been differential by either amenity diversity or mobility, but reliability of the database is not associated with neighborhood sociodemographic characteristics (18). In addition, we analyzed diversity in tertiles, so minor errors in estimates may not have affected diversity classification. Finally, this study was conducted in a large, urban area in the northeastern United States and may not be generalizable to other geographical regions, particularly suburban and rural environments.

Strengths of this study include the use of a comprehensive, theory-based measure of amenity diversity and a measure of achieved mobility. Stratifying our sample by routine travel habits allowed us to better assess the association of neighborhood amenities with mobility on the basis of an individual’s exposure to those amenities.

Maintenance of mobility in older adults is an important public health priority in that it allows older adults to live independently, promotes physical and mental health, and reduces the likelihood of disability and institutionalization. Amenity diversity should be the focus of policy efforts (43). These findings provide evidence that neighborhoods with diverse amenities are not likely to promote mobility among all seniors, but could promote mobility among those who spend a majority of their time within those neighborhoods.

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