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Neighborhood built environment and cognition in non-demented older adults: The Multi-Ethnic Study of Atherosclerosis

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ABSTRACT

Preliminary studies suggest that neighborhood social and built environment (BE) characteristics may affect cognition in older adults. Older adults are particularly vulnerable to the neighborhood environment due to a decreasing range of routine travel with increasing age. We examined if multiple neighborhood BE characteristics are cross-sectionally associated with cognition in a diverse sample of older adults, and if the BE-cognition associations vary by individual-level demographics. The sample included 4539 participants from the Multi-Ethnic Study of Atherosclerosis. Multivariable linear regression was used to examine the associations between five BE measures and four cognitive measures, and effect modification by individual-level education and race/ethnicity. In the overall sample, increasing social destination density, walking destination density, and intersection density were associated with worse overall cognition, whereas increasing proportion of land dedicated to retail was associated with better processing speed. Effect modification results suggest that the association between urban density and worse cognition may be limited to or strongest in those of non-white race/ethnicity. Although an increase in neighborhood retail destinations was associated with better cognition in the overall sample, these results suggest that certain BE characteristics in dense urban environments may have a disproportionately negative association with cognition in vulnerable populations. However, our findings must be replicated in longitudinal studies and other regional samples.

1. Introduction

Cognitive impairment, present in ≥10% of adults 65 years and older (Unverzagt et al., 2001), is associated with lower quality of life (Muangpaisan et al., 2008) and increased nursing home placement (Gaugler et al., 2007). The impending rise in the population of older adults (US Census) will be accompanied by an increase in the prevalence of cognition impairment, calling for strategies to address the associated economic, health, and social burden. Interventions focused on improving diet and reducing vascular risks may simultaneously delay the onset of cognitive impairment (Nelson and Tabet, 2015). Additionally, there is emerging recognition that residential environments are important in shaping health behaviors and health outcomes (Koohsari et al., 2015; Sallis et al., 2009). For example, lower neighborhood socioeconomic status has been associated with worse cognition in older adults in previous studies (Clarke et al., 2012). Older adults may be particularly influenced by their neighborhood environment due to a smaller range of routine travel and thus increased exposure to proximal environments (Marottoli et al., 2000). Therefore, policies that promote a safe and walkable neighborhood environment may help older adults age in place and delay the onset of cognitive impairment by providing an environment that is socially and mentally engaging (Cassarino and Setti, 2015) and supportive of a healthy lifestyle (Clarke et al., 2012).

The neighborhood built environment (BE) comprises all of the physical aspects of the environment (Oxford University Press)

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surrounding the home, including the road network, buildings, sidewalks and bike paths, parks and public spaces, and amenities such as lighting. The mechanisms by which the neighborhood BE affects cognition are likely complex and multifaceted, and thus the direction of the associations may depend on individual-level characteristics and the BE features under consideration. BE-cognition associations have been explored little to date, with prior studies providing little explication on likely mechanism(s) for any observed associations. Below we outline a number of causal mechanisms, each of which may individually or jointly help explain associations between a specific BE characteristic and cognition.

The neighborhood BE may influence health behaviors such as physical activity (PA) and diet, factors that have been associated with cognition (Boone-Heinonen et al., 2011; Groot et al., 2016). Additionally, urban environments may be associated with increased vehicular pollutant exposure due to decreased distances to busy roadways (Buonocore et al., 2009) and decreased air ventilation created by buildings (Yuan et al., 2014). Airborne pollutants (Power et al., 2011) have been associated with worse cognition and brain structure in older adults. Neighborhoods with more social engagement opportunities may improve well-being and decrease stress, anxiety, and depression, consequently improving cognition. On the other hand, neighborhood psychosocial disorder (e.g., crime, graffiti), fear of falls, and sensory overload (e.g., confusing spaces, noise, crowds) may increase social isolation (Aneshensel et al., 2011; James, 2009) and negatively impact cognition if residents minimize time spent in the neighborhood. In addition, neighborhood BE factors such as land use mix, population density, traffic, and noise may improve or worsen quality of life and associated mental health outcomes (e.g., stress) (Fassio et al., 2013; Sarmiento et al., 2010; Stansfeld et al., 1996), thereby affecting cognition. Stress in late-life has been associated with worse cognition in older adults (Aggarwal et al., 2014) and a decrease in stressors has been associated with improved cognition (Dickinson et al., 2011). Lastly, neighborhood BEs may provide cognitive stimulation, which can either improve cognition or cause cognitive overload that worsens cognition. Living in a complex neighborhood environment in older age may provide mental stimulation that helps delay cognitive decline by requiring constant but passive adaptation (Cassarino and Setti, 2015). However, the neighborhood BE may cause cognitive overload (Lindenberger et al., 2000) among those with physical or mental disabilities or cognitive impairment.

The few published studies on the BE and cognition in older adults found associations between cognition and the presence of a community center or transit stop, condition of public spaces, distance to community resources, street connectivity, land use mix, and area dedicated to the natural environment (Besser et al., 2017; Wu et al., 2017). Some but not all of these studies suggest a positive association between increasing urban density and better cognitive functioning. However, the types of BE and cognitive measures used and methods of defining neighborhoods differed markedly in the studies, and additional work is needed to narrow down the BE features that may have the greatest influence on cognition, to examine potential effect modifiers, and to investigate associations in diverse samples.

In this study, we examine if five neighborhood BE characteristics representing increased density, street accessibility, and land use mix, typically consistent with increasing urban density/less sprawl (Smart Growth America), are associated with better cognition. We additionally aimed to investigate if the BE-cognition associations vary by individual-level education or race/ethnicity, characteristics previously found to modify the association between neighborhood SES and health (Merkin et al., 2009; Wight et al., 2006). We focused on density of social destinations, walking destinations, and intersections, as well as proportion of land dedicated to residences and retail, because similar measures have been associated with walking in older adults (Cerin et al., 2013; Hall and McAuley, 2010; Li et al., 2005; Michael et al., 2006; Troped et al., 2017), aiming to investigate characteristics that are simultaneously associated with PA and cognition. Urban planners consider diverse implications of plans and policies, including economic, social, environmental, and health-related considerations. Therefore, it will be useful for studies to narrow down specific BE characteristics that may benefit multiple aspects of health (e.g., PA and cognition), to strengthen arguments for future plans and policies aimed at improving health.

2. Materials and methods

2.1. Sample

The analytic sample originated from 4716 participants who completed Exam 5 (2010–2012) of the Multi-Ethnic Study of Atherosclerosis (MESA), a longitudinal, population-based cohort study of subclinical cardiovascular disease. MESA has completed five exams since 2000, with a sixth exam currently underway. Participants aged 45- to 84-years-old were enrolled from six US regions (Forsyth County, North Carolina; New York, New York; Baltimore, Maryland; St. Paul, Minnesota; Chicago, Illinois; Los Angeles, California) and individuals of African American, Chinese, and Hispanic race/ethnicity were oversampled. Details about MESA have been published previously (Bild et al., 2002). The final sample excluded those (n = 357) who: 1) were missing all cognitive test scores; 2) were missing all BE measures; 3) were taking Alzheimer's disease medication at any exam (acetylcholinesterase inhibitors or *N*-methyl-D asparate receptor blocker); 4) had an International Classification of Disease (ICD) code suggesting dementia in death certificate and hospitalization records (Fujiyoshi et al., 2016); or 5) had a Cognitive Abilities Screening Instrument (CASI) score < 20, which lacks face validity.

2.2. Cognitive measures

MESA's Exam 5 was the only available exam that included cognitive measures (Fitzpatrick et al., 2015). The cognitive tests included: 1) the CASI (Teng et al., 1994) (version 2), a brief test of global cognition (range: 0–100); 2 and 3) Digit Span Forward (DSF) and Backward (DSB) (Wechsler Adult Intelligence Scale subtests [WAIS-III] (Wechsler, 1997)) (ranges: 0–16, 0–14, respectively), measures of attention, short term and working memory; and 4) Digit Symbol (DS; subtest of WAIS-III (Wechsler, 1997)), a measure of processing speed (range: 0–133). For the regression analyses, z-scores were calculated for each neuropsychological test by subtracting an individual's score from the entire sample's mean score and dividing the difference by the entire sample's standard deviation. The BE may influence certain aspects of cognition more than others (e.g., processing speed versus short-term memory), and therefore, each of the four cognitive tests were included separately in our analyses because they capture different cognitive domains.

2.3. Built environment measures

The neighborhood measures were originally developed as part of the MESA Neighborhood Study (Diez Roux et al., 2016). Land parcels for each study site were classified as residential (e.g., family homes, apartment complexes/condominiums) or retail (e.g., shopping centers, clothing stores), and the percent of the ¼-mile, ½-mile, and 1-mile buffers dedicated to residences or retail was calculated by dividing the residential/retail area by the total buffer area (Rodríguez et al., 2009). Intersection density was determined by dividing intersection counts (excluding culs-de-sac) for the ¼-mile, ½-mile, and 1-mile buffer by the total buffer area. The densities of social engagement (e.g., beauty shops/barbers, performance-based entertainment) and walking destinations (e.g., postal services, non-beverage eating/dining places) per square mile were calculated for the ¼-mile, ½-mile, and 1-mile area around the home using 2010 National Establishment Time Series (NETS) business data. Neighborhood SES, based on US Census