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Neighborhood resources and risk of cognitive decline among a community-dwelling long-term care population in the U.S.

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ABSTRACT

Objective: To examine the associations between neighborhood resources (i.e., number of restaurants, recreation centers, or social services for seniors and persons with disability per land area) and cognitive decline among a community-dwelling long-term care population and whether they differ by baseline cognition status.
Study design: Prospective longitudinal cohort study.
Methods: We used a longitudinal dataset that assessed over a two-year period older adults receiving state-funded home- and community-based services in Michigan Metropolitan areas (N = 9,802) and applied nonlinear mixed models with a random intercept with Poisson distribution.
Results: Cognitively intact older adults were less likely to experience cognitive decline when they resided in resource-rich neighborhoods, compared to those cognitively intact but living in neighborhoods that lacked resources. But their cognitively impaired or dementia-diagnosed counterparts did not similarly benefit from living in neighborhoods with rich resources.
Conclusions: Neighborhood resources may be an important aspect of intervention to mitigate cognitive decline before older adults become cognitively impaired.

1. Introduction

By 2050, more than 152 million people are projected to be living with Alzheimer's disease and related dementias (ADRD) worldwide, including 10 million people in the United States [1]. Largely resulting from a policy shift from institutional long-term care to community-based care in the U.S., Home- and Community-Based Services (HCBS) play an increasing role in the US health care system serving older adults at a high risk of ADRD and older adults living with ADRD [2]. In 2018, about 4.8 million individuals received Medicaid HCBS with joint federal and state spending totaling $92 billion [3], surpassing the Medicaid spending on institutional care [4]. Despite the growing share of HCBS spending, older adult recipients of HCBS, who have multimorbidity and overlapping disabilities [5] and thus a greater risk of cognitive decline, remain an understudied population. It is critical to understand whether and how community contextual features are associated with cognitive decline.

Primarily focusing on a cognitively healthy sample of older adults, prior studies documented that some aspects of neighborhood environments provide cognitive benefits [6–11]. Built environment features, such as residential blocks having community centers or public transit stops [9] and active aging infrastructures [10], may prevent cognitive decline by providing cognitively stimulating environments [12], and promoting active participation in physical activities [9,13,14] and social engagement [15,16].

The sociological literature on third places [17] or activity space [18] provides insights into how informal gathering places, such as local restaurants, clubs, or recreational facilities, contribute to a richer social experience that could provide cognitive benefits to older adults. Attributes of third places, such as facilitating unstructured and unscheduled activities, and not requiring a formal membership or significant monetary spending to occupy the space, provide value to residents (more so in low-income neighborhood settings) to socially interact [19]. In *Slim's Table*, Duneier (1992) illustrates restaurants as important local gathering places for the maintenance of social connections among working-class Black men [20]. Recreation centers also contribute to the cultivation of social connections by engaging residents in social and physical activities through designated programming [21]. Living in

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neighborhoods with dense services for older adults, such as senior centers and adult day care centers, could also directly benefit older adults, as these services offer active engagement opportunities and services tailored to older adults. Such services might be particularly relevant for older adults with functional and cognitive impairment [22]. While previous studies have primarily focused on cognitively healthy older adults, little research has examined whether cognitively impaired older adults might similarly benefit from rich neighborhood resources.

The goal of this study was to examine potential differences in the cognitive benefits of neighborhood resources among older adults with diverse levels of cognitive function. We leveraged a comprehensive longitudinal dataset that assessed health and social conditions of older adults, including those with cognitive impairment or having diagnosed dementia, who are not often represented in surveys. We focused on three types of neighborhood resources, whose data are readily available through Statistics of U.S. Businesses.

1.1. Research methods

The study design is a prospective longitudinal cohort study.

1.2. Data and study sample

Michigan inter Resident Assessment Instrument (interRAI)-Home Care (2008–2014) is an enumerative database of persons living in the state of Michigan using public home- and community-based services. Like most states, Michigan offers HCBS to eligible persons through various federal-, state, and county-funded programs, including the Medicaid 1915(c) HCBS waivers and aging services based on amendments to the 1965 Older Americans Act. Nursing and Social Work care management teams gather comprehensive social, functional, medical/clinical information of participating individuals at intake and follow-up assessments every 90–180 days [23].

Using the participant's baseline ZIP Code information, we merged individual data with the 2012 County Business Patterns (CBP) database. CBP offers ZIP Code-level subnational economic data, using 6-digit North American Industry Classification System (NAICS) codes. Using the existing relationship file [24], we cross-walked ZIP Code and ZIP Code Tabulation Areas (ZCTA) to obtain other contextual data from American Community Survey (ACS) 5-year estimates (2008–2012) and the 2010 Centennial Census.

A total of 24,239 people were enrolled in Michigan HCBS programs between 2008 and 2012. We focused on metropolitan participants aged 55 and older with full residential ZIP Code information who had at least two outcome assessments during the follow-up (n = 12,822). We excluded 805 individuals who resided in institutions during the observation period (2008–2014), 417 without baseline residential status information, and 565 with missing values on either the Cognitive Performance Scale (CPS) or dementia diagnosis status at baseline. Finally, we excluded 1,179 participants with moderately severe or severe cognitive impairment at baseline, measured as a CPS score of 4 or higher to focus on the early stages of the cognitive decline process. Our analytic sample included 9,802 individuals followed up to two years (58,152 observation points, corresponding to an average of 4 assessment visits (SD = 2.38) for each individual).

1.3. Measurements

1.3.1. Outcome: interRAI Cognitive Performance Scale (CPS)

InterRAI CPS (range 0–6) captures the magnitude of the person's loss in everyday cognitive performance—from independent (problem-free, fully cognitively intact) to fully dependent (unable to make decisions, follow instructions, or recall what has just occurred) [25]. This measure modeled the Mini-Mental State Examination and has been cross-validated in nursing home and home care settings [26,27]. Case-workers assessed participants' clinical states based on communication with the person and primary caregiver (if available), direct observation, and the secondary documents (e.g., physician's note) review [23].

1.3.2. Baseline cognitive status

Participants were grouped into three cognitive status groups (cognitively intact, minimally or moderately impaired, and dementia) based on baseline assessment. The cognitively intact group included older adults whose CPS was 0; the impaired group included those with CPS between 1 and 3; the dementia group included individuals who reported having a dementia diagnosis from physicians.

1.3.3. Exposures

We included the density of three organization types [1]: restaurants and other eating places (NAICS 7225) [2], fitness and recreational sports centers (NAICS 71394), and [3] services for the elderly and persons with disability (NAICS 624120), which consisted of organizations primarily providing non-residential social assistance to improve the quality of life for the elderly, the developmentally handicapped, or persons with disability, and included senior centers, adult day-care, and non-medical home care. We divided the total count of establishments by the size of the ZCTA land area, creating a density measure. Previous studies avoided the uncertain geographic context problem [28] by using 0.5–1-mile radius of participants' residential address as denominators [29,30], which are not available in this study.

1.3.4. Covariates

We included baseline age, sex, race/ethnicity (categorized as Non-Hispanic White, Non-Hispanic Black, and Hispanic and additional race/ethnic groups), and residential housing type (private housing versus supportive housing). Physical functioning was assessed using Activities of Daily Living (ADL) Scale (range 0–28) [31], which captures the extent of dependency on seven individual items (e.g., bed mobility, dressing, eating). For mental health conditions, we used Depression Rating Scale (range 0–14) [32], which measures the frequency of seven symptoms (e.g., crying or tearfulness, the expression of what appears to be unrealistic fears).

As neighborhood-level covariates, we included three sociodemographic characteristics. Socioeconomic disadvantage index averaged five neighborhood composite variables: poverty, education (less than a high school degree), household income (less than $15,000 annually), welfare receipt, and unemployment (Cronbach's alpha = 0.82). Age structure was proxied by the proportion of individuals 65 years and older. Population density was measured as the number of residents dived by the land area and log-transformed to correct skew.

1.4. Statistical analyses

We developed three analytic models for each type of neighborhood resource exposure. We used three-level nonlinear mixed models with a random intercept to account for correlations among repeated observations within an individual and neighborhood. We fitted models using the Poisson distribution given that the outcome is a count of impairment in multiple domains with discrete values (with excessive lower value counts), and that residual diagnostics from linear mixed regression models showed a non-random pattern of residuals. In estimating the associations between neighborhood organizational resources and CPS over time, we excluded the baseline outcome assessment as it was used to generate comparison groups. Conditioning on baseline health (e.g., in the form of stratification) may result in a biased estimate of the exposure and cognitive decline associations [33]. Thus our model estimates the first follow-up assessment and changes in the logarithm of the expected number of impairments (i.e., incidence rate ratio or IRR) by the unit change in neighborhood resource density (i.e., cross-level interactions) [34]. We examined the differential association between the neighborhood resources and the change in cognitive performance by cognitive status group by including three-way interaction terms (i.e., time,

neighborhood exposure, and baseline cognitive status). We adjusted for individual-level and neighborhood-level confounders listed above. We modeled physical function and mental health conditions as time-varying variables.

To improve interpretability, neighborhood variables were centered by grand-mean values and rescaled time into 6 months. We did not use weights, as these data were the enumeration of all HCBS participants. Analyses were performed with Stata 15.0.

1.4.1. Follow-up and lost cases

68.53% of the sample remained at the end of the first year, and 42.20% remained at the end of the second year. Such attrition could introduce bias in our estimates of neighborhood resources on cognitive decline associations unless reasons for attritions can be inferred from the data [35]. Neighborhood resource measures were not associated with attrition. We adjusted for individual characteristics such as age and physical function in the main analyses, which also explained the attrition.

2. Results

Table 1 presents the descriptive statistics of the study sample stratified by baseline cognitive status. The first follow-up CPS scores for cognitively intact, minimally or moderately impaired, and the dementia group were 0.09, 1.73, and 2.51, respectively. Participants in the cognitively intact group were, on average, 73 years old at baseline; the average ages of the minimally or moderately impaired group and dementia group were 75 and 80 years old, respectively. In our sample, the cognitively intact group had a relatively higher proportion of Non-Hispanic Black participants (31%, compared to about 28% in the other two groups) and a smaller number of residents living in supportive housing (2%, compared to about 7–15% in the other two groups) versus private homes (98%, compared to about 93–85% in the other two groups). The cognitively intact group also had fewer ADL limitations and depressive symptoms.

Across all three groups, the average number of restaurants per square mile was 3 or more, while the number of recreation centers averaged 0.13–0.14 per square mile, and the number of social services averaged 0.21–0.23 per square mile. The cognitively intact group lived in neighborhoods of greater socioeconomic disadvantage on average (mean 16.01) compared to the impaired (mean 13.55) and dementia (mean 13.72) groups. Neighborhoods in this study had on average 13% older adults (i.e., over age 65), and average densities of 2,171 people per square mile.

Table 2 presents estimates of the association between each type of neighborhood resource and the first follow-up cognitive performance and changes over time. We focused on reporting the changes of CPS given that the associations between neighborhood resources and levels of cognitive performance may likely reflect the results of residential sorting that occurs during later life (e.g., older adults with poor health may be selected into neighborhoods with dense social service organizations). For each additional 6 months of follow-up, participants on average had a 74% increase in the expected number of cognitive impairments.

We found some evidence of differential patterns in the association between neighborhood resources and cognitive decline by older adults' baseline cognitive status (Table 2). In a model using the density of restaurants as a key predictor, the expected number of cognitive impairments decreased by a factor of 0.99 (95% CI (hereafter, CI) 0.99–1.00), or 1% in every 6 months for the cognitively intact group, for each unit increase in the density of restaurants. Recreation center density also showed a similar pattern, explaining the lower likelihood of cognitive decline in the cognitively intact group (IRR 0.87, CI 0.76–0.99). Social service density was also associated with an expected decrease of cognitive impairment counts for every 6 months of change (IRR 0.93, CI 0.87–1.00).

Estimates of three-way interaction terms among time, resource density, and cognitive impairment status were positive (e.g., restaurant IRR 1.01, CI 1.00–1.01; fitness/recreation centers IRR 1.14, CI 0.99–1.31; social service IRR 1.08, CI 1.00–1.16 for impaired group compared to cognitive intact group), although estimated confidence intervals were close to null (Table 2). This suggests that poorer baseline

Table 1
Sample characteristics by baseline cognitive status.

	Total	SD	Cognitively Intact	SD	Mildly or Moderately Impaired	SD	Diagnosed with Dementia	SD	P value
	(N = 9,802)		(N = 3,180)		(N = 4,052)		(N = 2,570)		
	Mean or %		Mean or %		Mean or %		Mean or %		
Neighborhood Characteristics									
Number of restaurants per square mile	3.21	4.38	3.25	4.73	3.30	4.46	3.02	3.74	
Number of recreation centers per square mile	0.14	0.23	0.13	0.23	0.14	0.23	0.14	0.21	*
Number of social services per square mile	0.23	0.40	0.23	0.45	0.24	0.40	0.21	0.31	*
Disadvantage Index	15.20	10.57	16.40	11.34	14.88	10.10	14.21	10.16	***
Proportion of individuals over 65	13.60	3.17	13.52	3.12	13.56	3.21	13.79	3.18	**
Population density per square mile	2171.23	2086.36	2292.23	2180.27	2162.36	2055.35	2035.49	2006.58	**
Individual Characteristics									
Follow-up Cognitive Performance Scale (CPS) (0–6)	1.40	1.20	0.09	0.37	1.73	0.80	2.51	0.88	***
Race/Ethnicity									**
Non-Hispanic White (Reference)	64.72		62.55		65.55		66.11		
Non-Hispanic Black	29.00		31.57		27.94		27.51		
Hispanic and additional Groups	6.07		5.72		6.39		5.99		
Age	75.64	10.73	72.73	10.26	74.95	10.99	80.33	9.22	***
Female	72.41		75.69		70.71		72.41		***
Residential environment (Reference Private home)									***
Supportive housing	7.17		1.86		6.56		14.71		
ADL dependency score (0–28)	6.61	7.15	5.41	6.69	7.16	7.41	7.23	7.09	***
Depressive symptoms (0–14)	1.09	1.83	0.72	1.46	1.20	1.93	1.37	2.02	***

Note: ***$p < 0.001$; **$p < 0.01$; *$p < 0.05$.

Table 2
Estimates for relative institutional resource density as a key predictor of cognitive impairment by resource types.

	Restaurants			Fitness/Recreation Centers			Social Services		
	IRR	CI	P value	IRR	CI	P value	IRR	CI	P value
Intercept (at age 55)	0.00	0.00–0.00	***	0.00	0.00–0.00	***	0.00	0.00–0.00	***
Individual Factors									
Cognitively Intact (Reference)									
Impaired	15.14	14.08–16.27	***	15.16	14.10–16.30	***	15.13	14.10–16.27	***
Dementia	20.87	19.38–22.48	***	20.91	19.42–22.52	***	20.85	19.36–22.45	***
Race/Ethnicity (Ref. NH White)									
NH Black	1.03	0.99–1.07		1.03	0.99–1.07		1.03	0.99–1.07	
Hispanic and additional groups	1.08	1.02–1.14	**	1.08	1.02–1.14	**	1.08	1.02–1.14	**
Age	1.01	1.01–1.01	***	1.01	1.01–1.01	***	1.01	1.01–1.01	***
Female	0.93	0.90–0.96	***	0.93	0.90–0.96	***	0.93	0.90–0.96	***
Supportive housing (Ref. Private home)	1.15	1.09–1.20	***	1.15	1.10–1.20	***	1.15	1.09–1.20	***
Cohort	1.03	1.02–1.04	***	1.03	1.02–1.04	***	1.03	1.02–1.04	***
ADL scale (0–5)†	1.01	1.00–1.01	***	1.01	1.00–1.01	***	1.01	1.00–1.01	***
Depression rating scale†	1.03	1.02–1.03	***	1.03	1.02–1.03	***	1.03	1.02–1.03	***
Neighborhood Factors									
Resource density	1.01	1.00–1.03		1.68	1.29–2.18	***	1.16	1.02–1.31	*
Resource density × Impaired	0.98	0.97–1.00	*	0.59	0.45–0.78	***	0.86	0.75–0.98	*
Resource density × Dementia	0.98	0.97–1.00	*	0.60	0.45–0.79	***	0.84	0.72–0.98	*
Disadvantage index	0.99	0.99–1.00	***	0.99	0.99–1.00	***	1.00	0.99–1.00	***
Percent 65 and older	0.99	0.99–1.00	*	0.99	0.99–1.00	*	0.99	0.99–1.00	*
Population density (logged)	1.02	0.99–1.03		1.00	0.99–1.02		1.01	0.99–1.02	
Rate of Change									
Six Months	1.43	1.40–1.48	***	1.43	1.39–1.48	***	1.43	1.39–1.47	**
Individual Factors									
Cognitive Status									
Six Months × Impaired	0.71	0.69–0.73	***	0.71	0.68–0.73	***	0.71	0.69–0.73	***
Six Months × Dementia	0.73	0.70–0.75	***	0.73	0.70–0.75	***	0.73	0.70–0.75	***
Six Months × ADL scale	1.00	1.00–1.01	***	1.00	1.00–1.01	***	1.00	1.00–1.01	***
Six Months × Depression rating scale	1.00	0.99–1.01		1.00	0.99–1.01		1.00	0.99–1.01	
Neighborhood Factors									
Six Months × Resource density	0.99	0.99–1.00	*	0.87	0.76–0.99	*	0.93	0.87–1.00	*
Six Months × Resource density × Impaired	1.01	1.00–1.01		1.14	0.99–1.31		1.08	1.00–1.16	*
Six Months × Resource density × Dementia	1.01	1.00–1.01		1.12	0.97–1.29		1.05	0.98–1.14	
Random Effects Parameters									
Neighborhood-level variance (Constant)	0.01			0.01			0.01		
Individual-level variance (Constant)	0.21			0.21			0.21		

Abbreviations: IRR. Incidence Rate Ratios. CI. Confidence Intervals. ADL. Activities of Daily Living.
Note: ***$p < 0.001$; **$p < 0.01$; *$p < 0.05$. † Entered as time-varying variables.

cognitive performance reduced the protective association between resource density and subsequent cognitive performance while the differential association between neighborhood resource density and the decline of cognitive performance across groups also could be due to chance.

3. Discussion

Using a unique longitudinal dataset of community-dwelling long-term care population that overrepresents cognitively and physically vulnerable older adults, this study examined the varying association between the density of neighborhood resources and cognitive impairment over a two-year period by older adults' baseline cognitive functional status. Our key finding is that living in areas that have a high density of restaurants, fitness/recreational sports centers, and social service establishments for seniors and persons with disability was associated with a lower likelihood of cognitive decline for older adults who were cognitively intact at baseline. However, living in areas with dense neighborhood resources did not confer the same benefits to older adults who were cognitively impaired at baseline.

We found all types of resources examined were associated with a lower chance of experiencing cognitive decline among cognitively intact older adults. This is in line with previous research showing the cognitive benefits of living in a neighborhood in which a community center is located nearby [9], retail shops are plentiful [29], and there is a high integration of residential and other commercial environments [36]. A previous natural experiment study in Japan also reported a lower cognitive decline risk among older adults relocated to neighborhoods with high community-level informal socializing and social participation resources [37]. Different types of neighborhood resources may have offered cognitive benefits to older adults who are cognitively intact, in part through pathways such as a high density of restaurants offering seniors a space for informal gathering; recreational facilities directly facilitating physical and social activities; and social service establishments increasing opportunities for social interaction [19] or engagement [38].

Our findings also suggest that living in an area with a high density of recreational centers, and/or services for seniors and individuals with disabilities, may not confer similar benefits to older adults with cognitive impairment or those diagnosed with dementia. This may be due to two reinforcing forces that limit them from benefiting from these resources. First, physical outdoor spaces proxied by dense businesses, without inclusive features, may be perceived as a risk of out-of-home mobility among persons living with dementia [39]. Second, many urban spaces may lack features that embrace the social participation of individuals with cognitive needs [40]. Additionally, we found that living in neighborhoods with dense social services for seniors and individuals with disabilities was associated with a faster rate of cognitive decline among cognitively impaired (but not dementia-diagnosed) older adults, relative to cognitively intact older adults. Older adults with mild or moderate cognitive impairment in our study represent those with advanced neuropathological conditions. The social service densities we captured may have distinct formal features such as the provision of social care, unlike what is considered third places that function as stages for informal social interactions [19].

Our finding on the protective association between neighborhood

resource density and cognitive decline only for cognitively intact older adults has practice implications concerning optimizing living conditions for older adults across the diverse cognitive spectrum. First, neighborhood resource density can potentially be a useful place-based marker for identifying older adults who are at greater risk of cognitive decline. Public health officials and community health initiatives could focus on developing infrastructure for social interactions, such as through the provision of tax incentives or grant funding. This would complement the case approach from HCBS case managers, who could communicate with older adults about unmet social needs, and devise a plan of action, such as providing supplementary social support programs. Second, public health approaches that focus only on neighborhood resource density may be unlikely to meet the needs of older adults with varying cognitive function who represent a large segment of the community-dwelling long-term care population. Studies explicating how neighborhood resource features improve or maintain the cognitive function of older adults with various degrees of cognitive impairment would help identify supportive strategies. For example, a recent photovoice study with persons with dementia identified that persons with dementia use geographical landmarks, such as public art and heritage structures, to navigate and engage in everyday outdoor activity [41]. Integrating quantitative data sources (such as the current study) with such qualitative approaches could inform city- and community-level efforts to support the participation and well-being of older persons living with dementia [40,42].

This study has some limitations. First, we used ZCTA as neighborhood boundaries, which may not reflect the neighborhood boundaries that residents perceive. Also, resource density may not capture more proximate environments relevant to HCBS participants (e.g., older adults with mobility limitations). Second, we did not include socioeconomic status or educational attainment in the model as these variables were not available. Educational attainment affects the increase of cognitive resilience [43–45] and cognitive reserve, which help flexible adjustment to brain pathology, and fewer manifestation of later-life cognitive deficits [46,47]. However, our focus was not on individual differences in cognitive function but on individual change in cognitive functioning based on how neighborhood resource density may have shaped such change. Third, associations found in this study should not be interpreted as causal. Our results may suffer from reverse causation (e.g., individual health problems may result in a move to high- or low-resourced neighborhood). Yet, we adjusted for a robust set of indicators that may confound the relationship between resources and cognitive decline. Finally, our research findings are only generalizable to the urban, low-income, community-dwelling long-term care population in Michigan. While the share of HCBS spending, a major component of public funding from Long Term Social Services and Support, increased from 18.3% in 1994 to 35% in 2014 in Michigan [4], state-funded HCBS had a long waiting list [48]. Regardless, our sample observation start years expanded 4 years, and ~30% of our sample were low-income individuals and caregiving families who were ineligible for state programs but had access to HCBS via funding support from the Older Americans Act or other county-level resources. Future research should use similar data sets from other regions or across time frames to generalize our findings.

4. Conclusion

Our study calls attention to neighborhood resources that may protect against cognitive decline in the community-dwelling long-term care population. Our findings indicate that dense neighborhood resources that provide informal spaces for interactions are protective against cognitive decline only for cognitively intact older adults, whereas cognitively impaired or dementia-diagnosed counterparts did not similarly benefit from living in neighborhoods with rich resources. This suggests that supporting older adults living in neighborhoods with a lack of resources could be a potentially useful prevention strategy.

Ethical approval

All procedures applied in this research had been approved by the University of Michigan and the State of Michigan Institutional Review Board.

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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.

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