

Community Environmental Factors Are Associated With Disability in Older Adults With Functional Limitations: The MOST Study

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Background. There is limited evidence supporting the hypothesized environment–disability link. The objectives of this study were to (a) identify the prevalence of community mobility barriers and transportation facilitators and (b) examine whether barriers and facilitators were associated with disability among older adults with functional limitations.

Methods. Four hundred and thirty-five participants aged 65+ years old with functional limitations were recruited from the Multicenter Osteoarthritis Study, a prospective study of community-dwelling adults with or at risk of developing symptomatic knee osteoarthritis. Presence of community barriers and facilitators was ascertained by the Home and Community Environment survey. Two domains of disability, (a) daily activity limitation (DAL) and (b) daily activity frequency (DAF), were assessed with the Late-Life Disability Instrument. Covariates included age, gender, education, race, comorbidity, body mass index, knee pain, and functional limitation. Multivariable logistic regression was used to examine adjusted associations of community factors with presence of DAL and DAF.

Results. Approximately one third of the participants lived in a community with high mobility barriers and low transportation facilitators. High mobility barriers was associated with greater odds of DAL (odds ratio [OR] = 2.0, 95% confidence interval [CI] 1.2–3.1) after adjusting for covariates, and high transportation facilitators was associated with lower odds of DAL (OR = 0.5, 95% CI 0.3–0.8) but not with DAF in adjusted models.

Conclusion. People with functional limitations who live in communities that were more restrictive felt more limited in doing daily activities but did not perform these daily activities any less frequently.

Key Words: Activities of daily living—Environment—Residential characteristics.

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A growing body of literature supports the notion that features of the environment, such as street connectivity, housing density, and safety, are linked to physical activity in older adults (1–6). Whether the community environment is related to an older person's participation in their daily role activities (i.e., disability) is unclear. Disability is hypothesized to result from an interaction between the person, level of disease and impairment, and the environment (7–11). In theory, a greater presence of mobility barriers in an older person's community (e.g., curb cuts or uneven walking surfaces) should be associated with a higher degree of disability, whereas more facilitators in the community (e.g., public transportation and handicap parking) should be related to less disability.

Mobility barriers clearly are present in the community (12–17), and older adults frequently report that they have difficulty with physical elements of their environment (18). Features of the community environment such as housing density, the number of residential and commercial buildings, socioeconomic advantage and disadvantage, residential stability, and street pattern are associated with disability among older adults (19,20), particularly when they have functional limitations (21). Census and state administrative data are often used to ascertain elements of a community, and although providing an objective measure of the environment, these features do not characterize an older person's community environment at the "street level." Street

level factors such as even sidewalks, safe walking areas, and curb cuts could enhance people's ability to navigate their environment and remain engaged in daily role activities. The few studies in which street level features of the community environment have been assessed and statistically linked to functional outcomes show a significant association with community mobility (i.e., ambulating around a community) (22,23) but no association with disability (24,25).

Traditionally, disability has been assessed using self-report measures in which "difficulty," "limitation," or "help needed" was ascertained for activities, such as bathing, dressing, grooming, getting out of a chair, performing light or heavy household activities, and shopping for groceries. This approach addresses a single dimension of disability (i.e., perceived limitation), an approach that may be too restrictive in conceptualizing disability (26). For example, people may report difficulty or limitation with daily activities yet regularly engage in activities. The Late-Life Disability Instrument (Late-Life DI) (26), designed to broaden the conceptual underpinnings of disability, addresses two aspects of daily activity disability: (a) daily activity limitation (DAL) and (b) daily activity frequency (DAF). Perceived DAL pertains to how limited people are in performing the activity; perceived DAF pertains to how often people engage in daily activities. The environment, in particular, may be related to whether someone perceives limitation in doing the activities as well as the extent to which activities are performed. There are, however, no studies that examine the relationship of the environment with both limitation disability and frequency disability.

The aims of this study were to (a) identify the prevalence of mobility barriers and transportation facilitators in the older person's community and (b) examine whether the presence of community mobility barriers and transportation facilitators was associated with disability in two domains: (i) DAL and (ii) DAF restriction among older adults with functional limitations. We hypothesized that a greater presence of mobility barriers in peoples' communities would be associated with more disability, whereas a greater presence of transportation facilitators would be associated with less disability.

METHODS

Participants were recruited from the Multicenter Osteoarthritis (MOST) Study, a prospective cohort study of risk factors for incident and progressive symptomatic knee osteoarthritis (OA) among community-dwelling adults in Alabama and Iowa ($N = 3,026$). Study participants were recruited via mass mailings of letters and study brochures, supplemented by media and community outreach campaigns between 2003 and 2005 (27). In brief, persons were enrolled if they had radiographic knee or hip OA with knee or hip pain (symptomatic disease) or if they were at risk of developing symptomatic disease because of obesity, report

of knee pain, history of disabling knee or hip injury, or report of previous knee or hip surgery. Persons were excluded if they had rheumatoid arthritis, ankylosing spondylitis, psoriatic arthritis, or Reiter's syndrome; had bilateral knee replacements; had a history of cancer in the past 3 years; were unable to walk without the help of another person or walker; had problems with kidneys requiring hemodialysis or peritoneal dialysis; or planned to move out of the area in the subsequent 3 years.

This study, the MOST-Knee Pain and Disability (MOST-KPAD) study, was an ancillary study to MOST involving participants with some degree of functional limitation. Participants ($N = 479$) were recruited from the MOST cohort between February 2004 and April 2005. Eligibility criteria included (a) aged 65 years and older and (b) report of "any difficulty" on at least two of the following three items on the Western Ontario and McMaster Osteoarthritis Index (WOMAC): (i) going upstairs, (ii) rising from sitting, and (iii) bending or squatting to the floor. This screening mechanism was selected because it identified people with at least some functional limitation as scored on the WOMAC. Consecutive eligible MOST participants were approached during the MOST baseline clinical visit to ascertain their interest in participating in the MOST-KPAD study. Five hundred and thirty-four persons met eligibility criteria and were approached; 476 persons consented to the study (89%). Reason for refusal was not documented. Four hundred and thirty-five participants completed 30-minute telephone interviewer-administered assessments of disability and the environment. Forty-one participants were unable to be contacted after three attempts. The order of administration of the disability and environmental instruments was randomized. The average length of time between the MOST baseline visit and the MOST-KPAD interview was 43 days. Persons who did not complete the MOST-KPAD baseline interview were more likely to be African American ($p < .01$) but did not differ on age, sex, education, body mass index (BMI), comorbidity, functional level, or pain. The MOST-KPAD study was approved by the Institutional Review Boards at the University of Alabama-Birmingham, the University of Iowa, and Boston University.

The Late-Life DI (26) was used to ascertain disability. The 16-item Late-Life DI ascertains an older person's DAL and DAF and has acceptable reliability and validity (26,28,29). Higher scores on the continuous Late-Life DI scales represent less disability (i.e., less DAL or DAF restriction). DAL and DAF scores were dichotomized into two groups using previously established cutpoints that discriminated DAL and DAF by functional limitation among 150 older adults (28). Low DAL included scores ranging from 68.7 to 100 (coded 0), and high DAL included scores ranging from 0 to 68.6 (coded 1). Low DAF included scores ranging from 51.5 to 100 (coded 0), and high DAF included scores ranging from 0 to 51.4 (coded 1).

Table 1. Descriptive Characteristics of Participants ($N = 438$)

Variables	
Female, N (%)	304 (70%)
White, N (%)	392 (90%)
More than high school, N (%)	283 (65%)
Age in y, M (SD)	70 (4)
Comorbidity (none), N (%)	260 (60%)
Body mass index, M (SD)	30.2 (5.3)
WOMAC functional difficulty (range 2–55), M (SD)	21 (11)
WOMAC pain (range 0–16), M (SD)	6 (4)
Late-Life Disability Instrument: limitation total score*, M (SD)	73 (11)
Late-Life Disability Instrument: frequency total score*, M (SD)	55 (5)
High daily activity limitation, N (%) [†]	166 (38%)
High daily activity frequency restriction, N (%) [‡]	100 (23%)

Notes: WOMAC = Western Ontario and McMaster Osteoarthritis Index.

*High score means less DAL and greater DAF.

[†]Dichotomized zero to one minimal barrier = 1; two to five high barrier = 2.

[‡]Dichotomized zero to three low facilitators = 1; four to five high facilitators = 2.

Community mobility barriers and transportation facilitators were assessed with the Home and Community Environment (HACE) survey (30). Two subscales of the HACE are used for these analyses: (a) community mobility barriers and (b) transportation facilitators. The kappa statistics for the community mobility barrier and transportation facilitator scales are 0.49 and 1.0. Some individual items of the scales, however, have low reliability estimates. The “community mobility barrier” subscale contained five items that assessed to what extent the older person’s local community had (a) uneven sidewalks or other walking areas; (b) parks and walking areas that are easy to get to and easy to use; (c) safe parks or walking areas; (d) places to sit and rest at bus stops, in parks, or in other places where people walk; and (e) curbs with curb cuts. Response options were a lot, some, not at all, and don’t know. Each item was scored to reflect the presence or absence of the barrier, and the five items were summed. For example, responses “a lot” and “some” on the “uneven sidewalk” item were coded to 1 (barrier present) and response “not at all” was coded to 0 (no barrier). For the other barrier items (e.g., parks and walking areas, places to sit and rest, and curbs with curb cuts), response option “not at all” was coded to 1 (barrier present) and response options of “some” and “a lot” were coded to 0 (no barrier). The response option of “don’t know” was coded to missing. The items were then summed and dichotomized into low barriers (zero or one barrier) and high barriers (two to five barriers). The transportation subscale included two items pertaining to driving (response options were yes or no), two items pertaining to public transportation, and one item pertaining to handicapped parking (response options were “a lot”, “some”, “not at all”, or “dont know”). Transportation facilitators were scored as present when respondents indicated “a lot” or “some” on the items pertaining to public transportation and handicap parking and “yes” on the two items pertaining to driving. Scores were summed and then dichotomized into high facilitators (four and five facilitators) and low facilitators (zero to three facilitators).

Age, sex, race, educational attainment, comorbidity, BMI, pain, function, and study site were ascertained in MOST at baseline and were used as covariate variables. Weight was measured at baseline without shoes or heavy jewelry in light-weight clothing using a standard balance beam scale. Height was measured at baseline without shoes at the peak of inhalation using a Harpenden stadiometer. BMI was calculated as weight in kilograms divided by height in square meter. Comorbidity was assessed by using a modified Charlson comorbidity index (31). Knee pain severity and functional limitation were measured by the WOMAC (32). Study site (categorized as Alabama or Iowa) was included to account for variations in the environment and disability due to geographic location. Race, sex, education, and comorbidity were used as categorical variables.

Bivariate analyses were performed to examine the associations between age, gender, race, education, BMI, comorbidity, knee pain, and functional limitation with the dichotomized DAL and DAF scores and the dichotomized environmental barrier and facilitator scores. Unadjusted logistic regressions were performed to examine the relationships between the dichotomized environmental barrier and facilitator barrier scores and the dichotomized DAL and DAF scores. Multi-variable logistic regressions were performed to examine the association of community mobility barriers and community transportation facilitators with DAL and DAF after adjusting for age, gender, race, education, comorbidity, study site, BMI, knee pain, and functional limitation. Data were missing for one participant on BMI.

Because people may not know about aspects of their community environment, we included a “don’t know” response option on the HACE. To examine whether selection of “don’t know” responses affected study results, we performed sensitivity analyses. First, we used Student’s t tests and chi-square tests to examine whether report of “dont know” or missing scores was associated with functional status, pain, BMI, or comorbidity because these factors could be associated with reporting of environmental factors. Second, variables were created that coded “dont know” and missing scores to barrier “absent” and facilitator “present.” This coding scheme was used so that the presence of a barrier or absence of a facilitator would be underestimated. Adjusted logistic regression models were performed with these recoded values. Lastly, observations with “missing” or “don’t know” on two or more HACE items of each subscale were deleted from the data set, and the results of the adjusted logistic regression models were compared with adjusted models with the full data set. SAS version 9.0 was used for analyses.

RESULTS

The mean age of the participants was 70 years. The sample was primarily women and white, with 34% having a high school degree or less (Table 1). Twenty percent reported one comorbidity, 12% reported two comorbidities, and 7% reported

Table 2. Descriptive Statistics Community Mobility Barriers and Transportation Facilitators (N = 435)

	% With Barrier/ Facilitator Present	N (%) With Don't Know or Missing Values
Community mobility barrier items		
Uneven sidewalks or other walking areas (some or a lot)	79	15 (3)
No parks and walking areas that are easy to get to and easy to use	12	7 (2)
No safe parks or walking areas	12	20 (4)
No places to sit and rest at bus stops, in parks, or in other places where people walk	21	32 (7)
No curbs with curb cuts	20	21 (5)
Transportation facilitators		
Public transportation that is close to your home (some or a lot)	58	78 (18)
Public transportation with adaptations for people who are limited in their daily activities (some or a lot)	93	5 (1)
Handicap parking (some or a lot)	45	21 (5)
Have a car available to you at your home (yes)	98	1 (1)
Able to drive (yes)	97	1 (1)

three or more comorbidities. The most frequently reported community barriers were “uneven sidewalks or walking areas,” “no places to sit or rest,” and “no curbs with curb cuts” (Table 2). Thirty percent of participants lived in communities that had two to five barriers (high barriers). Transportation facilitators were common with the majority of participants having a car available to them at home and being able to drive. Thirty-seven percent had three or fewer transportation facilitators (low facilitators). The mean score of DAL was 72.88 (SD = 10.56) with a range of 48–100; the mean score of DAF was 54.97 (SD = 5.29) with a range of 39–73. Thirty-eight percent of the population had high DAL; 23% of the population had high DAF. Total DAL and DAF domains of the Late-Life DI were correlated at 0.37. Of those with low DAL, 15% had DAF restriction; of those with high DAL, 34% had high DAF restriction. Ninety-six percent of respondents rated at least four of five community mobility barriers and transportation facilitator scale items as present or absent.

Bivariate analyses revealed that sociodemographic factors (i.e., older age, male sex, African American, less education, and site [Alabama]) were associated with a greater presence of community mobility barriers. With the exception of comorbidity, biomedical factors were not associated with environmental factors (functional limitation approached significance $p = .06$). Report of transportation facilitators varied only by site (Table 3). On the other hand, bivariate

analyses of covariate variables with DAL and DAF scores showed that sociodemographic factors as well as pain, functional limitation, and comorbidity were associated with DAL and DAF (Table 4).

Unadjusted logistic regression results showed that people who reported community mobility barriers had about twice the odds of reporting high DAL (OR = 2.2, 95% CI 1.4–3.3) and high DAF restriction (OR = 1.9, 95% CI 1.2–3.1). People who reported high transportation facilitators reported less DAL (OR = 0.5, 95% CI 0.4–0.8). Transportation facilitators were not associated with DAF in unadjusted models (OR = 0.8, 95% CI 0.5–1.3).

After adjusting for age, gender, educational attainment, race, comorbidity, BMI, study site, pain, and functional limitation, the association of mobility barriers with DAL was slightly attenuated but remained significant, whereas the association of community mobility barriers with DAF restriction was attenuated and lost significance (Table 5). After adjusting for age, gender, educational attainment, race, comorbidity, BMI, study site, pain, and functional limitation, the association of transportation facilitators with DAL remained significant. In other words, people who reported a greater presence of community mobility barriers were likely to also report more DAL (i.e., more disability) and showed a nonstatistically significant trend toward reporting less frequent performance of the daily activities. People who reported

Table 3. Bivariate Associations of Community Mobility Barriers and Transportation Facilitators With Covariate Variables

Variable	Mobility Barriers			Transportation Facilitators		
	High, N = 133	Low, N = 302	p Value	Low, N = 161	High, N = 274	p Value
Age (y), M (SD)	71 (4)	70 (4)	.04	70 (4)	70 (4)	NS
Female (%)	62	73	.02	73	67	NS
White (%)	83	93	.002	89	92	NS
Body mass index (kg/m ²), M (SD)	30 (5)	30 (5)	NS	30(5)	30(5)	NS
High school diploma or equivalent or more (%)	57	69	.02	58	69	.03
Alabama (%)	70	44	<.0001	70	42	<.0001
WOMAC functional difficulty (range 2–55), M (SD)	22 (11)	20 (10)	.06	21(11)	20(10)	NS
WOMAC pain (range 0–16), M (SD)	6 (3)	6 (3)	NS	6 (3)	6 (3)	NS
Any comorbidity (%)	47	37	.04	38	42	NS

Note: NS = Not significant; WOMAC = Western Ontario and McMaster Osteoarthritis Index.

Table 4. Bivariate Associations of DAL and DAF With Covariate Variables

Variable	DAL			DAL		
	Moderate/Severe, N = 166	None/Mild, N = 269	p Value	Moderate/Severe, N = 100	None/Mild, N = 335	p Value
Age in y	71 (4)	70 (4)	NS	71(4)	70 (4)	NS
Female (%)	75	67	NS	55	74	.0002
White (%)	86	93	<.01	83	92	.007
High school diploma or equivalent or more (%)	58	70	.01	43	72	<.0001
Alabama (%)	60	48	.01	57	51	NS
Any comorbidity (%)	49	35	.002	53	36	.003
Body mass index, <i>M</i> (<i>SD</i>)	31 (5)	30 (5)	.05	31(5)	30(5)	NS
WOMAC functional difficulty (range 2–55), <i>M</i> (<i>SD</i>)	26 (11)	18 (10)	<.0001	24 (12)	20 (10)	.003
WOMAC pain (range 0–16), <i>M</i> (<i>SD</i>)	7 (4)	5 (3)	<.0001	7(4)	6(4)	.02

Note: DAL = daily activity limitation; DAF = daily activity frequency; NS = Not significant; WOMAC = Western Ontario and McMaster Osteoarthritis Index.

more transportation facilitators reported less DAL (i.e., less disability), whereas a greater presence of transportation facilitators was not associated with DAF.

Sensitivity analyses showed persons who reported “don’t know” who did not answer the HACE questions (missing value) on the summary scale and individual items were similar to persons who scored the environmental factor as present or absent with no differences found with functional status, pain, or comorbidity level. Sensitivity analyses examining different coding schemes of the HACE produced results that were similar to those we report in this article with no difference in the overall findings (results not shown).

DISCUSSION

Similar to studies (12–17), we found a number of mobility barriers and facilitators present in the community. We also found that people reporting more mobility barriers and fewer facilitators in their community perceived more limitation in their daily activities. In contrast, peoples’ perceptions regarding how often daily activities were performed were not associated with mobility barriers and facilitators of the community environment after adjusting for covariates.

These findings suggest that environmental characteristics could make involvement in daily activities difficult but that older adults with functional limitations related to lower extremity musculoskeletal impairments are able to adapt and remain involved in daily activities. On the other hand, our findings suggest that people may feel limited in performing a task even when performance is not impacted, as others

have found (33). These findings could be reflective of our sample, which was a relatively young older adult population with little comorbidity, generally ambulatory, with mild-to-moderate functional limitation.

Our findings are supported by researchers using census data and administrative databases to characterize the environment. Residential and commercial mix and greater street connectivity have been linked to less disability in older adults, particularly when functional limitations are present (21,34). Using a single item of physical disability, in adjusted models, Beard and colleagues (20) showed that socioeconomic status, residential stability, racial/ethnic composition, neighborhood decay (street and sidewalk filth and poor building interior structure), and street connectivity were associated with a disability. However, in models adjusted for all the environmental features, the association of neighborhood decay lost significance and socioeconomic disadvantage explained most of the variance in disability. Our analysis only controlled for educational attainment at the individual level, thus it is possible that we did not adequately adjust for socioeconomic environmental status, which could attenuate our positive findings.

Our findings diverge from others who show no association between community mobility barriers and disability among older adults. Haak and colleagues (24) and Oswald and colleagues (25) using the same environmental assessment ascertained that a count of environmental barriers was not associated with disability among elders, but a computed variable representing a person’s functional status and presence of barriers in the community (i.e., accessibility) was

Table 5. Adjusted Associations of Community Mobility Barriers and Transportation Facilitators* With DAL and DAF (N = 434)

	DAL		DAF Restriction	
	Unadjusted OR (95% CI)	Adjusted OR* (95% CI)	Unadjusted OR (95% CI)	Adjusted OR* (95% CI)
Community mobility barriers [†]	2.2 (1.4–3.3)	2.0 (1.2–3.1)	1.9 (1.2–3.1)	1.4 (0.9–2.4)
Transportation facilitators [‡]	0.5 (0.4–0.8)	0.5 (0.3–0.8)	0.8 (0.5–1.3)	0.8 (0.5–1.4)

Notes: CI = confidence interval; DAL = daily activity limitation; DAF = daily activity frequency; OR = odds ratio.

* Adjusted for age, gender, race, education, body mass index, comorbidity, WOMAC function, site, and WOMAC pain.

[†] Dichotomized zero to one minimal barrier = 1; two to five high barrier = 2.

[‡] Dichotomized zero to three low facilitators = 1; four to five high facilitators = 2.

associated with disability in their studies. Haak and colleagues and Oswald and colleagues used an observational method to identify and count environmental factors, which could explain the difference between their findings and our findings.

In a related area of study, the association of neighborhood features to community ambulation (e.g., ability to walk one fourth a mile or ability to get out and about the community) shows small but positive associations with the environment. Clarke and colleagues (22), using an observational approach to characterize broken streets and sidewalks, showed that neighborhoods with poor street structure were associated with decreased community ambulation but only among elders with functional limitations, thereby suggesting that the environment was limiting when persons had mobility limitations. Balfour and Kaplan (35), using a self-report assessment of neighborhood problems pertaining to noise, light, traffic, trash, litter, and access to public transportation, found that persons who reported more barriers in their neighborhood were more likely to experience the onset of severe self-reported functional limitation over the course of 1 year. The availability of transportation factors has also been associated with increased community mobility, at least cross-sectionally (23). Wilkie and colleagues (23), however, did not find an interaction between transportation factors and the environment among 2,252 adults with knee pain who were 50 years of age or older as has been supported by others (22).

A self-report measurement approach, as used with the HACE, has some methodological challenges as well as advantages. People may become aware of barriers and facilitators in their community when they encounter the environmental factor and are negatively impacted by it. As such, they may overestimate the presence of barriers and underestimate the presence of facilitators in their communities. On the other hand, it is also possible that environmental factors could be misreported if people do not encounter them. In such instances, one might anticipate a high number of "don't know" responses. Interestingly, the only environmental factor with a relatively high number of "don't know" responses was the item pertaining to public transportation close to your home. This could reflect low utilization of public transportation; however, it could also indicate that people did not know how to interpret "near one's home." People could also, however, overestimate the presence of barriers because they anticipate the factor being a problem for them. It is reassuring, though, that other measurement approaches including use of administrative data and observation find significant associations between community mobility (20,22,23) and disability (19–21). Furthermore, although not providing conclusive evidence, it is reassuring that our bivariate descriptive statistics showed that sociodemographic factors were strongly associated with report of the environment, whereas factors related to mobility were not associated.

Despite potential misclassification bias, our study has several strengths. First, the self-assessment approach used in the HACE reflects people's perceptions regarding the resources in the environment that are available to them. Given the importance of individual perceptions to health behaviors, it is plausible that people's perceptions of the environment could impact how much people participate in their communities regardless of actual presence of the feature. Second, the measurement approach with the HACE asks people to characterize their environment irrespective of how much it affects them. Other approaches ascertain the environment in a manner that incorporates the extent to which features of the environment pose a problem for the respondent—an approach that could confound function with the environmental feature, which could result in biased estimates. Third, we use a new measure of disability that extends typical instrumental activity of daily living and basic activities of daily living, thereby minimizing ceiling effects.

There are a few noteworthy limitations to this study. First, the study is cross-sectional and causality cannot be inferred. Second, because of power limitations, we were unable to examine whether persons with more severe functional limitations who live in environments with more barriers and fewer facilitators have more disability. Third, although the overall kappa coefficients for the HACE scales are moderate and high, reliability for three individual items is lower than desired. Poor reliability can bias associations but in most instances associations are underestimated. Fourth, participants were recruited based on report of functional limitation. This method resulted in a population with mild to severe self-reported functional limitations. Thus, we do not have anyone without any functional limitations. Fifth, the MOST cohort is designed to assess community-dwelling persons who are at high risk for incident and progressive symptomatic knee OA. This population is not representative of the full U.S. population, and generalizability is limited.

Our findings suggest that characteristics of an older person's community could make involvement in daily activities more difficult yet that older adults with functional limitations related to lower extremity musculoskeletal impairments appear to be able to remain involved in life activities. More research is needed to investigate if these associations between the environment and disability are causal because longitudinal and intervention studies are scarce (35,36).

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