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Household and neighborhood conditions partially account for associations between education and physical capacity in the National Health and Aging Trends Study

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Abstract

Socioeconomic resources, such as education, prevent disability but are not readily modifiable. We tested the hypothesis that household and neighborhood conditions, which may be modifiable, partially account for associations between education and physical capacity in a population-based sample of older adults.

The National Health and Aging Trends Study measured education (<high school, high school, some college, and Bachelor's), household and neighborhood conditions, using a 16-item environmental checklist and a 3-item social cohesion scale, and physical capacity with the Short Physical Performance Battery (SPPB), grip strength and peak expiratory flow. Structural equation models were used to decompose total educational effects into direct effects and indirect effects via

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household and neighborhood conditions, using sample weights and adjusting for age, sex, race/ethnicity, marital status, household size, BMI, self-reported health, and number of medical conditions in 6874 community-dwelling participants.

Education was directly associated with SPPB scores ($\beta=0.055$, $p<0.05$) and peak flow ($\beta=0.095$, $p<0.05$), but not grip strength. Also, indirect effects were found for household disorder with SPPB scores ($\beta=0.013$, $p<0.05$), grip strength ($\beta=0.007$, $p<0.05$), and peak flow ($\beta=0.010$, $p<0.05$). Indirect effects were also found for street disorder with SPPB scores ($\beta=0.012$, $p<0.05$). Indirect effects of household and neighborhood conditions accounted for approximately 35%, 27% and 14% of the total association between education and SPPB scores, grip strength level, and peak expiratory flow level, respectively.

Household disorder and street disorder partially accounted for educational disparities in physical capacity. However, educational disparities in SPPB scores and peak expiratory flow persisted after accounting for household and neighborhood conditions and chronic conditions, suggesting additional pathways. Interventions and policies aiming to support aging in place should consider addressing household-level and street-level disorder.

Keywords

physical function; disability; socioeconomic status; education; household conditions; neighborhood; environment; older adults

Introduction

Socioeconomic resources generally protect older adults from progressive declines leading to disability. Higher levels of educational achievement, income and occupational grade are consistently associated with better lower extremity function (Brunner et al., 2009; Coppin et al., 2006; Haas, Krueger, & Rohlfen, 2012; Thorpe et al., 2011; Thorpe et al., 2008; Zaninotto, Sacker, & Head, 2013), greater grip strength (Haas et al., 2012; Hansen et al., 2014; Hurst et al., 2013), and better lung function (Haas et al., 2012; Hurst et al., 2013). Education, unlike other socioeconomic measures such as income and wealth, has also been shown to predict trajectories in change in lower extremity function over time (Haas, 2008). Also, limited evidence from early educational trials suggest causal associations between education and health outcomes (Muennig et al., 2011; Muennig, Schweinhart, Montie, & Neidell, 2009). Socioeconomic disparities in physical capacity result in a large burden of disability and loss of quality of life for many older adults.

Educational achievement can shape an individual's socioeconomic trajectory through adulthood by predicting occupational status, income and wealth (Glymour, Avendano, & Kawachi, 2014). Higher levels of income and wealth confer greater material resources, such as nutrition and health care, and greater psychosocial resources, such as social capital (Lynch & Kaplan, 2000). Education improves literacy, which has also been linked with fewer functional limitations (Wolf, Gazmararian, & Baker, 2005). The material and psychosocial resources and skills gained from education likely protect older adults from disability through a plethora of mechanisms (Link & Phelan, 1995), but these can be

reduced to two key, and overlapping, pathways (Adler & Newman, 2002). One pathway is by enhancing an individual's ability to prevent and control chronic diseases. However, socioeconomic disparities in physical capacity are consistently found after accounting for health behaviors and presence of chronic diseases, suggesting additional pathways (Coppin et al., 2006; Lantz et al., 2001; Louie & Ward, 2011; Thorpe et al., 2011; Zaninotto et al., 2013).

The other key hypothesized pathway is by shaping the environmental conditions in which individuals live their daily lives (Adler & Newman, 2002). Educational achievement is generally fixed early in life and can influence environmental conditions of adulthood, such as the location and quality of housing and desirability of neighborhood. As described elsewhere (Evans & Kantrowitz, 2002; Macintyre, Ellaway, & Cummins, 2002), household and neighborhood environments comprise numerous determinants of health, including pollutants, safety hazards, psychosocial hazards that can induce stress response mechanisms, and access to services, facilities, and social resources. There may be modifiable aspects of these conditions that confer similar protective effects as the less modifiable socioeconomic resources. Such knowledge is needed to support independence in this growing segment of the population (Kelley-Moore & Thorpe, 2013).

Household conditions have been associated with functional status in older adults. As examples, barriers at the home entrance are associated with less mobility (Clarke & Gallagher, 2013) and worse physical capacity (Lan, Wu, Chang, & Chen, 2009), while absence of tripping hazards and adequate space and lighting for maneuvering have been associated with better physical capacity (Lan et al., 2009). Further, limited evidence suggests that alterations to home environments may improve mobility, health and quality of life for older adults (Seplaki et al., 2014; Szanton et al., 2011).

Neighborhood conditions have also been associated with functional status in older adults. Living on a block with flat, wide sidewalks and houses in good condition is associated with better physical capacity for older adults (Clarke, Ailshire, Bader, Morenoff, & House, 2008; Schootman et al., 2006). Objectively-measured adverse neighborhood conditions, including noise, and poor air quality and street conditions, are associated with functional limitations (Schootman et al., 2006), although associations have not been found for similar subjectively-measured neighborhood variables (Bowling & Stafford, 2007; Freedman, Grafova, Schoeni, & Rogowski, 2008). Also, low socioeconomic status is often associated with poor neighborhood social cohesion (Laurence, 2009; Mujahid et al., 2008) which is associated with higher mortality (Bjornstrom, 2011; Clark et al., 2011). These factors may mediate the relationship between education and physical capacity.

Therefore, the purpose of this study is to test the hypothesis that better household and neighborhood conditions partially account for associations between greater education and higher levels of physical capacity in a population-based sample of older adults. Education was selected as the socioeconomic indicator because it is generally fixed early in adulthood, and, unlike income and occupation, is invariant to retirement and other workforce changes in later life (Thorpe, Szanton, Bell, & Whitfield, 2013). Also, education has been more reliably associated with health outcomes for older adults than income or wealth (Grundy & Holt,

2001; Huisman et al., 2004; Whitfield, Thorpe, & Szanton, 2011). Since chronic diseases have already been tested as a mediating pathway, this study estimates the portion of associations between education and physical capacity not attributable to chronic conditions.

Methods

The National Health and Aging Trends Study (NHATS) conducts annual in-person interviews of U.S. Medicare beneficiaries ages 65 and older. Age-stratified random sampling strategies were utilized and are described in detail elsewhere (Montaquila, Freedman, Edwards, & Kasper, 2012). Persons at older ages and those reporting black race were oversampled. NHATS had a response rate of 71%. The weighted NHATS sample is a nationally representative sample of Medicare beneficiaries aged 65 years and older. Baseline data was collected by a trained interviewer in the participant's home for 8245 participants in 2011, including 7197 community-dwelling participants.

In NHATS, physical capacity was objectively assessed with three measures that have predicted disability and death in large studies (Cook, Evans, Scherr, Speizer, & Taylor, 1991; Guralnik, Ferrucci, Simonsick, Salive, & Wallace, 1995; Guralnik, 1994; Rantanen et al., 1999; Rantanen et al., 2003). Each captures a distinct domain of physical capacity that should be differentially affected by health conditions (Freedman, 2009). Sarcopenia of lower and upper extremities contributes to diminished lower extremity function (Ferrucci et al., 1997), and hand grip strength (Kallman, Plato, & Tobin, 1990), respectively, as part of the cycle of frailty (Fried et al., 2001). Chronic disease burden is linked with diminished peak expiratory flow (Roberts & Mapel, 2012), and this likely represents a separate mechanism of health decline (Buchman, Boyle, Leurgans, Evans, & Bennett, 2009). Grip strength was measured with a digital hand dynamometer in the dominant hand while seated the arm rested against the side. Lung function was measured by peak expiratory flow while the participant stood, if possible. Scoring for physical capacity measures is explained in detail elsewhere (Kasper, Freedman, & Niefeld, 2012). Briefly, participants were assigned a score of zero if unable or ineligible to complete the test. Planned sensitivity analyses were conducted, excluding these participants, who may be qualitatively different than participants who completed the testing. For participants who completed the tests, scores were assigned according to quartiles of the weighted distribution of test results for NHATS participants, using the better of two test trials. Use of ordinal, rather than continuous, values for outcomes facilitates inclusion of NHATS participants who did not complete the testing and may experience the greatest limitations while also achieving good regression model fit.

Lower extremity function was measured with the Short Physical Performance Battery (SPPB), which has demonstrated reliability (Ostir, Volpato, Fried, Chaves, & Guralnik, 2002) and includes three components (Guralnik et al., 1994). Nested balance stands were conducted by directing participants to complete increasingly difficult tandem and one leg stands. Three meter usual walking speed was recorded either without or with an aid, such as a cane or walker. The repeated chair stand was conducted by asking participants to stand up, as quickly as possible for up to five times, from a chair, while folding their arms across their chest. Scores, ranging from 0 to 4, were assigned for each test component, in the manner described above. For the balance test, scores were assigned based on rank order of stand

difficulty and duration (Kasper et al., 2012). Scores for the three components were summed to create a SPPB score.

Education was recorded for the participant and their spouse. The higher level of education in the household was used in these analyses. This approach accounts for homemakers, whose education may not reflect their social status. A planned sensitivity analyses addressed potential misclassification that may have been induced from this approach by using individual, rather than household, education. Household education was analyzed as < high school (reference group), high school, some college, and Bachelor's degree.

Household and neighborhood conditions were measured with two scales. A perceived neighborhood social cohesion scale, adapted from the Project on Human Development in Chicago Neighborhoods (Sampson, Raudenbush, & Earls, 1997), asked participants if people in their community know each other well, are willing to help each other, and can be trusted. A 16-item environmental checklist was completed by the interviewer. It assessed neighborhood conditions observed on the participant's street including presence of litter, broken glass, or trash; graffiti; vacant or deserted buildings; and houses with foreclosure signs (rated as none, a little, or some/a lot). It also assessed household conditions, such as peeling or flaking paint, evidence of pests, broken furniture or lamps, flooring in need of repair, other tripping hazards in the home, any broken or boarded up windows, a crumbling foundation, any missing bricks or siding, any roof problems, and any uneven surfaces or broken steps leading to the home (using binary indicators), and clutter in the interview room or other rooms (rated as not at all, somewhat or very cluttered).

Participants provided data on age in years, sex (referent male), race/ethnicity (categorized as white (referent), black, Hispanic and other). Marital status (categorized as married/living with a partner (referent), separated/divorced, widowed, or never married) and the number of people living in the household were considered to be a potential confounder since they may influence an individual's ability to maintain household conditions and may also influence social integration into the neighborhood (Bierman, 2009). In these analyses, health status variables were treated as potential confounders since health declines may cause older adults to alter household conditions and since the study aims to estimate the portion of associations between education and physical capacity not attributable to chronic conditions. Body mass index (BMI) was measured with self-reported height and weight. NHATS participants also recorded whether a doctor ever told them they had any of the following medical conditions: arthritis, heart disease or heart attack, cancer that was not skin cancer, diabetes, lung disease, dementia or Alzheimer's, a stroke, a fractured hip or other serious illness. A medical condition summary score was created, summing the total number of medical conditions, which was truncated at 5 conditions, due to small numbers above that threshold and to improve linear associations with physical capacity scores. Participants were also asked to rate their overall health, with response options of poor, fair, good, very good and excellent.

Statistical Methods

Structural equation modeling was conducted to test hypothesized direct and indirect associations in this study. Associations with SPPB scores were estimated using linear regression and associations for grip strength and peak flow levels were estimated with

ordinal logistic regression. Latent variables were extracted as mediators to reduce measurement error in the mediating variables in the model, since mediation measurement error can cause underestimation of mediational effects (MacKinnon, 2008). Structural equation modeling also allowed us to account for multiple mediators in a single model. In this study, household education was assumed to be fixed early in adulthood, thus temporally preceding both current household/neighborhood environmental conditions and physical capacity in older adults.

The first phase of analysis focused on developing a measurement model for the mediators with optimal fit to the data. To confirm unidimensional factors and model parsimony, exploratory factor analysis with oblique rotation was conducted using indicators from the 16 item environmental checklist and the three-item perceived neighborhood social cohesion scale. Exploratory factor analyses compared models containing one to five factors, and the preferred model was selected based both on eigenvalues > 1 and lowest RMSEA and CFI. Confirmatory factor analyses were then conducted. Theoretically plausible error correlations and cross-loading indicators were tested individually and retained in the model if they improved model fit and had statistically significant coefficients. One loading coefficient for each latent variable was fixed at one to define the measurement scale of the latent variable.

After a satisfactory mediation measurement model was obtained, structural models were constructed for each physical capacity outcome. Hypothesized structural associations were each tested separately, adjusting for potentially confounding variables. Finally, all hypothesized relationships were tested simultaneously by adding all variables to a final model for each outcome. All analyses were conducted in version 6 of Mplus (Muthén & Muthén, 2010). Binary and ordinal indicators were accommodated in modeling by using weighted least-squares with mean and variance adjustment. Indirect mediating effects and total educational effects were estimated and tested for statistical significance with the indirect command option in MPlus. Sample weights, accounting for sampling design and nonresponse, were used such that the results were considered to be representative of the community-dwelling population of Medicare beneficiaries over 65 in 2011.

Several planned sensitivity analyses were conducted, separately, for each physical capacity outcome. First, to address potential exposure misclassification, additional models were run using individual educational achievement, rather than highest level of educational achievement in the household. Second, to address potential outcome misclassification, models were run excluding participants who did not complete physical capacity testing and had scores of zero. Also, additional models allowed the latent variables of household disrepair and perceived neighborhood social cohesion to be freely correlated. Finally, to address potential self-selection into homes and/or neighborhoods due to physical capacity limitations, additional models were limited to participants who had resided in their homes for five years or longer.

Results

Sample characteristics are presented in Table 1. Briefly, higher household educational attainment was associated with being male, younger, white, married and having slightly

smaller household size. Higher education was also associated with lower BMI, better self-rated health and fewer medical conditions. Exploratory factor analysis results supported the use of a four-factor model. The four factors (seen in Figure 1) represented household disorder, including indicators for signs of disorder and clutter inside the home, household disrepair, capturing mainly exterior household conditions, street disorder, describing observed street-level conditions, and perceived neighborhood social cohesion. Since the factor encompassing neighborhood social cohesion was very weakly correlated with the factor encompassing exterior household disrepair, ($\rho=-0.036$, $p=0.124$), this correlation was fixed at zero. The final measurement model, shown in Figure 1, has excellent fit statistics.

Table 2 shows unstandardized and standardized coefficients from linear (SPPB scores) and ordinal logistic (grip strength and peak expiratory flow) regression models testing non-mediated associations separately for education and each household and neighborhood condition variable, adjusting for potential confounders. As Table 2 shows, greater household education was associated with higher, and household disorder and street disorder with lower, SPPB scores, grip strength levels and peak expiratory flow levels. Household disrepair was associated with lower, and neighborhood social cohesion with higher, SPPB scores and peak expiratory flow levels.

Figures 2–4 present regression coefficients from structural equation models, testing hypothesized pathways between education, household and neighborhood conditions and physical capacity. Coefficients are standardized to both the X and Y variable in each relationship (STDYX coefficients in MPlus). Estimated direct, indirect and total effects are presented for each model. For each model, the total indirect effect represents the sum of all estimated indirect pathways, whether or not that estimate was statistically significant. In all structural equation models, greater household education was associated with less household disorder ($\beta=-0.123$), household disrepair ($\beta=-0.089$), and street disorder ($\beta=-0.184$) and slightly higher perceived neighborhood social cohesion ($\beta=0.057$).

Figure 2 shows structural equation model results for SPPB scores. Greater education had a direct association with greater SPPB scores ($\beta=0.055$). However, indirect associations were also found, representing almost 35% of the total association between education and SPPB scores. Household disorder ($\beta=-0.107$) and street disorder ($\beta=-0.063$) were associated with lower and neighborhood social cohesion with slightly higher ($\beta=0.040$), SPPB scores. Indirect effects through household disorder and street disorder accounted for 15% and 14%, respectively, of the total association between education and SPPB scores.

Figure 3 shows results for grip strength level. There was no direct association between education and grip strength. However, household disorder was associated with lower grip strength level ($\beta=-0.053$) accounting for 27% of the total association between education and grip strength.

Figure 4 shows results for peak expiratory flow level. Greater education was directly associated with higher peak expiratory flow level ($\beta=0.095$). However, indirect associations were also found, representing about 14% of the total association between education and peak expiratory flow. Household disorder ($\beta=-0.078$) and neighborhood social cohesion

($\beta=0.040$) were associated with peak expiratory flow level and household disorder accounted for 9% of the total association between education and peak expiratory flow. Several different sensitivity analyses were conducted for each physical capacity outcome, as described in the methods, and results from those models did not alter inferences.

Discussion

This study found evidence to support the hypothesis that household and neighborhood conditions partially account for associations between household educational achievement and physical capacity in a representative sample of U.S. community-dwelling Medicare beneficiaries aged 65 years and older. Education was associated with less household disorder, household disrepair, street-level disorder and slightly higher perceived neighborhood social cohesion in structural equation models. Household disorder was associated with worse lower extremity function, grip strength and lung function and partially accounted for educational disparities in all three physical capacity measures. Street disorder was associated with worse lower extremity function and partially accounted for its educational disparity. Perceived neighborhood social cohesion was associated with slightly worse lower extremity function and lung function, but did not represent a statistically significant indirect effect. Indirect effects through household and neighborhood conditions accounted for 14–35% of the total associations between education and physical capacity measures in structural models that also adjusted for chronic conditions and health status. Importantly, however, household education was directly associated with greater lower extremity function and better lung function in these models, suggesting additional pathways.

Few studies have tested potential pathways linking socioeconomic resources with health outcomes. Another cross-sectional study of older adults showed that perceived neighborhood conditions, including neighborhood satisfaction, air quality, upkeep and safety partially account for associations between both income and education with self-rated health (Weden, Carpiano, & Robert, 2008). Also, limited neighborhood experimental data, such as the Moving to Opportunity trial (Leventhal & Dupéré, 2011) suggest that modest health gains may be achieved by improving access to community resources. Thus, results from this study add to a small number of studies examining the role of household and neighborhood conditions in socioeconomic disparities. Trials are needed to elucidate causal mechanisms, such as interventions aimed at improving household conditions, natural experiments of neighborhoods undergoing economic transition, and rigorous evaluations of urban planning strategies and policies.

Prior work, reviewed earlier, has shown that individual-level factors, including health behaviors and chronic disease, partially account for associations between socioeconomic resources and physical capacity in older adults. However, health behaviors (Lantz et al., 2001) and chronic diseases (Louie & Ward, 2011) each account for only a small amount of the total socioeconomic disparities. This study adds to the literature by finding that household and neighborhood conditions partially account for associations between household education and physical capacity, after adjusting for BMI, presence of medical conditions and self-rated health. These results suggest that associations between educational achievement, household and neighborhood environment and physical capacity are

independent of individual health status. It is possible that these models are over-adjusted, since chronic conditions likely mediate associations between education, household and neighborhood conditions, and physical capacity. This may bias results toward the null for both the total effect of education and the indirect effects of household and neighborhood conditions.

There are several potential alternative explanations for these results. Educational achievement may be limited by early life adversity, which could also influence health later in life, thus confounding associations between education and physical capacity (Glymour et al., 2014). However, even if education is serving as a proxy for a different aspect of early adversity, these results still suggest pathways leading from socioeconomic adversity to increased disease burden in vulnerable populations.

Two other potential explanations for these results are based on different causal interpretations of the cross-sectional data. In the first scenario, education, but not household and neighborhood conditions, are causally linked with physical capacity. Education and neighborhood conditions are so strongly correlated that Oakes has used the phrase structural confounding to describe the difficulty in identifying an exchangeable group for statistical comparison (Oakes & Johnson, 2006). This may result in non-causal associations between neighborhoods and physical capacity in these models. This study is stronger than others to address this by using a large, nationally representative sample, but experimental data is needed to tease out causal links.

The second plausible alternative causal scenario is reverse causality. This study assumes that educational achievement temporally precedes current household and neighborhood conditions for older adults and that this effect drives associations noted in this study. However, reverse causality cannot be excluded. For example, early life neighborhood conditions may influence educational achievement. It is also plausible that individuals experiencing declining physical capacity may move to a new home or neighborhood. However, results from sensitivity analyses excluding participants who moved within the past five years suggest that changes in home or neighborhood environments are not responsible for the results in this study. Still, certain functional limitations, such as reduced grip strength, may preclude older adults from cleaning and maintaining their home, resulting in feedback mechanisms not specified. This could account for weaker associations in the grip strength model. Analyses of longitudinal data, particularly using instrumental variables or propensity score matching methods, may aid in elucidating causal associations.

In this study, after accounting for indirect effects of household and neighborhood conditions and adjusting for individual health status, household education was still directly associated with greater lower extremity function and lung function. This is consistent with other studies, which have found that education (Weden et al., 2008), income (Weden et al., 2008; Wen, Hawkey, & Cacioppo, 2006), and assets (Bowling & Stafford, 2007) are associated with better health outcomes in older adults after adjusting for neighborhood quality. Also, neighborhood-level socioeconomic status has been associated with subjectively-measured physical capacity limitations after adjusting for perceived neighborhood quality (Bowling & Stafford, 2007; Freedman et al., 2008). Together these results support the theory that

socioeconomic resources are fundamental causes of disability (Link & Phelan, 1995) that exert influence via a plethora of pathways, which are not limited to household and neighborhood conditions and chronic disease (Adler & Newman, 2002; Krieger, 2005).

These results also suggest that some aspects of environments partially account for educational disparities in physical capacity, while others do not. In this study, household-level and street-level disorder had statistically significant indirect pathways between education and physical capacity measures, but neighborhood social cohesion and household disrepair did not. Household and street disorder may capture aspects of neighborhood-level socioeconomic disadvantage, which has been associated with poor physical capacity (Beard et al., 2009; Freedman et al., 2008). For example, in this study, indicators for street disorder, such as vacancy or foreclosure, and indicators of household disorder, such as pests or broken furniture, may be well correlated with neighborhood disadvantage. Older adults lacking socioeconomic resources are likely not able to afford to live in affluent neighborhoods, and there is likely a summative effect of individual-level and neighborhood-level socioeconomic disadvantage on adverse health outcomes for older adults (Diez Roux et al., 2001; Diez Roux, Stein Merkin, Hannan, Jacobs, & Kiefe, 2003).

This study relied on cross-sectional data. Therefore, causal interpretations require great caution. Also, the household and neighborhood conditions measured in this study are not exhaustive. Neighborhood safety and other conditions may also be relevant to physical capacity in older adults. Further, the indicators used for latent variable modeling in this study had a small range of responses, which could induce measurement error or bias. In addition, Medicare beneficiaries, while generally considered a population-based sample, do not perfectly represent all adults over age 65 (Fisher, Baron, Malenka, Barrett, & Bubolz, 1990). This study is strengthened by use of objectively-measured physical capacity, and household and street-level neighborhood variables, and multiple indicators for latent variable modeling. Also, results in this study were found after adjusting for health status, including BMI, medical conditions and self-rated health, suggesting that these associations persist even after controlling for these potentially mediating pathways from education to disability.

Household and neighborhood conditions may be modifiable targets for interventions to reduce socioeconomic disparities in disability. Older adults, especially those with limited mobility, are sensitive to changes in their household and street environments (Clarke et al., 2008). Other studies suggest potential strategies, such as repairing houses (Szanton et al., 2011) and limiting the presence of alcohol outlets and increasing green space in the neighborhood (Cohen, Inagami, & Finch, 2008; Theall et al., 2009). Results from this study suggest that interventions should focus on household conditions, such as disrepair, clutter, or pests in the home, and street conditions, such as litter, graffiti, vacancy or foreclosures on the block and. Greater attention should be given to identify modifiable resources and find ways to leverage those resources in the community to address disparities in functional status.

In conclusion, in this study, household disorder partially accounted for educational disparities in SPPB scores, grip strength and peak flow. Street disorder partially accounted for educational disparities in SPPB scores. However, educational disparities in SPPB scores

and peak expiratory flow persisted after accounting for household and neighborhood conditions and chronic conditions, suggesting additional pathways. These results provide limited evidence of hypothesized pathways, which may mediate educational disparities in older adults. Interventions aiming to help adults age in place should consider household-level and street-level disorder.

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- Educational resources prevent disability, but are not readily modifiable
- Modifiable household and neighborhood conditions may contribute to disparities
- We test the role of these conditions as mediators of disparities in NHATS data
- Household and street disorder account for 14–35% of physical capacity disparities
- Addressing household and street disorder may reduce educational disparities

Figure 1.

Confirmatory factor analysis measurement model for household and neighborhood conditions based on 7197 community-dwelling NHATS participants. Unstandardized estimates are presented and all loading coefficients and correlations statistically significant at $p < 0.05$. Sampling weights were used to represent the community-dwelling population of Medicare beneficiaries aged 65 years and older.

^aIndicates loading coefficient fixed at 1

Figure 2.

Adjusted standardized coefficients from a structural equation model, testing hypothesized direct and indirect pathways between education, household and neighborhood conditions, and lower extremity function, measured by Short Physical Performance Battery (SPPB) scores, based on data from 6874 NHATS participants. IE denotes estimate for indirect effect. Sampling weights were used to represent the community-dwelling population of Medicare beneficiaries aged 65 years and older. Regression estimates are standardized to both X and Y variables.

*Indicates $p < 0.05$.

^aAdjusted for age, sex, race/ethnicity, marital status, and household size

^bAdjusted for age, sex, race/ethnicity, marital status, household size, BMI, self-reported health, and number of medical conditions

Figure 3.

Adjusted standardized coefficients from a structural equation model, testing hypothesized direct and indirect pathways between education, household and neighborhood conditions, and levels of grip strength, based on data from 6874 NHATS participants. IE denotes estimate for indirect effect. Sampling weights were used to represent the community-dwelling population of Medicare beneficiaries aged 65 years and older. Regression estimates are standardized to both X and Y variables.

*Indicates $p < 0.05$.

^aAdjusted for age, sex, race/ethnicity, marital status, and household size

^bAdjusted for age, sex, race/ethnicity, marital status, household size, BMI, self-reported health, and number of medical conditions

Figure 4.

Adjusted standardized coefficients from a structural equation model, testing hypothesized direct and indirect pathways between education, household and neighborhood conditions, and lung function, measured by levels of peak expiratory flow, based on data from 6874 NHATS participants. IE denotes estimate for indirect effect. Sampling weights were used to represent the community-dwelling population of Medicare beneficiaries aged 65 years and older. Regression estimates are standardized to both X and Y variables.

*Indicates $p < 0.05$.

^aAdjusted for age, sex, race/ethnicity, marital status, and household size

^bAdjusted for age, sex, race/ethnicity, marital status, household size, BMI, self-reported health, and number of medical conditions

Selected characteristics of community-dwelling National Health and Aging Trends Study (NHATS) participants, according to household educational status

Table 1

	< High school	High school graduate	Some college	Bachelor's degree	p value ^a
Sex (%)					
Male	566 (35.2)	711 (38.8)	769 (41.5)	975 (53.6)	
Female	1040 (64.8)	1122 (61.2)	1085 (58.5)	845 (46.4)	<0.001
Age (%)					
65–69	187 (11.6)	308 (16.8)	436 (23.5)	449 (24.7)	
70–74	289 (18.0)	368 (20.1)	441 (23.8)	427 (23.5)	
75–79	331 (20.6)	403 (22.0)	354 (19.1)	354 (19.4)	
80–84	360 (22.4)	381 (20.8)	335 (18.1)	333 (18.3)	
85–89	235 (14.6)	248 (13.5)	180 (9.7)	181 (10.0)	
90	204 (12.7)	125 (6.8)	108 (5.8)	76 (4.2)	<0.001
Race/Ethnicity (%)					
White	705 (44.0)	1333 (72.8)	1378 (74.6)	1437 (79.0)	
Black	591 (36.9)	385 (21.0)	351 (19.0)	265 (14.6)	
Other	60 (3.8)	35 (1.9)	42 (2.3)	72 (4.0)	
Hispanic	246 (15.4)	77 (4.2)	76 (4.1)	44 (2.42)	<0.001
Marital status (%)					
Married/Partnered	439 (27.4)	846 (46.2)	1065 (57.5)	1321 (72.6)	
Separated/Divorced	243 (15.2)	222 (12.1)	233 (12.6)	164 (9.0)	
Widowed	822 (51.2)	705 (38.5)	508 (27.4)	280 (15.4)	
Never married	100 (6.2)	58 (3.2)	46 (2.5)	55 (3.0)	<0.001
Mean household size (SD)	2.13 (1.30)	1.98 (1.05)	1.99 (0.98)	2.01 (0.86)	<0.001
BMI category (%)					
<25	541 (35.6)	651 (36.3)	658 (36.1)	659 (36.6)	
25–29	520 (34.2)	631 (35.2)	651 (35.7)	736 (40.9)	
30	458 (30.2)	510 (28.5)	515 (28.2)	403 (22.4)	<0.001
Self-rated health (%)					
Poor	252 (15.7)	134 (7.3)	121 (6.5)	56 (3.1)	

	< High school	High school graduate	Some college	Bachelor's degree	p value ^a
Fair	530 (33.0)	432 (23.6)	329 (17.8)	196 (10.8)	
Good	452 (28.2)	663 (36.2)	621 (33.5)	523 (28.7)	
Very good	263 (16.4)	445 (24.3)	553 (29.8)	648 (35.6)	
Excellent	107 (6.7)	157 (8.6)	229 (12.4)	397 (21.8)	<0.001
Number of medical conditions (%)					
0	173 (10.8)	268 (14.7)	258 (14.0)	333 (18.4)	
1	395 (24.7)	503 (27.6)	527 (28.6)	576 (31.8)	
2	407 (25.5)	514 (28.2)	504 (27.3)	500 (27.6)	
3	358 (22.4)	325 (17.8)	335 (18.2)	246 (13.6)	
4	179 (11.2)	137 (7.5)	155 (8.4)	108 (6.0)	
5 or more	85 (5.3)	77 (4.2)	66 (3.6)	47 (2.6)	<0.001

Note: Based on unweighted data

^a p value based on chi-square statistic or ANOVA

Table 2

Non-mediated adjusted associations between household educational status, household conditions and neighborhood conditions with lower extremity function (measured by the Short Physical Performance Battery (SPPB)), grip strength, and lung function (measured by peak expiratory flow), NHATS participants

	SPPB score β (p value) (n=36020)		Grip strength level β (p value) (n=36483)		Peak expiratory flow level β (p value) (n= 6334)	
	Unstandardized	Standardized ^a	Unstandardized	Standardized ^a	Unstandardized	Standardized ^a
Education	0.262**	0.084**	0.034*	0.026*	0.148**	0.116**
Household disorder	-0.444**	-0.115**	-0.076*	-0.048*	-0.136**	-0.087**
Household disrepair	-0.203**	-0.060**	-0.037	-0.026	-0.069*	-0.051*
Street disorder	-0.425**	-0.112**	-0.061*	-0.039*	-0.128**	-0.083**
Perceived neighborhood social cohesion	0.226**	0.063**	0.016	0.011	0.090**	0.062**

Note: Sampling weights were used to represent the community-dwelling population of Medicare beneficiaries aged 65 years and older. Each model adjusted for age, sex, race/ethnicity, marital status, household size, BMI, self-reported health, and number of medical conditions

^a Standardized to both X and Y variables

** Indicates p<0.01

* Indicates p<0.05