Staying Connected: Alternative Transportation Use, Neighborhoods, and Social Participation among Older Americans

Kenzie Latham-Mintus, PhD[1,*] Matthew Manierre, PhD[2] and Keith Miller, MSW[3]

[1] Department of Sociology, School of Liberal Arts, IUPUI, Indianapolis, Indiana, USA

[2] Department of Humanities and Social Sciences, School of Arts and Sciences, Clarkson University, Potsdam, New York, USA

[3] Indiana University School of Social Work, IUPUI, Indianapolis, Indiana, USA

*Address correspondence to: Kenzie Latham-Mintus, PhD, Department of Sociology, 425 University Boulevard, Cavanaugh Hall 303 Indianapolis, IN 46202 USA. E-mail: keelatha@iupui.edu

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Abstract

Background and Objectives. A wealth of empirical evidence documents improved health among older adults who participate in social activities. Alternative transportation can serve as a bridge linking older adults to social activities and improving person-environment fit.

Research Design and Methods. Using Waves 1-8 of the National Health and Aging Trends Study (NHATS), this research examines whether alternative transportation use is associated with participation in diverse social activities among a sample of Medicare beneficiaries aged 65 or older. Additionally, this research explores whether the effect of transportation use varies across neighborhood environments. We analyzed individual trajectories of participation in social activities by estimating two-level growth curve models.

Results. The use of public transportation, paratransit, getting a ride, or walking/using wheelchair/scooter to get places was associated with participating in more types of social activities. Respondents who used alternative transportation had less steep declines in participation. The effect of getting rides and using paratransit services was more pronounced among respondents living in disordered neighborhoods.

Discussion and Implications. This research underscores the importance of alternative transportation use and the neighborhood context for participation among older adults. Age-friendly initiatives aimed at fostering greater community engagement should think broadly about the role of multiple forms of transportation.

Keywords: Age-friendly, Neighborhoods, Social participation, Transportation

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Social participation is a keystone of healthy or successful aging (Hsu, 2007; Levasseur et al. 2010). Staying connected with family and friends and engaged in the community is strongly linked with positive health and well-being among older adults (Ang, 2018; Levasseur et al., 2010). Though numerous individual-level factors shape social participation such as health and socioeconomic status, prior research also documents the role of the environment for shaping patterns of participation (Levasseur et al. 2020; Richard et al., 2009). This research underscores the potential of community-level interventions aimed at increasing social participation among older adults. However, much of the current literature is limited by a lack of longitudinal or nationally representative data. The purpose of this study is to examine to what extent the environment, specifically alternative transportation (i.e., not driving oneself) and neighborhood contexts, promotes participation in social activities.

Due to age-related factors such as physical impairment and driving cessation, participation in social activities tends to decline in later life (Desrosiers et al., 2004; Duppen et al., 2020). Yet, it has been argued that age-friendly environments that feature "policies, services, settings and structures support and enable people to age actively" can promote fuller participation and inclusion of older adults and people with disabilities (WHO, 2007, p. 5). To explore this, we capitalize on eight waves of annual data from a nationally representative sample of American Medicare beneficiaries 65 years and older to examine participation in social activities. We investigate whether alternative transportation use serves as a community

facilitator, connecting older adults to a diversity of social activities, and how the neighborhood context influences participation.

Participation in Diverse Social Activities and Well-Being among Older Adults

There are multiple dimensions to social participation including frequency/intensity of activities, types of activities, and diversity of activities (Ang, 2018; Hsu, 2006; Levasseur et al. 2010; Tomioka et al., 2018). Prior research suggests that each dimension may contribute to health and well-being. For example, certain social activities, such as volunteering, are known to confer large health benefits (Morrow-Howell et al., 2003). Barron and colleagues (2009) found that older adults who participated in an intensive volunteer program (≥ 15 hours per week for an entire school year) had improved performance-based measures of functioning and reported more energy, regardless of baseline health. Frequent meet ups or contact with friends and family has been found to decrease disease risk (Hill et al., 2014). However, participating in diverse social activities is also an important predictor of health and well-being (Wang et al., 2019).

According to Fingerman et al. (2020), social integration theories suggest that diversity in social activities increases diversity in social ties including weak ties. Indeed, Fingerman et al. (2020) note that "[b]y definition, socially integrated individuals participate in diverse behaviors such as attending church or doing volunteer work" (p. 378). Prior empirical work underscores that participation in diverse social activities is health-protective (Wang et al., 2019). These salubrious effects are thought to stem from the cultivation of weak ties, increasing access to resources, and reinforcing norms related to health behaviors (Thomas, 2012). Diverse networks, representing more weak ties, are more closely linked with well-being than networks solely comprising strong ties (e.g., family and friends) (Fiori et al., 2006; Huxhold et al., 2020).

Moreover, using a novel methodology of ecological momentary assessment (EMA), Fingerman et al. (2020) find that diversity in social ties and behaviors were associated with more physical activity and positive moods among older adults.

Taken together, social integration theories, along with empirical data, suggest that diversity in social activities enhance health and well-being by augmenting social networks, increasing sense of belonging and purpose, and exposing individuals to different experiences (Fingerman et al., 2020; Thomas, 2012). However, social participation declines over time (Desrosiers et al., 2004; Duppen et al., 2020). Vogelsang (2021) examined social participation trajectories using the Wisconsin Longitudinal Survey and found that participation in number of social activities generally declined in later life; however, a little over a third of the respondents had relatively flat trajectories of participation with only a slight decline from ages 35 to 71 years. As leaving the home becomes more difficult, older adults may participate in fewer activities, yet gerontologists have drawn attention to the potential of lowering environmental demands to increase participation in later life.

Increasing Person-Environment Fit through Alternative Transportation and Neighborhood Context

Although multiple factors contribute to declines in social participation in later life, a primary driver of this trend is acquired impairment and the loss of functioning (Bukov et al., 2002; Meek et al., 2018; Rosso et al., 2013). However, increasing person-environment fit may allow older adults to continue to participate in the number and frequency of social activities that they desire. Environmental gerontological approaches to enhancing social participation have long recognized the role of environment for limiting activity outside the home (Byrnes et al., 2006). According to the ecological model of aging (Lawton, 1983), the person-environment fit

approach describes the dynamic interplay between the person's competencies (e.g., personal attributes such as physical capacity) and the demands of physical and social environments (i.e., environmental press). As individuals age and experience functional decline, problems with person-environment fit increase (Iwarsson, 2005).

A core component of age-friendly environments is increasing person-environment fit by lowering environmental demands (Menec et al., 2011). Previous research demonstrates that supportive transportation environments are associated with driving cessation among older adults, which may increase road safety by providing older adults with safe and reliable transportation options outside of driving (Choi et al., 2012). A robust alternative transportation system is a way communities can increase person-environment fit and facilitate participation around the community (Broome et al., 2009; Menec et al., 2011); however, alternative transportation use, as part of an age-friendly environment, must be contextualized. The neighborhood context may be an important barrier or facilitator to social participation (Menec et al., 2011). However, alternative transportation use can serve as a facilitator among those living in disadvantage and divested communities by connecting residents to important points of interest and opportunities in other areas (Saif et al., 2019). Alternative transportation use may take on heightened meaning for older adults living in neighborhoods with few amenities or a high degree of disadvantage. We draw upon the person-environment fit framework to delineate how alternative transportation and the neighborhood contribute to participation in diverse social activities in later life. In the next section, we provide a brief overview of the empirical data linking these dimensions of the environment to social participation in activities.

Alternative Transportation Use and Social Participation

As older adults begin to experience age-related declines in sensory, physical, or cognitive health, driving frequency decreases or stops (Dahan-Oliel et al., 2010; Dickerson et al., 2007; Ryvicker et al., 2020). Given the car-centric environments in much of the United States, this presents a challenge for individuals and communities (Dickerson et al., 2007). Most gerontological research into transportation has focused on driving and driving cessation among older adults, yet there is a growing recognition of the role of alternative transportation for filling this void (Ryvicker et al., 2020; Scharlach & Lehning, 2013). Alternative transportation may operate as a bridge connecting older adults to public and private "third places," where people regularly gather and socialize (Alidoust et al., 2018).

Previous empirical research has shown that transportation is a key determinant of social participation (Lamanna et al., 2020). For example, Dahan-Oliel et al. (2010) observed that drivers, public transportation users, and walkers had greater participation compared with paratransit users and those who received rides from family and friends. Using data from the Canadian Health Survey and geographic data, Levasseur et al. (2020) documented greater participation among older adults living in metropolitan areas with larger paratransit fleets. Using U.S. data, Pristavec (2018) found that older adults who received consistent rides participated in more social activities, relative to those who did not receive rides. On the other hand, Lehning et al. (2018) observed that *health-related* participation restriction in social activities was more likely among older adults who received rides from family and friends. Yet, the majority of this research has explored alternative transportation use and social participation cross-sectionally. We expand on this research by examining whether alternative transportation use is associated with less steep declines in social participation over time. We posit that alternative transportation will increase person-environment fit; therefore, we anticipate that older adults who use alternative

transportation will participate in more types of social activities (H1) and that they will have flatter trajectories of participation over time (H2).

The Neighborhood Context and Social Participation

The neighborhood context is an important source of environmental demands for older adults that fundamentally shapes older adults' participation outside the home (Levasseur et al., 2020; Menec et al., 2011). Neighborhood disorder captures physical aspects of the environment such as graffiti, abandoned buildings, and litter as well as perceptions of safety that create barriers to participation (Latham & Clarke, 2018; Millar, 2020). Neighborhoods with a high degree of disorder pose physical barriers (e.g., broken sidewalks or vacant buildings) and psychosocial barriers (e.g., fears about safety) that limit activities around the community (Latham & Clarke, 2018). On the other hand, social cohesion taps into the relational interconnections within a community. More specifically, social cohesion refers to individual feelings of trust, reciprocity, and shared norms (Henderson, et al., 2016). High levels of perceived social cohesion may act as a facilitator by engendering feelings of trust and belonging, which encourages older adults to engage in their community (Latham & Clarke, 2018).

Based on the above research, we hypothesize (H3) that older adults living in more disordered neighborhoods will participate in fewer types of social activities whereas, older adults who perceive their neighborhoods as cohesive will participate in more types of social activities. Furthermore, given the potential for alternative transportation to lower environmental demands, we hypothesize (H4) the effect of alternative transportation use on participation will be stronger among older adults who live in more disadvantaged environments (i.e., neighborhoods characterized by high degree of disorder). To test our set of hypotheses including those related to

alternative transportation, we used eight waves of longitudinal data and estimate individual trajectories of participation in social activities.

Methods

Data

Data for this research come from the first eight waves (i.e., 2011-2018) of the National Health & Aging Trends Study (NHATS). The NHATS is a nationally representative panel survey of Medicare beneficiaries 65 years or older (Kasper & Freedman, 2020). The original sample was drawn from the Medicare enrollment database in 2010 and a stratified three-stage sample design was used (for detailed information see, Montaquila et al., 2012). Data collection has occurred annually with detailed information collected about older adults' health, well-being, and living environments—making it well suited for our research objectives. Our analyses focus on the original 2011 cohort. Our sample included older adults who were living in the community. The Wave 1 response rate was 71.3% with follow-up waves ranging from 73.6% to 94.0% (Kasper & Freedman, 2020). After pooling all observations from 6,718 respondents across eight waves, the final analytic sample was 27,464 person-year observations. On average, respondents contributed 3.62 observations to the sample.

Measures

Dependent Variable: Social Participation. Social participation was operationalized as the number of different types of valued, social activities completed in the past month. The NHATS collected information about whether respondents had participated in four types of social activities within the past month: (1) visiting friends and family, (2) attending religious services, (3) participating in clubs or organized events, and (4) going out for enjoyment. The number of

social activities reported for the past month were summed to create a count ranging from 0 to 4 activities. Additionally, respondents were asked how much they valued each activity (i.e., "How important is it to you to do [activity]?)." The response categories included very important, somewhat important, and not so important. We created a count of participation in valued activities by recoding any "not so important" activity as "0." Although Lehning and colleagues (2018) looked at individual social activities, this approach is similar in its focus on valued activities. However, we completed sensitivity analyses with raw counts of participation in social activities and the value-specific measure. The measures were highly correlated (r=0.92) and yielded identical substantive findings.

Transportation Use. The NHATS asked respondents about their driving frequency and transportation use in the past month. Because alternative transportation use must be understood within the context of driving in the United States, we include a measure of driving frequency, which ranged from 0 (never drives) to 4 (drives every day). In Waves 2-8, if a respondent reported not driving in the past year, then they were coded as "0" for never drives. In all other cases, driving frequency was measured the same across all waves. We grand mean centered driving frequency.

Related to alternative transportation, respondents were asked, "In the last month, how did you get to places outside your home? Did you use/take [type of transportation]?" We created four dummy variables of alternative transportation use: (1) paratransit (i.e., taxis, residential shuttles, or shuttles services for seniors/people with disabilities), (2) gets rides from friends, family, or paid helper, (3) public transportation (i.e., bus, subway, or train), and (4) walked/used wheelchair or scooter to get places. Respondents who reported not leaving the home in the past

month were not asked about transportation use. We set respondents who did not leave the home to zero on all transportation use measures.

Neighborhood Context. Two measures were used to capture the neighborhood context: (1) neighborhood disorder and (2) social cohesion. Interviewers were asked "When standing in front of the sample person's home/building, and looking around in every direction, how much of the following did you see: litter, broken glass, or trash? Graffiti on buildings and walls? Vacant or deserted houses or storefronts?" Responses ranged from none (1) to a lot (4). The average was taken of all three items to measure neighborhood disorder. Social cohesion comprised three items about perceptions of the community. Respondents were asked whether they agreed with the following statements: (1) "People in this community know each other very well," (2) "People in this community are willing to help each other," (3) "People in this community can be trusted." Responses ranged from do not agree (1) to agree a lot (3). Similar to neighborhood disorder, the average was taken of all three items. Both measures had Cronbach's alpha scores exceeding 0.70 in each wave. To disaggregate within-person (level 1) and between-person (level 2) effects, we included a version of person-centered means alongside the time-varying indicator. As stated succinctly by Howard (2015), "[a] person-mean centered time-varying covariate quite literally *is* within-person residual variance" (p. 403). By including both versions, we were able to distinguish within- and between-person effects of our neighborhood measures.

Controls. We included five time-invariant (level 2) controls in our models: five-year age brackets at baseline, sex (female=1), race and ethnicity (i.e., white (reference), Black/African American, Hispanic/Latino/a/x, and other race), educational attainment (high school education=reference), and residential duration at baseline (≥5 years=1). The time-varying (level 1) controls captured important social, economic, and health predictors of social participation. We

include dummy variables for marital status (married or living with a partner=1), home ownership (home owned and paid off=1), living in a metropolitan area (metro=1), whether or not a respondent moved locations since last wave (moved=1), and income quartiles (low income=reference). The NHATS defined metropolitan areas using Rural-Urban Continuum Codes, and categorized respondents based on whether or not they lived in a metro county. The income quartiles were based on the unweighted values for Waves 1, 3, 5, and 7, as NHATS does not collect income information on even-numbered waves. We pulled the income information from the previous wave forward to account for missing information on the even-numbered waves.

Because health is a strong predictor of social participation, the remaining time-varying controls reflected multiple dimensions of health. These included a five-category variable of self-rated health ranging from poor health (=1) to excellent health (=5), a summed frequency of four depressive symptoms (i.e., little interest, feel depressed/hopeless, feel nervous, and unable to stop worrying) ranging from no symptoms (=4) to symptoms nearly every day (=16), and three measures of physical mobility. Respondents who reported not being able to walk six blocks or walk up 20 stairs were classified as having a mobility limitation. A binary indicator was created for mobility device use, where respondents who reported using any type of device in the past month were coded as "1." A final indicator was created for respondents who reported having a fall in the past year. A series of dummy variables were also created to identify if respondents had the following sensory impairments or symptoms: vision impairment (does not see well across street with or without corrective lenses=1), hearing impairment (uses hearing aid/deaf=1), chronic bothersome pain, or balance problems. A control for cognitive impairment was constructed using a question where respondents rated their memory from poor to excellent.

Respondents were flagged as having poor memory if they responded with fair or poor, or if they used a cognition proxy for the interview.

Analytic Strategy

To analyze individual trajectories of social participation over time, we employed a two-level growth curve model. This approach was advantageous because it accounts for the nested structure of the data (i.e., repeated measures). Additionally, the growth curve models provided estimates of fixed effects (within-person changes across waves) and random effects (differences across individuals). This approach allowed for unbalanced data and included trajectories for all respondents regardless of their attrition status, which typically yields the least biased estimates in circumstances with some non-random attrition. However, the possibility of bias due to mortality is unavoidable (Rabe-Hesketh & Skrondal, 2012).

Analyses were estimated as a series of models, entered manually, where each model introduced a new set of covariates or interactions. First, time/wave was entered into the model to identify the best fitting parameterization. Next, all controls were introduced with level 2 and level 1 sociodemographic characteristics added first, followed by level 1 health factors. To test our first hypothesis, the four alternative transportation dummy variables were entered into the model alongside all controls. Our second hypothesis specified that the alternative transportation variables might attenuate a downward trend in social participation over time. To test this, interactions between time and transportation method were entered in models, first separately and then all at once. This approach was taken in light of concerns of overfitting. Our third hypothesis was testable by including social cohesion and neighborhood disorder variables into a model with

all controls. Our fourth hypothesis was tested by estimating interaction terms between each transportation method and neighborhood disorder (both level 1 and level 2). These were entered into their own separate models as well as a model with all interactions at once.

All models assume an unstructured covariance matrix, which was found to be the best fit. No matter the covariance matrix choice, the substantive conclusions of all analyses remained the same. Although the outcome variable had only a limited range, it was roughly normally distributed so a linear model was used. As a robustness check, models were also fit with multilevel logit model, estimating a binary high/low indicator of social participation. Most conclusions from the linear model were consistent with the binary model, though some interactions depended on the cutoff used. Final analyses were estimated using Stata 14's meglm suite to account for the study's complex weighting design.

Results

Table 1 presents descriptive statistics for the analytic sample (N=27,464 person-year observations), which represents all observations pooled across eight waves (see Supplemental Table 1 for descriptive statistics per wave). The mean number of social activities participated in the past month was 2.52. Among our focal measures, public transportation and paratransit were used by fewer than 8% of the sample, while nearly half the sample reported getting rides or walking/using wheelchair/scooter to get places. In general, neighborhood disorder was relatively low with the mean value of 1.05, while social cohesion was relatively high with value of 2.44.

[INSERT TABLE 1 ABOUT HERE]

Growth Curve Models

The results for the growth curve models are presented in Table 2. These models included time-varying (level 1) coefficients and time invariant (level 2) coefficients. The level 1

coefficients should be interpreted as the predicted change in social participation between-waves coinciding with a 1-unit change in the independent variable. The level 2 coefficients indicate an average difference between individuals based on static characteristics, such as race or baseline age. These coefficients are reflective of average differences across individuals, regardless of wave. In these models, the intercept/constant value was the mean social participation with all indicators at zero as well as a random intercept component that reflects the range of variation in mean social participation scores between respondents. Model 1 indicated that the best time trajectory was a quadratic trend (see Figure 1).

[FIGURE 1 ABOUT HERE]

In Model 2, we entered our level 1 and level 2 sociodemographic characteristics. The level 2 controls represented between-person differences in social participation among respondents. Older respondents and racial and ethnic minorities participated in fewer types of social activities, whereas women participated in more types of activities. Compared with respondents who had earned a high school degree, respondents without a high school degree participated in fewer types of activities, while those with more than a high school degree participated in more. Among the level 1 measures, higher incomes were positively associated with social participation. Additionally, married respondents participated in more activities, relative to non-married respondents. Respondents who lived in their residence for more than five years and homeowners (i.e., home paid off) reported participating in more types of activities.

[TABLE 3 ABOUT HERE]

In Model 3, we further adjusted for health status. Each of the health measures were level 1, which captured within-person change. Better ratings of health were associated with participation in more types of social activities. More depressive symptoms, having a mobility

limitation, and using a mobility device were all associated with decreased social participation. Similarly, vision impairment and poor memory were negatively associated with social participation. Unexpectedly, the use of a hearing aid and bothersome pain were associated with participating in more types of social activities. From Model 2 to Model 3, we observed an attenuation in the effect of age on social participation.

Model 4 introduced transportation use. All transportation measures were associated with increased social participation. As expected, driving frequency was most strongly associated with participation in diverse social activities; however, paratransit, getting rides, public transportation, and walking/using wheelchair/scooter to get places were all positively associated with social participation. In Model 5, we entered the within-person measures of neighborhood disorder and social cohesion. These measures represented the effect of a change in neighborhood disorder or cohesion across waves on a person's social participation score. Only the within-person social cohesion was associated with social participation. Respondents who reported increased social cohesion were more likely to report participating in more types of social activities.

In Model 6, we included the between-person measures of neighborhood disorder and social cohesion, which reflected differences between respondents. Both measures of the neighborhood context were significantly associated with social participation. For each additional unit of disorder, respondents, on average, participated in 0.35 (p <.0001) fewer types of activities, while for each additional unit of social cohesion, respondents participated in 0.39 more types of activities.

To test whether alternative transportation use was associated with changes in social participation over time, we tested a three-way interaction that interacted the linear form of time, quadratic form of time, and each type of alternative transportation (see Supplemental Table 2).

We graphed the marginal predicted means for the significant interactions (see Figure 2). All four alternative transportation measures were significantly associated with non-linear changes in social participation over the eight waves. However, when all four interactions were entered into the final model (Supplemental Table 1; Model 5), public transportation use became insignificant at an alpha-level of 0.05. We elected to graph the time and public transportation interaction, but interpret this finding with caution. In general, the significant interactions indicated that individuals who used alternative transportation had higher baseline social participation *and* reduced social participation at a lower rate over time.

[FIGURE 2 ABOUT HERE]

Finally, to explore our fourth hypothesis (i.e., alternative transportation use would moderate the relationship between the neighborhood disadvantage and social participation), we tested four same-level interactions (Level 1 Alternative Transportation X Level 1 Neighborhood Disorder) and four cross-level interactions (Level 1 Alternative Transportation X Level 2 Neighborhood Disorder) (see Supplemental Table 3). The crossed-level interactions yielded two significant interactions. Figure 3 displays the predictive margins for paratransit use and getting rides interacted with between-person neighborhood disorder. Among respondents living in areas with a high degree of disorder, using paratransit or getting rides from family and friends was associated with participating in more types of social activities relative to those who did not use those types of transportation.

[FIGURE 3 ABOUT HERE]

Discussion

The purpose of this research was to examine the role of the alternative transportation use and the neighborhood context on social participation among older Americans. More specifically,

we explored whether alternative transportation use served as a facilitator of social participation—by lowering environmental demands and connecting older adults to important social activities. Additionally, we investigated whether the neighborhood context shaped social participation. In relation to our original hypotheses, we found support that alternative transportation use was associated with participating in diverse social activities. Results from the growth curve models documented increased social participation among older adults who used alternative transportation. Older adults who used paratransit, sought rides from others, public transportation, or walked/used wheelchair/scooter to get places participated in more types of social activities. These findings speak to the within-person changes—providing strong evidence that *uptake* of these forms of transportation are effective in maintaining social participation and enhancing social integration.

We also examined whether alternative transportation shaped social participation over time. We hypothesized that alternative transportation use could slow the decline in participation—enabling older adults to participate in more types of social activities for a longer duration. We found support for this hypothesis. In Figure 2, we see that alternative transportation was associated with less steep declines in social participation. These findings suggest that alternative transportation increases connectivity and participation in diverse social activities. Alternative transportation may increase person-environment fit by providing additional transportation options when driving stops or becomes more limited among older adults. Our results underscore previous work that has described alternative transportation as a critical component of age-friendly environments (Dickerson et al., 2019; Menec et al, 2011).

Our third hypothesis investigated how the neighborhood context influenced social participation. Specifically, we examined the within- and between-person effect of neighborhood

disorder and perceived social cohesion. Higher levels of social cohesion were associated with increased social participation during the observation period. This was true for the within- and between-level measures. In other words, older adults who lived in more cohesive neighborhoods at baseline were more likely to participate in social activities, relative to those who lived in less cohesive neighborhoods. Additionally, among respondents who reported positive changes in their perceived social cohesion, we were able to document greater participation. The within-person results are particularly striking because it suggests that perceptions of social cohesion are amendable and possibly part of an effective community-level intervention strategy.

Unlike social cohesion, we did not document an association for the within-person measure of neighborhood disorder and social participation. However, the between-person measure was significantly associated with participation in fewer social activities. We believe that this finding suggests that neighborhood disorder does matter for social participation, but capturing within-person changes may be particularly challenging because older adults move infrequently (e.g., about 3% of the sample moved locations over the observation window). Considering the two dimensions of the neighborhood context, we conceptualize subjective assessments of social cohesion as a more modifiable aspect of one's neighborhood context as perceptions of the social environment can change based on social interactions and decreasing threats of violence (Mair et al., 2015).

Finally, we examined whether alternative transportation use moderated the relationship between neighborhood disorder and social participation. We anticipated that alternative transportation use would buffer the adverse effects of neighborhood disadvantage (i.e., neighborhood disorder). We found partial support for this hypothesis. The effect of getting rides and using paratransit services was stronger among respondents living in more disordered

neighborhoods. Our findings suggest that alternative transportation use increases connectivity, which confers greater advantages, in terms of participation, to those who are living in disordered neighborhoods.

Limitations

As with all research, there are several limitations worth noting. Although diversity in social activities is an important dimension of social participation, we are unable to capture intensity or other dimensions of participation. For instance, there may be important changes in the amount of time spent in each social activity that occurs as a response to environmental press. Second, the NHATS measures transportation use within the past month, but does not measure access to alternative transportation. Furthermore, we had limited information about the physical features of the neighborhood and lacked detailed information about geography including walkability, proximity to points of interests, and other environmental factors associated with participation. Common indicators of social disorganization, such as neighborhood poverty rates and crime rates, were also not available. These missing indicators may be a source of potential omitted variable bias as well as bias due to uncontrolled endogeneity. Third, there is always a possibility of biased estimates due to nonrandom attrition because of premature death—particularly related to socioeconomic status. Finally, although these data are representative of Medicare beneficiaries over the age of 65 years, the sampling frame does not include those who are not eligible for Medicare, which limits generalizability.

Conclusion

Despite limitations, this research provides robust evidence that alternative transportation and the neighborhood context are integral parts of an age-friendly environment. All four types of

alternative transportation were associated with increased participation in diverse activities valued by older adults. In particular, there was evidence that alternative transportation use was associated with less steep declines in social participation. Our findings suggest that alternative transportation use increases person-environment fit by lowering environmental demands (i.e., connecting older adults to points of interest); thus, facilitating participation in diverse social activities for longer durations and fostering social integration among older adults.

However, some communities, such as rural communities, may have few resources to create walkable environments or provide public transportation options. A potential alternative is to create policies that encourage the giving and receiving of rides among community members and/or increase paratransit services. We observed that getting rides from family and friends and paratransit were associated with slower declines in participation over time and improved participation among older adults living in disordered neighborhoods. Dabelko-Schoeny et al. (2021) discusses the four major attributes for facilitating alternative transportation use: (1) availability, (2) accessibility, (3) acceptability, and (4) affordability. Getting rides and targeted paratransit services may be particularly high on all four attributes. Programs aimed at connecting community members or addressing barriers to paratransit services may help older adults maintain their social participation levels over time.

The neighborhood context was also a significantly associated with social participation. Older adults who perceived their communities as more cohesive were more likely to participate in social activities. It is quite possibly that this relationship is bidirectional and self-reinforcing, where older adults who feel a sense of belonging and trust engage more in the community, which then fosters greater feelings of social cohesion. However, our findings suggest that these feelings are modifiable within-person and that positive changes in social cohesion translate to greater

social participation. Between-person levels of neighborhood disorder acted as barriers to social participation. Furthermore, certain alternative transportation options mitigated the effect of neighborhood disorder on participation in diverse social activities. These findings suggest that alternative transportation is an effective strategy to increasing person-environment fit and increasing social participation among those living in disadvantaged neighborhoods. By addressing both alternative transportation and the neighborhood context communities may be able to facilitate community engagement among older adults; thus, enhancing social integration and improving the health and well-being of community members.

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Table 1. Descriptive Statistics (n=27,464 person-year observations)

Variable	%	Mean	Observations	SD	Range
Social Participation		2.52	27,464	1.17	0-4
Level 2 Sociodemographic Characteristics					
Age Group at Baseline:					
65-69 Years (ref.)	33.6%		6,335		0-1
70-74 Years	26.6%		6,411		0-1
75-79 Years	19.2%		5,868		0-1
80-84 Years	12.9%		5,131		0-1
85-89 Years	5.8%		2,509		0-1
90+ Years	1.9%		1,210		0-1
Sex (female=1)	54.0%		15,275		0-1
Race/Ethnicity:					
White (ref.)	84.6%		20,043		0-1
Black/African American	7.1%		5,354		0-1
Hispanic/Latinx	5.6%		1,406		0-1
Other Race	2.8%		661		0-1
Education:					
Less than High School	17.4%		6,102		0-1
High School (ref.)	25.9%		7,299		0-1
More than High School	56.6%		14,063		0-1
Residential Duration (≥5 yrs.)	85.8%		23,710		0-1
Level 1 Sociodemographic Characteristics					
Married/Partnered	58.5%		14,214		0-1
Income Quartiles:					
Low Income (ref.)	16.7%		5,893		0-1
Lower-Middle Income	21.6%		6,641		0-1
Upper-Middle Income	27.5%		7,262		0-1
Upper Income	34.2%		7,668		0-1
Home Paid Off	55.6%		15,030		0-1
Lives in Metro Area	80.6%		21,913		0-1
Moved Locations	2.9%		826		0-1
Level 1 Health Factors					
Self-Rated Health:					
Poor Health (ref.)	4.7%		1,575		0-1
Fair Health	16.5%		5,314		0-1
Good Health	32.7%		9,340		0-1
Very Good Health	32.6%		8,101		0-1
Excellent Health	13.5%		3,134		0-1
Mobility Limitation	36.2%		12,031		0-1
Fall in Past Year	11.3%		3,257		0-1
Uses Mobility Device	24.1%		8,343		0-1
Hearing Aid Used/Deaf	15.8%		4,621		0-1
Vision Impairment	4.8%		1,644		0-1
Bothersome Pain	54.0%		14,958		0-1
Balance Problems	31.5%		9,502		0-1
Poor Memory	21.6%		7,007		0-1
Depressive Symptoms		5.61		2.24	0-16
Transportation Use					
Uses Paratransit	7.7%		2,431		0-1
Gets Rides	47.4%		13,933		0-1
Uses Public Transportation	7.2%		1,963		0-1
Walks/Uses Wheelchair to Get Places	51.6%		13,152		0-1
Driving Frequency		2.56	27,464	1.47	0-4
Neighborhood Context					
Between-Person					
Neighborhood Disorder		1.05	27,464	0.15	1-4
Social Cohesion		2.44	27,464	0.45	1-3
Within-Person					
Neighborhood Disorder		0.00	27,464	0.15	-2.0-2.4
Social Cohesion		0.00	27,464	0.30	-1.7-1.6

Table 2. Growth Curve Models Predicting Rate of Change in Number of Social Activities Completed in the Past Month, NHATS (2011-2018)

	Model 1		Model 2		Model 3		Model 4		Model 5		Model 6	
Variable	**Coef**	**SE**	**Coef**	**SE**	**Coef**	**SE**	**Coef**	**SE**	**Coef**	**SE**	**Coef**	**SE**
Time	0.01	(0.01)	0.00	(0.01)	0.01	(0.01)	0.02	(0.01)	0.02	(0.01)	0.01	(0.01)
Time*Time	-0.00***	(0.00)	-0.00**	(0.00)	-0.00*	(0.00)	-0.00**	(0.00)	-0.00**	(0.00)	-0.00**	(0.00)
Level 2 Sociodemographic Characteristics												
Age Group at Baseline												
65-69 Years (ref.)												
70-74 Years			-0.04	(0.04)	-0.02	(0.04)	0.00	(0.04)	0.00	(0.04)	-0.02	(0.04)
75-79 Years			-0.07	(0.04)	0.01	(0.04)	0.06	(0.04)	0.06	(0.04)	0.03	(0.04)
80-84 Years			-0.18***	(0.05)	-0.07	(0.05)	-0.01	(0.05)	-0.01	(0.05)	-0.02	(0.04)
85-89 Years			-0.42***	(0.05)	-0.23***	(0.05)	-0.11*	(0.05)	-0.11*	(0.05)	-0.14**	(0.05)
90+ Years			-0.68***	(0.06)	-0.46***	(0.06)	-0.30***	(0.05)	-0.31***	(0.05)	-0.34***	(0.05)
Sex (female=1)			0.29***	(0.03)	0.34***	(0.03)	0.41***	(0.03)	0.41***	(0.03)	0.39***	(0.03)
Race/Ethnicity:												
White (ref.)												
Black/African American			-0.13***	(0.04)	-0.05	(0.03)	-0.02	(0.03)	-0.02	(0.03)	0.05	(0.03)
Hispanic/Latinx			-0.33***	(0.06)	-0.23***	(0.05)	-0.20***	(0.05)	-0.20***	(0.05)	-0.09	(0.05)
Other Race			-0.35***	(0.06)	-0.33***	(0.06)	-0.29***	(0.05)	-0.29***	(0.05)	-0.25***	(0.06)
Education:												
Less than High School			-0.43***	(0.03)	-0.36***	(0.03)	-0.33***	(0.03)	-0.33***	(0.03)	-0.30***	(0.03)
High School (ref.)												
More than High School			0.28***	(0.03)	0.22***	(0.03)	0.19***	(0.03)	0.19***	(0.03)	0.17***	(0.03)
Residential duration (≥5 years)			0.07*	(0.04)	0.07*	(0.04)	0.05	(0.04)	0.03	(0.03)	0.03	(0.03)
Level 1 Sociodemographic Characteristics												
Married/Partnered			0.05*	(0.02)	0.04*	(0.02)	0.06**	(0.02)	0.06**	(0.02)	0.04*	(0.02)
Income Quartiles												
Low Income (ref.)												
Lower-Middle Income			0.07**	(0.02)	0.07**	(0.02)	0.05*	(0.02)	0.03	(0.02)	0.03	(0.02)
Upper-Middle Income			0.17***	(0.03)	0.17***	(0.02)	0.14***	(0.02)	0.11***	(0.02)	0.11***	(0.02)
Upper Income			0.25***	(0.02)	0.25***	(0.03)	0.21***	(0.03)	0.18***	(0.03)	0.18***	(0.03)
Home Paid Off			0.08***	(0.05)	0.08***	(0.02)	0.05*	(0.02)	0.03	(0.02)	0.03	(0.02)
Lives in Metro Area			0.01	(0.03)	0.01	(0.05)	0.00	(0.05)	0.00	(0.05)	0.01	(0.05)
Moved Locations			-0.06	(0.04)	-0.06	(0.03)	-0.05	(0.03)	-0.04	(0.03)	-0.04	(0.03)
Level 1 Health Factors												
Self-Rated Health:												
Poor Health (ref.)												

Fair Health					0.17***	(0.03)	0.15***	(0.03)	0.14***	(0.03)	0.14***	(0.03)
Good Health					0.27***	(0.03)	0.23***	(0.03)	0.23***	(0.03)	0.22***	(0.03)
Very Good Health					0.31***	(0.04)	0.26***	(0.04)	0.26***	(0.04)	0.24***	(0.04)
Excellent Health					0.30***	(0.04)	0.25***	(0.04)	0.24***	(0.04)	0.22***	(0.04)
Depressive Symptoms					-0.04***	(0.00)	-0.03***	(0.00)	-0.03***	(0.00)	-0.03***	(0.00)
Mobility Limitation					-0.18***	(0.02)	-0.14***	(0.02)	-0.14***	(0.02)	-0.13***	(0.02)
Fall in Past Year					-0.00	(0.01)	-0.00	(0.01)	-0.00	(0.01)	-0.00	(0.01)
Uses Mobility Device					-0.14***	(0.02)	-0.08***	(0.02)	-0.08***	(0.02)	-0.09***	(0.02)
Hearing Aid Used/Deaf					0.12***	(0.02)	0.11***	(0.02)	0.11***	(0.02)	0.11***	(0.02)
Vision Impairment					-0.11**	(0.03)	-0.08*	(0.03)	-0.08*	(0.03)	-0.07*	(0.03)
Bothersome Pain					0.03*	(0.01)	0.02*	(0.01)	0.02*	(0.01)	0.03*	(0.01)
Balance Problems					-0.02	(0.01)	-0.01	(0.01)	-0.01	(0.01)	-0.01	(0.01)
Poor Memory					-0.08***	(0.02)	-0.06***	(0.02)	-0.06***	(0.02)	-0.06***	(0.02)
Transportation Use												
Uses Paratransit							0.10***	(0.02)	0.10***	(0.02)	0.10***	(0.02)
Gets Rides							0.13***	(0.01)	0.13***	(0.01)	0.13***	(0.01)
Uses Public Transportation							0.06*	(0.02)	0.06*	(0.02)	0.07**	(0.02)
Walks/Uses Wheelchair							0.08***	(0.01)	0.08***	(0.01)	0.07***	(0.01)
Number Days Drive							0.14***	(0.01)	0.14***	(0.01)	0.14***	(0.01)
Neighborhood Context												
Within-Person												
Neighborhood Disorder									-0.03	(0.03)	-0.03	(0.03)
Social Cohesion									0.07***	(0.02)	0.07***	(0.02)
Between-Person												
Neighborhood Disorder											-0.35***	(0.07)
Social Cohesion											0.39***	(0.03)
Constant	2.44***	(0.03)	2.09***	(0.08)	1.93***	(0.08)	1.72***	(0.07)	1.72***	(0.07)	1.20***	(0.13)
Random Components												
Random intercept	1.02***	(0.02)	0.79***	(0.02)	0.68***	(0.02)	0.62***	(0.02)	0.62***	(0.02)	0.59***	(0.01)
Residual variance	0.42***	(0.01)	0.42***	(0.01)	0.41***	(0.01)	0.41***	(0.01)	0.41***	(0.01)	0.41***	(0.01)
N, Level 1	27,464		27,464		27,464		27,464		27,464		27,464	
N, Level 2	6,718		6,718		6,718		6,718		6,718		6,718	
Model Fit Statistics												
Akaike information criterion (AIC)	72927.64		70304.23		70304.23		69329.56		69295.55		68978.34	
Bayesian information criterion (BIC)	72968.88		70609.33		70609.33		69675.9		69658.37		69357.66	
Degrees of Freedom	5		37		37		42		44		46	

Notes. all models weighted using analytic weights; *** p<0.001, ** p<0.01, * p<0.05

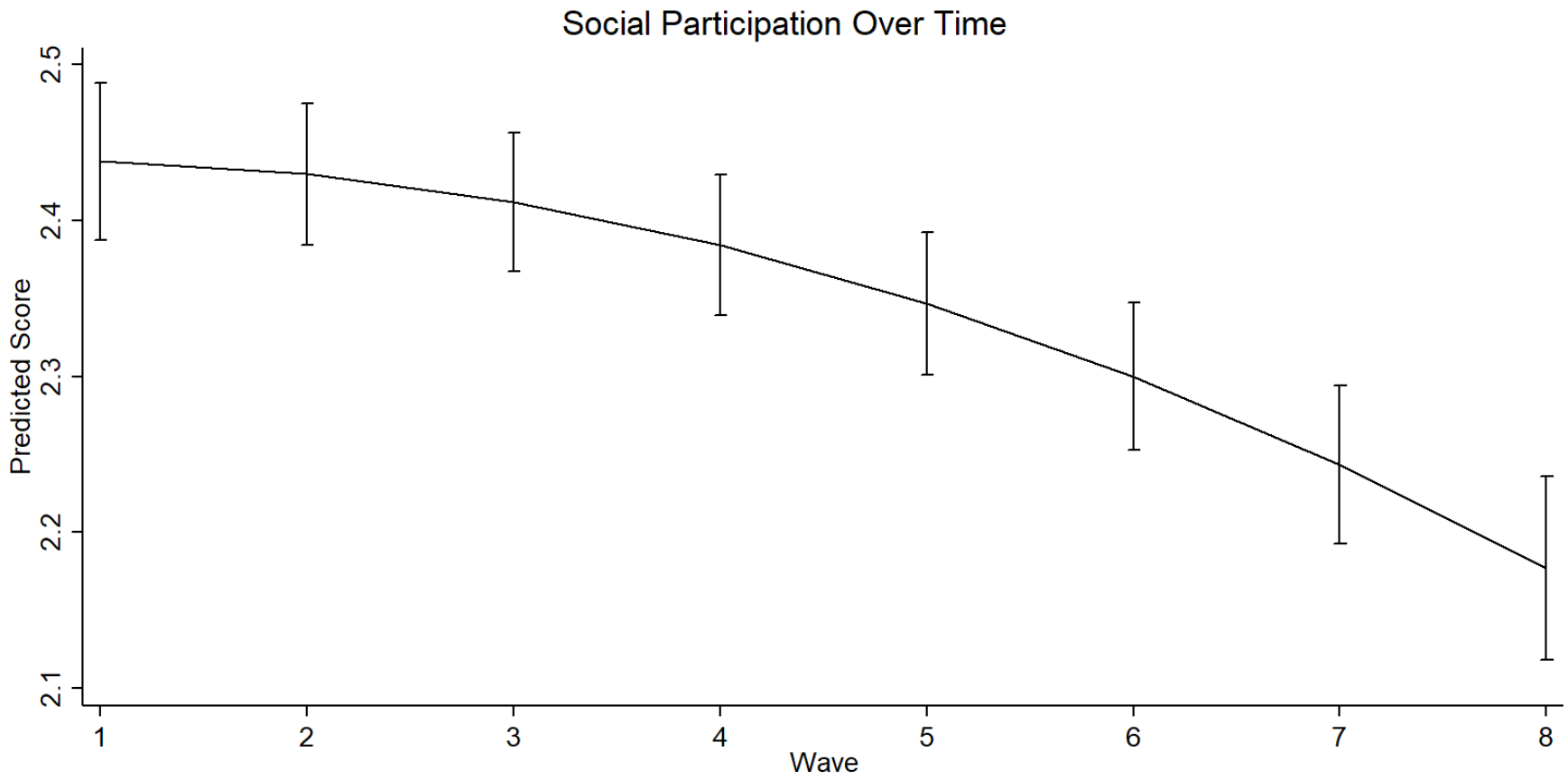

Figure 1. Social Participation over Time

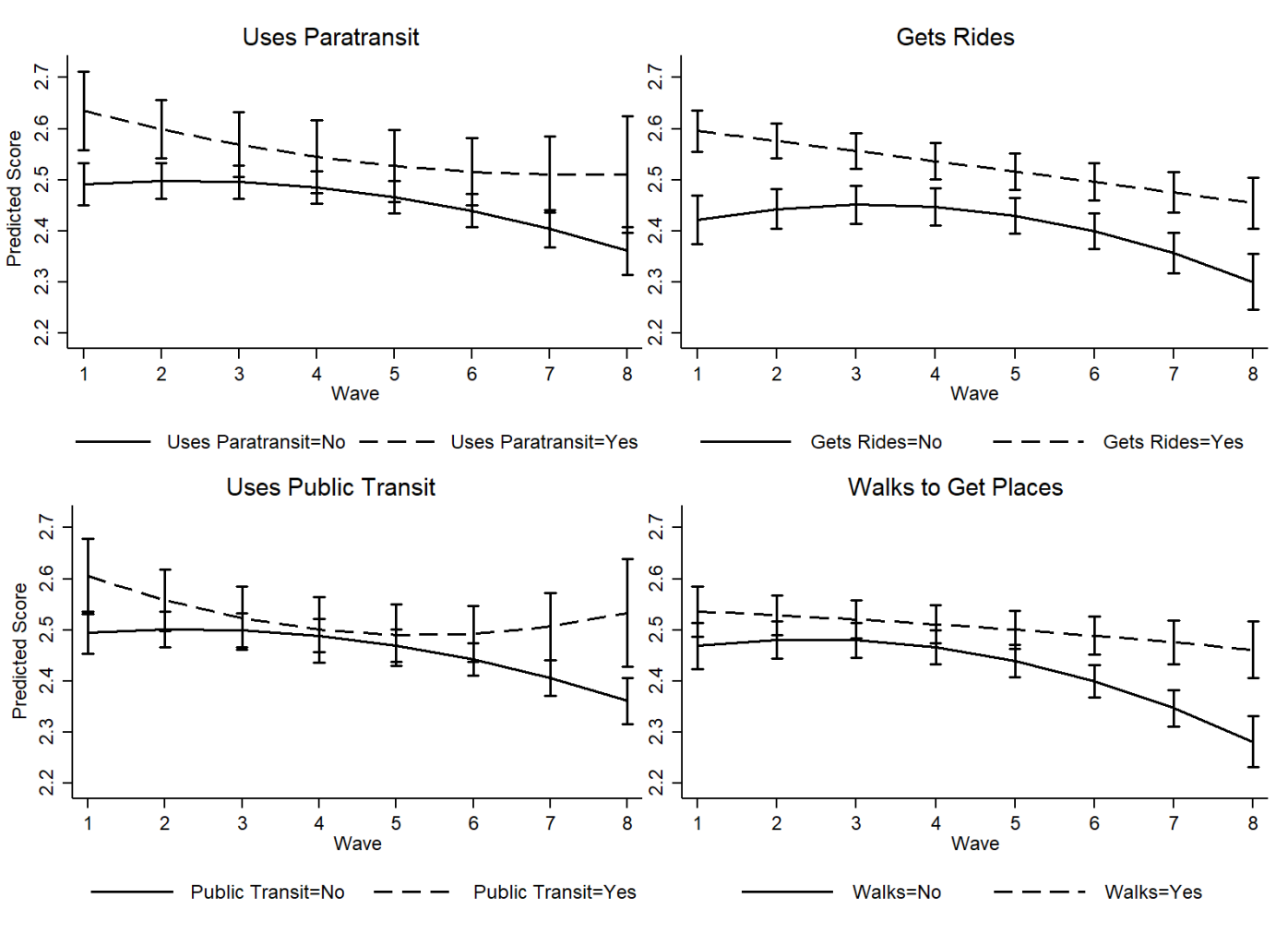

Figure 2. The Effect of Alternative Transportation on Social Participation over Time

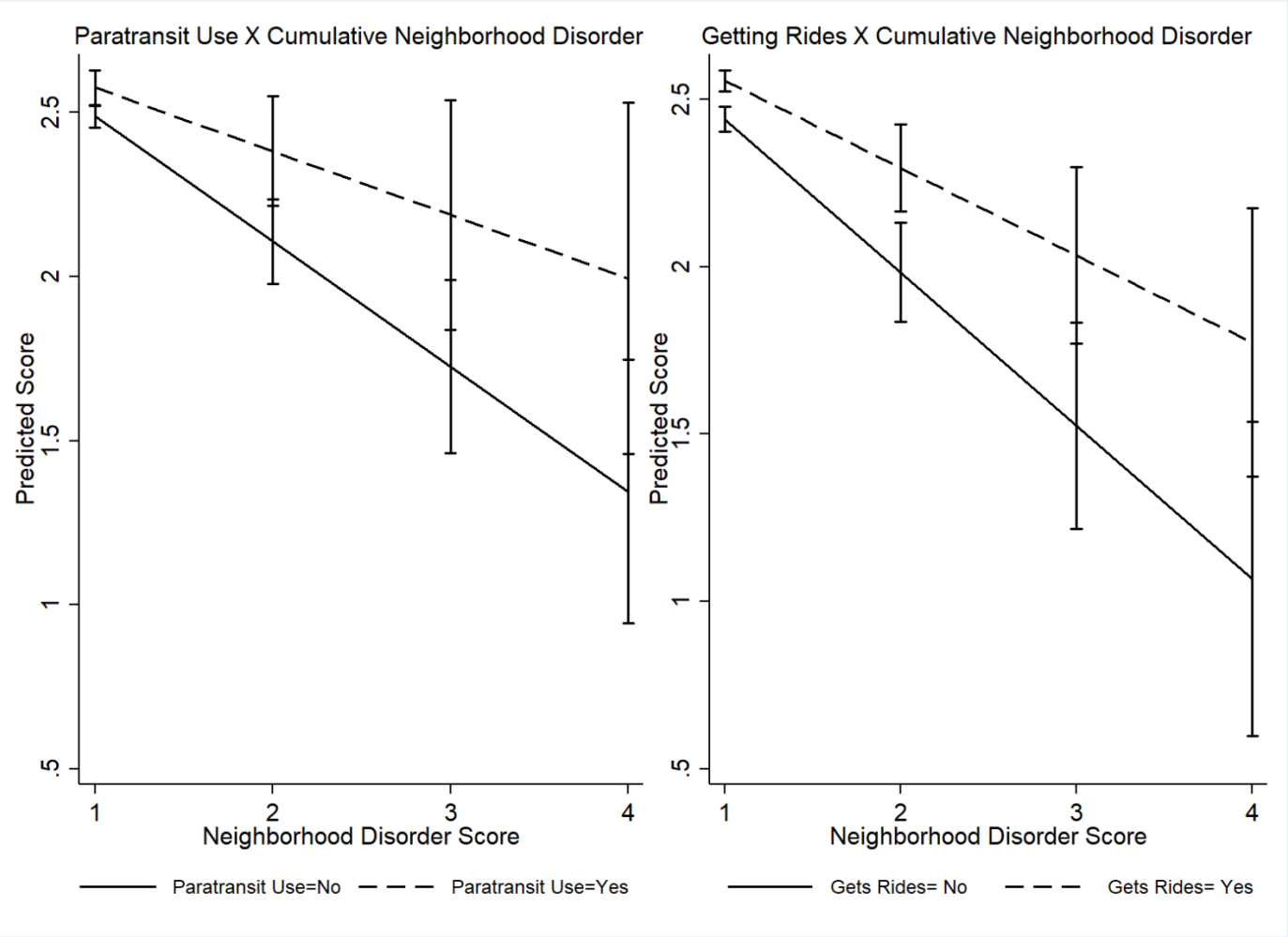

Figure 3. Predictive Margins of Alterative Transportation Use and Between-Person Neighborhood Disorder (Level 2)

Supplemental Table 1. Descriptive Statistics

Variable	Wave 1 (n=6,719) Percent / Mean	SD	Wave 2 (n=4,788) Percent / Mean	SD	Wave 3 (n=3,735) Percent / Mean	SD	Wave 4 (n=3,013) Percent / Mean	SD	Wave 5 (n=2,920) Percent / Mean	SD	Wave 6 (n=2,603) Percent / Mean	SD	Wave 7 (n=2,327) Percent / Mean	SD	Wave 8 (n=2071) Percent / Mean	SD
Participation in Social Activities	2.42	1.19	2.57	1.14	2.57	1.15	2.57	1.16	2.54	1.17	2.53	1.19	2.5	1.2	2.48	1.17
Level 2 Sociodemographic Characteristics																
Age Group at Baseline																
65-69 Years (ref.)	29.70%		31.70%		32.80%		34.60%		34.70%		36.20%		37.00%		37.90%	
70-74 Years	25.80%		25.90%		26.60%		25.80%		26.70%		27.10%		27.90%		28.60%	
75-79 Years	19.20%		19.40%		19.30%		19.40%		19.40%		19.00%		19.10%		18.70%	
80-84 Years	14.30%		13.80%		13.30%		12.90%		12.50%		11.60%		11.00%		10.70%	
85-89 Years	7.90%		6.70%		6.20%		5.60%		5.30%		4.90%		4.30%		3.50%	
90+ Years	3.10%		2.50%		1.90%		1.60%		1.40%		1.20%		0.80%		0.60%	
Sex (female=1)	55.10%		53.00%		54.30%		54.10%		54.90%		54.50%		54.90%		54.10%	
Race/Ethnicity:																
White (ref.)	81.20%		83.50%		85.30%		86.00%		86.00%		86.10%		86.10%		86.20%	
Black/African American	8.20%		7.60%		6.90%		6.40%		6.70%		6.70%		6.80%		6.40%	
Hispanic/Latinx	7.00%		5.90%		5.20%		4.90%		5.00%		4.90%		4.70%		5.00%	
Other Race	3.60%		3.00%		2.60%		2.70%		2.20%		2.30%		2.40%		2.40%	
Education:																
Less than High School	21.80%		18.20%		17.30%		15.70%		15.70%		15.40%		14.80%		14.10%	
High School (ref.)	27.30%		27.30%		26.40%		25.60%		25.20%		24.60%		24.60%		24.30%	
More than High School	50.90%		54.50%		56.30%		58.70%		59.10%		60.00%		60.60%		61.60%	
Residential Duration (≥5 yrs.)	84.60%		85.20%		85.90%		85.90%		86.00%		86.00%		86.20%		86.20%	
Level 1 Sociodemographic Characteristics																
Married/Partnered	59.60%		60.20%		58.90%		58.90%		56.70%		56.90%		55.20%		54.60%	
Income Quartiles:																
Low Income (ref.)	19.50%		16.20%		16.40%		14.80%		16.40%		15.80%		16.70%		16.00%	
Lower-Middle Income	22.20%		21.70%		20.80%		20.10%		22.90%		22.20%		22.40%		22.30%	
Upper-Middle Income	26.40%		27.20%		28.80%		29.50%		26.50%		26.30%		28.10%		28.20%	
Upper Income	31.90%		34.90%		34.00%		35.70%		34.20%		35.70%		32.80%		33.50%	
Home Paid Off	53.20%		56.30%		56.10%		57.30%		55.50%		55.90%		55.50%		55.90%	
Lives in Metro Area	81.40%		80.90%		80.70%		81.00%		80.40%		80.20%		79.80%		80.30%	
Moved Locations	0.00%		3.10%		3.40%		3.80%		3.20%		4.30%		5.80%		4.80%	
Level 1 Health Factors																
Self-Rated Health																
Poor Health (ref.)	6.70%		4.90%		4.30%		4.20%		3.80%		3.80%		3.90%		4.20%	
Fair Health	18.00%		15.40%		15.80%		14.20%		16.60%		17.10%		16.00%		18.00%	
Good Health	30.40%		31.50%		32.10%		31.90%		34.30%		34.30%		37.80%		35.60%	
Very Good Health	29.90%		33.30%		33.30%		36.10%		32.60%		33.10%		31.30%		31.50%	
Excellent Health	15.10%		15.00%		14.40%		13.50%		12.70%		11.80%		11.10%		10.70%	
Mobility Limitation	36.10%		34.10%		34.60%		34.80%		37.30%		39.00%		39.70%		41.20%	

	Wave 1 (n=6,719)		Wave 2 (n=4,788)		Wave 3 (n=3,735)		Wave 4 (n=3,013)		Wave 5 (n=2,920)		Wave 6 (n=2,603)		Wave 7 (n=2,327)		Wave 8 (n=2071)	
Variable	**Percent / Mean**	**SD**	**Percent / Mean**	**SD**	**Percent / Mean**	**SD**	**Percent / Mean**	**SD**	**Percent / Mean**	**SD**	**Percent / Mean**	**SD**	**Percen t / Mean**	**SD**	**Percent / Mean**	**SD**
Fall in Past Year	10.10%		11.00%		10.20%		11.70%		12.40%		12.40%		12.80%		12.30%	
Uses Mobility Device	21.50%		20.30%		21.60%		24.50%		26.80%		28.20%		29.70%		31.60%	
Hearing Aid Used/Deaf	11.10%		13.00%		14.70%		16.00%		18.10%		20.00%		21.00%		23.00%	
Vision Impairment	5.20%		4.50%		4.50%		3.70%		5.10%		5.10%		5.30%		5.90%	
Bothersome Pain	52.90%		51.90%		53.10%		53.90%		55.30%		56.90%		55.10%		56.70%	
Balance Problems	27.10%		27.90%		29.90%		32.10%		33.90%		34.50%		38.20%		39.80%	
Poor Memory	20.90%		19.50%		20.00%		20.10%		23.60%		23.90%		23.80%		26.10%	
Depressive Symptoms	5.84	2.45	5.58	2.21	5.58	2.21	5.52	2.10	5.54	2.24	5.56	2.78	5.60	2.23	5.51	2.24
Transportation Use																
Uses Paratransit	7.50%		6.30%		6.80%		6.60%		7.40%		8.80%		9.90%		11.00%	
Gets Rides	45.10%		45.00%		47.90%		48.60%		48.30%		50.50%		50.30%		51.30%	
Uses Public Transportation	8.50%		6.90%		7.30%		6.40%		6.90%		6.30%		6.80%		7.10%	
Walks to Get Places	51.80%		52.30%		50.40%		51.00%		50.80%		51.70%		51.30%		48.50%	
Driving Frequency	2.55	1.55	2.66	1.42	2.66	1.42	2.62	1.12	2.51	1.46	2.50	1.47	2.43	1.47	-0.01	1.47
Neighborhood Context																
Between-Person																
Neighborhood Disorder	1.06	0.19	1.06	0.16	1.06	0.16	1.05	0.13	1.05	0.13	1.05	0.13	1.04	0.13	2.47	0.15
Social Cohesion	2.41	0.48	2.43	0.46	2.43	0.46	2.45	0.43	2.46	0.43	2.46	0.42	2.46	0.43	1.03	0.44
Within-Person																
Neighborhood Disorder	0.00	1.54	0.01	0.16	0.00	0.16	-0.01	0.14	0.00	0.14	0.00	0.16	0.00	0.14	0.01	0.15
Social Cohesion	-0.01	0.30	0.00	0.31	0.00	0.31	0.00	0.30	-0.01	0.30	0.00	0.31	0.01	0.32	1.04	0.31

Supplemental Table 2. Results from Interactions between Alternative Transportation and Time

Variable	Paratransit	Gets Rides	Public Transp.	Walks Places	Alt. Transp.
Time (linear)	0.02	0.04**	0.02	0.03*	0.06***
Time^2	-0.00**	-0.01***	-0.00***	-0.01***	-0.01***
Paratransit use					
x time	0.02				0.06***
x time^2	-0.00**				-0.01***
Gets rides					
x time		-0.06***			-0.06***
x time^2		0.01***			0.01***
Rides busses					
x time			-0.08*		-0.06
x time^2			0.01*		0.01
Walks places					
x time				-0.04*	-0.03
x time^2				0.01**	0.01*

Notes. All models are weighted with analytic weights; *** p<0.001, ** p<0.01, * p<0.05; all models adjust for sociodemographic characteristics, health factors, and driving frequency.

Supplement Table 3. Results from Interactions between Neighborhood Disorder (ND) and Alternative Transportation Use

	Model 1		Model 2		Model 3		Model 4		Model 5	
Variable	Coef	SE	Coef	SE	Coef	SE	Coef	SE	Coef	SE
Level 1 Transportation X Level 1 ND										
Uses Paratransit	-0.11	(0.12)							-0.11	(0.12)
Gets rides			-0.04	(0.07)					-0.03	(0.07)
Uses Public Transportation					-0.03	(0.08)			0.03	(0.08)
Walks/Uses Wheelchair to Get Places							-0.02	(0.08)	-0.01	(0.08)
Level 1 Transportation X Level 2 ND										
Uses Paratransit	0.18*	(0.09)							0.13	(0.09)
Gets rides			0.19**	(0.07)					0.19*	(0.07)
Uses Public Transportation					0.15	(0.14)			0.07	(0.16)
Walks/Uses Wheelchair to Get Places							0.12	(0.07)	0.11	(0.08)

Notes: ND=neighborhood disorder; all interactions were controlling for all covariates; all models are weighted with analytic weights.