Research Article

Trajectories of Homebound Status in Medicare Beneficiaries Aged 65 and Older

Xiaoling Xiang, PhD, MSW,^{1,*} Jieling Chen, MA,² and MinHee Kim, MSW¹

¹School of Social Work, University of Michigan, Ann Arbor. ²Department of Social Work and Social Administration, University of Hong Kong, Hong Kong, China.

*Address correspondence to: Xiaoling Xiang, PhD, MSW, School of Social Work, University of Michigan, 1080 S University Avenue, Ann Arbor, MI 48109. E-mail: xiangxi@umich.edu

Received: October 22, 2018; Editorial Decision Date: January 23, 2019

Decision Editor: Rachel Pruchno, PhD

Abstract

Background and Objectives: The purpose of this study was to examine the trajectories of homebound status in older adults and to investigate the risk factors in shaping the pattern of these trajectories.

Research Design and Methods: The study sample was a nationally representative sample of Medicare beneficiaries aged 65 and older ($N = 7,607$) from the National Health and Aging Trends Study (Round 1–Round 7). Homebound state was defined as never or rarely went out the home in the last month. Homebound trajectories were identified using an enhanced group-based trajectory modeling that accounted for nonrandom attrition. Multinomial logistic regression was used to examine risk factors of homebound trajectories.

Results: Three trajectory groups were identified: the “never” group (65.5%) remained nonhomebound; the “chronic” group were largely persistently homebound (8.3%); and the “onset” group (26.2%) had a rapid increase in their risk of being homebound over the 7-year period. The following factors increased the relative risk for being on the “onset” and “chronic” versus the “never” trajectory: older age, Hispanic ethnicity, social isolation, past or current smoking, instrumental activities of daily living limitations, probable dementia, and use of a walker or wheelchair. Male sex and living alone were associated with a lower risk of being on the “chronic” trajectory, whereas depression and anxiety symptoms, chronic conditions, and activities of daily living limitations increased the risk.

Discussion and Implications: The progression of homebound status among community-dwelling older adults followed three distinct trajectories over a 7-year period. Addressing social isolation and other risk factors may prevent or delay the progression to homebound state.

Keywords: Outdoor mobility, Disability, Group-based trajectory modeling

Homebound older adults are community-dwelling older adults confined to their homes due to physical, psychiatric, and social limitations (Qiu et al., 2010). An estimated 2 million older adults in the United States are homebound, defined as going out of the house once a week or less (Ornstein et al., 2015). Longitudinal studies have found that the state of homebound increases the risk of cognitive impairment (Harada et al., 2016), functional dependence (Hamazaki, Morikawa, Morimoto, & Nakagawa, 2016),

and premature death (Cohen-Mansfield, Shmotkin, & Hazan, 2010; Herr, Latouche, & Ankri, 2013). Homebound status is also associated with higher health care utilization and expenditures (Musich, Wang, Hawkins, & Yeh, 2015) and higher rates of noncompliance with medication and care patterns (Musich et al., 2015). Homebound older adults are therefore considered a unique population with complex care needs and have become a focus of health care innovations (Leff, Carlson, Saliba, & Ritchie, 2015).

Despite receiving increased attention from the medical field, homebound older adults remain an understudied population (Musich et al., 2015; Ornstein et al., 2015). Relevant studies have focused on describing the target population and examining correlates of homebound status, with most of these studies adopting a cross-sectional design (De-Rosende Celeiro, Santos-Del-Riego, & Muñiz García, 2017; Harada et al., 2016; Hirai et al., 2015; Musich et al., 2015; Negron-Blanco et al., 2016; Ornstein et al., 2015). Most studies examined the state of homebound as a static concept (e.g., Musich et al., 2015; Ornstein et al., 2015). However, homebound status may change over time (Xiang, An, & Oh, 2018). The progression from ambulatory to homebound status probably takes place over time, and the rates of progression may differ across population subgroups. Yet, very few studies have examined the changes or trajectories of homebound status over an extended period and correlates of these trajectories (Smith, Chen, Clarke, & Gallagher, 2016). Smith and colleagues (2016) identified four distinct trajectories of homebound status over a 15-month period in a sample of older adults receiving Medicaid home care in Detroit, MI. Nonetheless, this Detroit-based study was limited to an urban, community-dwelling sample with high homebound risk and had a short study period. An extended observation period is better suited to capture the patterns of progression of homebound status in population-based samples.

Conceptual Framework

Based on models and themes used in epidemiology, gerontology, and several related fields, Satariano (2006) devised an ecological model of aging to describe the dynamic process that biological, behavioral, and environmental factors affect disease, functioning, and disability. A strength of this framework is the specification of domains of variables that may affect health outcomes, making it well suited to guide the exploration of factors that may shape homebound trajectories. These variables include demographic (age, gender, race, and ethnicity); socioeconomic (such as education and income); social (such as living arrangements, social networks, and social support); psychosocial (such as self-efficacy); health behaviors, health conditions, functioning (physical and cognitive); and environment (built and physical).

Many variables included in the ecological model of aging have been linked to homebound status. Homebound individuals tended to be older, female, have a lower level of education and income, a higher level of depressive symptoms, more chronic conditions, poorer cognitive functioning, and more functional limitations (Clarke, 2014; De-Rosende Celeiro et al., 2017; Harada et al., 2016; Musich et al., 2015; Negron-Blanco et al., 2016; Ornstein et al., 2015). U.S.-based studies showed that the prevalence of homebound was higher among certain racial/ethnic minorities (Ornstein et al., 2015). Certain features of the

built environment, such as stairs at the home entrance and no elevator, have been associated with a higher risk of being homebound (Clarke, 2014; Cohen-Mansfield, Shmotkin, & Hazan, 2012; De-Rosende Celeiro et al., 2017). Regarding social factors, findings on living arrangements and marital status were inconsistent (Clarke, 2014; Cohen-Mansfield et al., 2012; De-Rosende Celeiro et al., 2017; Hamazaki et al., 2016) and the influence of social networks and social support on homebound status have rarely been explored. It is unclear, however, whether these ecological correlates of homebound status identified in cross-sectional data are linked with long-term trajectories of homebound status.

The primary aim of the present study was to examine the 7-year trajectories of homebound status in a nationally representative sample of community-dwelling older adults. Our secondary aim was to explore the factors shaping the patterns of these trajectories. We hypothesized notable differences in the trajectory patterns of homebound status over the 7-year period. We also hypothesized that an array of ecological factors would be associated with the trajectory membership. We used an enhanced group-based trajectory modeling accounting for nonrandom attrition to identify homebound trajectories. To our best knowledge, no prior studies have jointly modeled homebound trajectories and attrition, which is often associated with disability and thus nonrandom.

Methods

Participants

The National Health and Aging Trends Study (NHATS) is a nationally representative, longitudinal study of persons aged 65 and older and enrolled in Medicare (www.NHATS.org). The baseline interview, conducted in 2011, excluded nursing home residents. Annual follow-up interviews, however, were conducted for all eligible persons regardless of their residential status. A replenishment of the sample was added in 2015. NHATS uses proxy familiar with the sample person's health and daily routine when the sample person could not respond, typically due to an illness or impairment (Kasper & Freedman, 2018).

We analyzed Round 1 (2011) through Round 7 (2017) of the NHATS public use files, using data from the original sample ($N = 7,609$). Two respondents were excluded due to missing data on homebound status during all seven survey rounds, resulting in 7,607 participants in our analysis. Proxy respondents accounted for 7.6% of study sample at baseline. The proportions of proxies ranged from 12.7% to 14.7% during follow-ups. We included proxy responses because exclusion would have caused selection bias (Skolarus et al., 2010). Attrition was prevalent: 1,896 participants (24.9%) died and 2,827 (37.2%) dropped out due to other reasons over the 7 years. Our study sample yielded 33,821 person-years of observations, averaging 4.4 valid interviews per person.

Measures

Homebound status

Consistent with previous studies (Cohen-Mansfield et al., 2012; Fujita, Fujiwara, Chaves, Motohashi, & Shinkai, 2006), participants were classified as homebound if they replied that they “never” or “rarely” (once a week or less) left home/building to go outside during the last month. A person’s homebound status may change from one year to another. All sample persons, including nursing home residents (starting in Round 2), were administered the homebound question. A small number of sample persons ($N = 263$ or 3.5%) ever resided in a nursing home during the study period (N ranged from 64 to 86 across interviews). Considering the intraindividual changes in residential status, our analysis included persons who resided in a nursing home during follow-ups.

Ecological factors

We selected a set of predictors based on the ecological model of aging and earlier discussion of risk factors from previous studies. Final selection struck a balance between comprehensiveness and parsimony. All ecological factors were measured at baseline to reduce the possibility that these variables are influenced by the homebound trajectories themselves.

Demographic, socioeconomic, and social factors

Demographic factors included age groups, sex, and race/ethnicity. Socioeconomic factors included educational and family income in quartiles. Social factors included an indicator of living alone, social isolation, and social capital. Pohl, Cochrane, Schepp, and Woods (2017) developed a social isolation measure that consists of six NHATS items concerning marriage/partnerships, contact with family and friends, church participation, and club participation. Indicator scores were summed to create the social isolation score, with higher score indicating greater isolation. We used the cutpoint suggested by Pohl and colleagues (2017) to create a three-category variable (0–1: “not isolated,” 2–3: “somewhat isolated,” and ≥ 4 : “socially isolated”). Participants rated their agreement with the statements that people in this community “know each other well”; “are willing to help each other”; and “can be trusted” on a three-point Likert scale from “Agree a lot” to “Do not agree.” A summary measure of social capital was created taking the average of the three items, with a higher score indicates a higher level of social capital (Cronbach’s $\alpha = .73$).

Psychosocial factors

Depressive and anxiety symptoms were measured by the abbreviated versions of the Patient Health Questionnaire (PHQ-2) and generalized anxiety disorder (GAD-2; Kroenke, Spitzer, Williams, & Löwe, 2009). The optimal cutpoint is ≥ 3 on both scales (Kroenke, Spitzer, Williams, & Löwe, 2010). Because depression and anxiety often

co-occur, we created a dichotomous indicator of having either clinically significant depressive symptoms or anxiety symptoms.

Health behaviors and health conditions

We included an indicator of having ever smoked regularly and a count of self-reported physician diagnoses of eight chronic conditions (hypertension, heart disease, arthritis, osteoporosis, diabetes, lung disease, stroke, and cancer).

Functioning

NHATS assessed limitations in activities of daily living (ADL; including eating, bathing, toileting, and dressing) and instrumental activities of daily living (IADL; including laundry, grocery shopping, meal preparation, and keeping track of medication). Respondents were considered to have an activity limitation if (a) they had assistance with that activity (must be for health or functioning reasons for IADL activities) or (b) they had difficulty performing the activity alone. Summary indicators were created for ADL and IADL domains. Moreover, we included an indicator of self-reported activity limitations due to pain. NAHTS classification of dementia status (no dementia, possible dementia, and probable dementia; Kasper, Freedman, & Spillman, 2013) was included as a proxy for cognitive functioning.

Environment

Participants were asked if they used a cane, walker, wheelchair, or scooter to get around more easily, safely, or on their own. Features of the immediate built environment, collected using interviewer observations, included an indicator of stairs or a step at the entrance and whether there was a ramp. Because Clarke (2014) found a significant interaction effect between mobility devices and built environment on difficulty with outdoor mobility, we explored these interaction terms in our analysis. In addition to these ecological factors, we included a dichotomous indicator of proxy respondent to adjust for the potential bias associated with proxy responses (Skolarus et al., 2010).

Statistical Analysis

Weighted descriptive and bivariate analyses were conducted. Homebound trajectories were identified using a group-based trajectory modeling, enhanced to account for nonrandom attrition (Haviland, Jones, & Nagin, 2011). The basic group-based trajectory modeling is a specialized application of finite mixture modeling designed to identify clusters of individuals following similar progressions of some outcome over time (Nagin, 2005). Like other popular methods for estimating trajectories (e.g., growth curve modeling), it assumes independence of probabilities of group membership and attrition (i.e., missing at random). However, late-life disability is often

associated with mortality. The ecological profiles of our study sample differed significantly by attrition status (Supplementary Table 1). Previous studies have shown that methods with missing at random assumption led to biased estimates of trajectory group size (Haviland et al., 2011; Zimmer, Martin, Nagin, & Jones, 2012). In the enhanced model, attrition is modeled as a function of time before dropping out using a logit distribution simultaneously with the estimation of trajectory group. It allows the joint estimation of homebound trajectories and probabilities of dropping out where estimated probabilities of dropping out are specific to each homebound trajectory group. A series of models was fitted by using the Proc Traj plug-in (Jones & Nagin, 2007) by adding one trajectory group at a time and by varying polynomial type for each group. We included all causes of attrition and did not distinguish between mortality and other causes because they cannot be modeled as separate trajectories along with the homebound trajectory. We selected the final model using a combination of Bayesian information criterion, average posterior probability assignment, group size, and conceptual considerations of group distinctiveness and interpretability.

Each participant was assigned to the trajectory group for which they had the highest posterior probabilities of group membership. Subsequently, multinomial logistic regression models were estimated to identify risk factors associated with the homebound trajectory group. All analyses described earlier were conducted using Stata 15.1 (Stata Corp., College Station, TX) and adjusted for the baseline complex survey design of NHATS using Taylor linearization for variance estimation.

Sensitivity analysis

We performed a series of sensitivity analyses to check the robustness of our findings. First, we reran the joint trajectory model excluding nursing home residents. Second, we reran the trajectory modeling, without accounting for attrition, for the entire sample and for completers only. Third, we performed a set of models accounting for mortality only. Fourth, we reran the joint trajectory model using an alternative homebound measure that classified individuals as being homebound if they (a) never or rarely went out in the last month or (b) received help going outside and would never have gone outside by themselves (Ornstein et al., 2015).

Results

Joint Trajectory of Homebound Status and Attrition Over 7 Years

A logit model with three trajectory groups was the best solution for our data. As shown in Figure 1A, group 1 ("never") largely remained nonhomebound, best representing 65.5% (95% confidence interval [CI] = 64.3–66.7%) of the weighted sample. Group 2 ("onset") started

Figure 1. Trajectories of homebound status over 7 years jointly modeled with attrition. (A) The trajectories of homebound status with estimated probability of being homebound at each study wave for each trajectory group and the weighted proportions of the study population following each trajectory. The gray dash lines around the trajectory line represent 95% confidence intervals. (B) The annual attrition probabilities for each trajectory group.

with a low risk of being homebound, but this risk grew rapidly over time until most of them became homebound, best representing 26.2% (95% CI = 25.1–27.2%) of the weighted sample. Group 3 ("chronic") captured participants who were largely persistently homebound, best representing 8.3% (95% CI = 7.7–9.0%) of the weighted sample. Probabilities of attrition varied for each trajectory group (Figure 1B). The "never" group had the lowest attrition probability over time, followed by the "onset" and the "chronic" groups.

We assessed the adequacy of our trajectory model based on two criteria proposed by Nagin (2005). The average of posterior probabilities of membership was 0.9 for group 1 (ranging from 0.5 to 1.0), 0.7 for group 2 (ranging from 0.4 to 1.0), and 0.8 for group 3 (ranging from 0.4 to 1.0), meeting the standard of ≥ 0.7 . The second criterion states that the proportions of the sample assigned to groups based on their highest posterior probabilities of group membership should be about equal to the proportions generated by the maximum likelihood procedure. In our model, the former proportions were 65.5%, 26.2%, and 8.3%, and the latter were 65.8%, 26.5%, and 7.7%, respectively, for groups 1–3, which met the second criterion.

Study Population Characteristics

Over a quarter of study population were 65–69 years old and a quarter of participants were 70–74 years old. The majority of study population were female (56.6%), white (80.6%), reported somewhat socially isolated (57.6%) or isolated (23.2%), and smoked regularly at some point in their lives (52.7%). One in five had either elevated depression or anxiety symptoms, and possible or probable dementia. Study populations had an average of 2.4 chronic diseases. Bivariate analyses comparing sample characteristics by trajectory group showed monotonic worsening of socioeconomic status, social support, mental health, physical health, and physical and cognitive functioning as participants moved from the “never” group to the “onset” group to the “chronic” group. Use of mobility devices increased monotonically as participants moved from the “never” to the “chronic” group. (Table 1).

Risk Factors Shaping Homebound Trajectory

We ran two separate multivariable multinomial logistic regression models to identify risk factors associated with homebound trajectory. Both models used the entire study sample and included the same set of covariates. In the first model, “never” trajectory was the reference group. We ran a second model using the “onset” as the reference group to further compare risk factor profiles between the “onset” and the “chronic” groups. We tested the six interaction terms between use of mobility devices and features of the built environment, but none of them were statistically significant at $p < .05$. These interaction terms were excluded from the final model for parsimony.

Results from the multinomial logistic regression using “never” as the reference category showed a few common risk factors that distinguished the two homebound groups (“onset” and “chronic”) from the ambulatory group (“never” trajectory). Relative to the “never” trajectory group, the expected risk of being on the “onset” and the “chronic” trajectory groups increased with age, IADL limitations, and the use of walker or wheelchair, and was also higher for Hispanics when compared with whites, current, or former smokers, persons with experience of social isolation, and persons with probable dementia. College education uniquely distinguished the “onset” from the “never” group such that college graduates had a lower risk of being on the “onset” trajectory. Several factors uniquely explained the difference between the “chronic” and the “never” groups. The relative risk of being on the “chronic” was lower among men when compared with women, persons in the top income quartile, and persons who lived alone but was higher among persons with elevated depression or anxiety symptoms, more chronic conditions, and more ADL limitations (Table 2).

Results from the multinomial logistic regression using “onset” as the reference category showed that men and persons who lived alone had a lower expected risk of being

on the “chronic” trajectory. The expected risk of being on the “chronic” versus “onset” trajectory increased with age, chronic disease count, and ADL and IADL limitations, and was also higher among persons who were isolated, had elevated depression or anxiety symptoms, and used a walker (Table 2).

Sensitivity Analysis

Joint models accounting for attrition, including the joint model excluding nursing home residents and the model using an alternative homebound measure, resulted in a homebound trajectory distribution similar to the findings of the main analysis. Models not accounting for attrition severely overrepresented persons on the “never” homebound trajectory and underrepresented persons on the “onset” trajectory when compared with findings from the joint model accounting for attrition. Specifically, the model with the entire sample but not accounting for attrition assigned 84% of the sample to the “never” trajectory and 9% to the “onset” trajectory, and the model with completers assigned 93% of the sample to the “never” trajectory. The joint model accounting for mortality only, to a lesser degree, overrepresented the proportion of the sample on the “never” homebound trajectory (72%). These findings suggested that accounting for attrition had a substantial impact on the estimates of trajectory group membership (Supplementary Table 2).

Discussion

The present study expanded research on homebound older adults by examining the long-term progression of homebound status and the risk factors that shape this progression in community-dwelling older adults in the United States. We applied an enhanced group-based trajectory modeling that jointly estimated homebound trajectory and nonrandom attrition. We identified three distinct homebound trajectories over a 7-year period among a nationally representative sample of community-dwelling older adults. Most community-dwelling older adults were never homebound, over a quarter experienced onset of homebound, and a nontrivial proportion (8%) remained in a chronic homebound state. When translated into numbers, 3 million community-dwelling older adults were in a chronic homebound state whereas over 9 million older adults experienced onset of homebound during a 7-year period.

Consistent with the ecological model of aging, homebound trajectory was shaped by an array of demographic, socioeconomic, social, psychosocial, health behavioral, health condition, functioning, and environmental factors. Older adults had a higher risk of being on the two homebound trajectories if they were older, Hispanic, socially isolated, ever smoked regularly, and had more chronic conditions and probable dementia.

Table 1. Sample Characteristics by Homebound Trajectory Group

	All	Group 1: never	Group 2: onset	Group 3: chronic
Age groups, years (%)				
65–69	28.0 (27.0–29.0)	32.2 (30.8–33.6)	23.5 (21.3–25.7)	9.0 (6.4–12.7)
70–74	25.0 (24.1–25.8)	27.1 (25.7–28.4)	23.2 (21.2–25.3)	13.9 (11.1–17.3)
75–79	19.1 (18.2–19.9)	19.0 (17.9–20.3)	20.1 (18.1–22.2)	16.2 (13.2–19.7)
80–84	14.7 (14.0–15.4)	13.5 (12.5–14.5)	16.6 (15.0–18.2)	18.5 (15.7–21.6)
85–89	9.1 (8.5–9.8)	6.3 (5.7–7.0)	11.2 (9.9–12.6)	24.6 (21.3–28.2)
90 or older	4.3 (3.8–4.7)	2.0 (1.7–2.4)	5.6 (4.8–6.5)	17.8 (15.8–20.1)
Sex (%)				
Female	56.6 (55.2–58.0)	55.7 (54.1–57.4)	54.6 (52.0–57.2)	69.7 (66.3–72.8)
Male	43.4 (42.0–44.8)	44.3 (42.6–45.9)	45.4 (42.8–48.0)	30.3 (27.2–33.7)
Race/ethnicity (%)				
White, non-Hispanic	80.6 (78.8–82.2)	82.9 (81.2–79.5)	77.3 (75.0–79.5)	72.4 (67.5–76.8)
Black, non-Hispanic	8.1 (7.3–9.0)	7.4 (6.7–8.3)	9.1 (8.0–10.4)	10.4 (8.8–12.2)
Hispanic	6.7 (5.8–7.9)	5.5 (4.5–6.6)	8.2 (6.9–9.7)	12.4 (9.3–16.3)
Other	4.6 (3.7–5.7)	4.2 (3.3–5.4)	5.5 (4.1–7.2)	4.9 (3.1–7.5)
Education (%)				
Less than high school	21.8 (20.1–23.6)	17.6 (16.0–19.4)	26.5 (23.9–29.2)	39.8 (35.1–44.8)
High school	27.6 (26.3–29.0)	27.2 (25.5–28.9)	28.6 (26.1–31.2)	28.2 (24.6–32.1)
Some college, no degree	21.4 (20.3–22.6)	22.0 (20.5–23.5)	21.7 (19.7–23.9)	15.9 (13.0–19.2)
College graduate	29.2 (27.0–31.6)	33.3 (30.9–35.7)	23.3 (20.3–26.5)	16.2 (13.2–19.6)
Family income in 2011 (\$, mean)	58,060 (52,609–63,511)	65,014 (58,037–71,990)	50,457 (40,249–60,664)	27,271 (24,969–29,573)
Live alone (%)	29.9 (28.7–31.2)	28.4 (26.8–30.0)	31.7 (29.4–34.0)	36.7 (32.3–41.3)
Social isolation (%)				
Not isolated	19.2 (17.7–20.8)	23.0 (21.0–25.0)	14.9 (13.2–16.8)	2.8 (1.8–4.4)
Somewhat isolated	57.6 (56.2–59.0)	59.2 (57.3–61.1)	59.5 (57.3–61.8)	38.6 (34.8–42.5)
Socially isolated	23.2 (21.9–24.7)	17.8 (16.4–19.3)	25.6 (23.4–27.8)	58.6 (54.8–62.3)
Social capital score (mean)	2.40 (2.38–2.42)	2.41 (2.39–2.43)	2.39 (2.36–2.43)	2.31 (2.26–2.37)
Elevated depression or anxiety symptoms (%)	20.7 (19.3–22.1)	16.3 (14.9–17.8)	22.5 (20.6–24.5)	50.1 (45.6–54.7)
Ever smoked regularly (%)	52.7 (51.0–54.4)	52.2 (50.3–54.1)	54.9 (52.2–57.6)	49.2 (44.6–53.9)
Chronic disease count (mean)	2.4 (2.3–2.4)	2.3 (2.2–2.3)	2.4 (2.3–2.5)	3.2 (3.1–3.3)
ADL limitations (mean)	0.49 (0.47–0.51)	0.29 (0.27–0.31)	0.52 (0.47–0.57)	1.93 (1.81–2.06)
IADL limitations (mean)	0.76 (0.73–0.80)	0.49 (0.46–0.52)	0.85 (0.79–0.92)	2.62 (2.50–2.75)
Activity limitation due to pain (%)	29.5 (28.4–30.7)	26.5 (25.2–27.8)	30.8 (28.6–33.2)	49.3 (44.9–53.8)
Dementia status (%)				
No dementia	79.1 (77.4–80.6)	85.5 (83.9–87.0)	74.6 (71.7–77.2)	42.4 (38.0–46.9)
Possible dementia	10.9 (9.7–12.2)	9.2 (8.0–10.6)	13.3 (11.5–15.3)	16.5 (13.9–19.6)
Probable dementia	10.0 (9.3–10.8)	5.3 (4.6–6.0)	12.1 (10.6–13.9)	41.1 (37.0–45.2)

Table 1. Continued

	All	Group 1: never	Group 2: onset	Group 3: chronic
Use of mobility devices ^a (%)				
None	76.3 (75.2–77.4)	83.7 (82.5–84.9)	72.6 (70.3–74.8)	30.1 (26.7–33.9)
Cane	16.4 (15.5–17.3)	12.9 (11.8–14.1)	20.1 (18.2–22.1)	32.4 (28.7–36.3)
Walker	11.6 (10.8–12.5)	6.3 (5.7–7.0)	13.7 (12.1–15.5)	46.9 (43.1–50.8)
Wheelchair/scooter	6.0 (5.5–6.7)	2.7 (2.2–3.3)	6.6 (5.3–8.1)	30.7 (27.3–34.2)
Built environment				
Stairs at entryway	74.8 (72.7–76.8)	77.2 (74.9–79.3)	72.6 (69.7–75.4)	63.1 (58.1–67.8)
Ramp at entryway	9.6 (8.8–10.5)	8.0 (7.1–9.0)	10.0 (8.5–11.8)	20.8 (17.9–24.1)
Proxy respondents (unweighted %)	5.8 (5.2–6.5)	3.0 (2.5–3.5)	5.6 (4.6–6.9)	29.1 (25.7–32.7)
Attrition status (unweighted %)				
Completers	37.9	56.4	7.6	12.3
Attrition, due to mortality	24.9	12.2	36.1	66.8
Attrition, all other causes	37.2	31.4	56.4	20.9
Sample size	7,607	4,647	2,117	843
Estimated proportion in the population (%)	—	65.5 (64.3–66.7)	26.2 (25.1–27.2)	8.3 (7.7–9.0)

Notes: ADL = activities of daily living. IADL = instrumental activities of daily living. Unless otherwise noted, weighted % were presented, adjusting for NHATS complex survey design. 95% confidence intervals in parentheses. All comparisons were statistically significant at $p < .001$, with the exception of smoking status ($p = .056$).

^aCane, walker, and wheelchair uses were not mutually exclusive.

Table 2. Relative Risk Ratios for Homebound Trajectory Group Membership

Baseline characteristics	Onset versus never	<i>p</i> value	Chronic versus never	<i>p</i> value	Chronic versus onset	<i>p</i> value
Age in 5-year interval	1.17 (1.12–1.23)	<.001	1.49 (1.38–1.62)	<.001	1.28 (1.18–1.38)	<.001
Male (reference: female)	1.13 (1.00–1.29)	.059	0.79 (0.62–1.00)	.048	0.70 (0.56–0.87)	.002
Race/ethnicity	Joint hypothesis test: $F(6, 51) = 2.06, p = .074$					
White, non-Hispanic	Reference		Reference		Reference	
Black, non-Hispanic	1.14 (0.97–1.35)	.110	1.07 (0.84–1.37)	.56	0.94 (0.75–1.18)	.58
Hispanic	1.34 (1.02–1.78)	.037	1.77 (1.14–2.72)	.011	1.31 (0.83–2.08)	.24
Other	1.52 (1.02–2.25)	.038	1.26 (0.60–2.64)	.53	0.83 (0.37–1.86)	.65
Education	Joint hypothesis test: $F(6, 51) = 2.62, p = .027$					
Less than high school	Reference		Reference		Reference	
High school	0.90 (0.75–1.09)	.29	0.84 (0.63–1.12)	.24	0.93 (0.71–1.23)	.61
Some college, no degree	0.91 (0.77–1.08)	.29	0.76 (0.55–1.04)	.08	0.83 (0.60–1.16)	.28
College graduate	0.70 (0.57–0.86)	.001	0.78 (0.55–1.11)	.16	1.12 (0.82–1.52)	.48
Family income in 2011	Joint hypothesis test: $F(6, 51) = 2.11, p = .068$					
First quartile	Reference		Reference		Reference	
Second quartile	0.93 (0.77–1.13)	.48	1.08 (0.82–1.43)	.57	1.16 (0.89–1.50)	.26
Third quartile	0.89 (0.76–1.05)	.16	0.94 (0.70–1.26)	.67	1.05 (0.78–1.42)	.73
Fourth quartile	0.82 (0.68–1.01)	.056	0.72 (0.52–0.99)	.043	0.87 (0.59–1.28)	.48
Live alone	0.89 (0.76–1.04)	.15	0.65 (0.51–0.83)	.001	0.72 (0.55–0.96)	.027
Social isolation status	Joint hypothesis test: $F(4, 53) = 15.3, p < .001$					
Not isolated	Reference		Reference		Reference	
Somewhat isolated	1.23 (1.04–1.45)	.015	2.35 (1.47–3.75)	.001	1.91 (1.16–3.12)	.011
Socially isolated	1.31 (1.08–1.59)	.007	4.42 (2.78–7.05)	<.001	3.38 (2.02–5.66)	<.001
Social capital	1.06 (0.94–1.21)	.33	1.01 (0.84–1.22)	.88	0.95 (0.78–1.17)	.64
Elevated depression or anxiety symptoms	1.13 (0.97–1.30)	.10	1.80 (1.47–2.21)	<.001	1.60 (1.28–2.01)	<.001
Ever smoked regularly	1.18 (1.03–1.36)	.022	1.30 (1.03–1.63)	.026	1.10 (0.87–1.39)	.41
Chronic disease count	0.99 (0.94–1.03)	.60	1.16 (1.08–1.26)	<.001	1.18 (1.09–1.27)	<.001
ADL limitations	1.05 (0.95–1.15)	.35	1.29 (1.15–1.46)	<.001	1.24 (1.12–1.36)	<.001
IADL limitations	1.10 (1.02–1.19)	.014	1.47 (1.33–1.61)	<.001	1.33 (1.20–1.48)	<.001
Activity limitation due to pain	1.05 (0.89–1.23)	.58	1.02 (0.77–1.34)	.92	0.97 (0.73–1.29)	.83
Dementia status	Joint hypothesis test: $F(4, 53) = 3.3, p = .020$					
No dementia	Reference		Reference		Reference	
Possible dementia	1.15 (0.94–1.42)	.17	1.44 (1.09–1.91)	.012	1.25 (0.94–1.66)	.13
Probable dementia	1.46 (1.11–1.92)	.008	1.71 (1.15–2.54)	.009	1.17 (0.83–1.66)	.37
Mobility device (reference: no device)						
Cane	1.11 (0.92–1.34)	.26	0.91 (0.69–1.20)	.50	0.82 (0.61–1.10)	.19
Walker	1.25 (1.00–1.56)	.047	1.69 (1.30–2.20)	<.001	1.35 (1.02–1.79)	.036
Wheelchair/scooter	1.43 (1.02–2.01)	.038	1.84 (1.29–2.64)	.001	1.29 (0.89–1.86)	.18
Stairs at entryway	0.87 (0.74–1.03)	.11	0.81 (0.63–1.04)	.09	0.93 (0.72–1.19)	.54
Ramp at entryway	0.87 (0.68–1.11)	.24	0.94 (0.68–1.29)	.70	1.08 (0.77–1.53)	.64
Proxy respondents	0.86 (0.65–1.15)	.30	1.25 (0.82–1.91)	.30	1.45 (1.01–2.08)	.047

Notes: ADL = activities of daily living; IADL = instrumental activities of daily living. Results from two separate multinomial logistic regressions, using “never” and “onset” group as the reference, respectively. 95% confidence intervals in parentheses.

These findings are in line with previous studies, which have consistently reported the cross-sectional association of homebound status with old age, functional limitations, and chronic diseases (De-Rosende Celeiro et al., 2017; Harada et al., 2016; Hirai et al., 2015; Musich et al., 2015; Negron-Blanco et al., 2016; Ornstein et al., 2015). Our study adds to the literature by providing a more nuanced understanding of the influence of these factors on the patterns of progression to the state of homebound. Individuals on the “chronic” homebound trajectory had the

highest burden of depression, dementia, social isolation, chronic diseases, and functional limitations.

Aside from physical and cognitive impairment, mental health problems emerged as an important factor that differentiated the “chronic” group from the “never” and the “onset” groups. A previous study found a reciprocal relationship between depressive symptoms and homebound status (Xiang et al., 2018). Depression and anxiety can lead to functional impairment, restrict social activities, and cause withdrawal and social isolation, which can lead to

disability. It is also possible that persons on the “chronic” homebound trajectory had more mental health problems due to their homebound state preceding the start of the study period. Mental health symptoms, however, did not explain the difference between the “onset” and the “never” trajectory group. We focused on predisposing risk factors and measured all predictors at baseline only. The abbreviated PHQ-2 and GAD-2 in NHATS measured symptoms in the last month, which can vary greatly. Measures of lifetime major depression or personality traits prone to depression or anxiety may yield different findings.

We expanded existing literature by examining the role of social isolation and social capital on homebound trajectories. Although the social capital measure was not a significant predictor of trajectory membership, social isolation, even partially, was strongly associated with a higher risk of being on the two homebound trajectories. Socially isolated older adults had 30% higher risk of being on the “onset” versus “never” trajectory, 238% higher risk of being on the “chronic” versus “onset” trajectory, and 342% higher risk of being on the “chronic” versus “never” trajectory. Existing literature often discusses social isolation as a consequence of being homebound and focuses on addressing social isolation among already homebound older adults (Choi, Hegel, Marinucci, Sirrianni, & Bruce, 2012). Although confinement to the home environment probably exacerbates social isolation, our study points to the possibility that social isolation may also accelerate the progression to homebound state. Several potential mechanisms underlie homebound state among socially isolated older adults. Studies have found that socially isolated older adults were more likely to engage in unhealthy lifestyle behaviors such as physical inactivity, poor diet, and smoking (Kobayashi & Steptoe, 2018; Locher et al., 2005). These unhealthy lifestyle behaviors have been consistently linked to chronic diseases and functional limitations in late life (Brinkman et al., 2018), which are strong predictors of becoming homebound. Social isolation can also increase the risk of depression (Teo, Choi, & Valenstein, 2013), which has been shown to be a predictor of homebound state (Xiang et al., 2018). However, due to the observational nature of this study, we could not claim that social isolation had a causal effect on homebound trajectories. Although social isolation was measured at baseline, persons who were already homebound at the baseline were also more likely to be socially isolated, suggesting that social isolation may be, in part, an outcome of being homebound. Nevertheless, social isolation was associated with a higher risk of being on the “onset” versus the “never” group. In both groups, the prevalence of homebound state was very low at the baseline, which makes it less plausible that baseline social isolation is a function of the homebound trajectories. These findings point to a complex, bidirectional relationship between social isolation and outdoor mobility that warrants more investigations.

Interestingly, living alone was associated with a lower risk of being on the “chronic” versus the other two

trajectories. This finding appears to contradict our finding regarding the higher risk of progressing to homebound state among socially isolated older adults. Although living arrangement has been linked to social isolation, living alone, and social isolation are two distinct concepts that capture different aspects of the social context (Perissinotto & Covinsky, 2014). Person who lived alone may need to go out more often to carry out daily tasks such as grocery shopping out of necessity. It is also possible that for some older adults, being able to live alone reflects a high level of functioning and independence that is reversely associated with homebound risk.

Inconsistent with a previous study (Clarke, 2014), we did not find a significant modification effect of built environment on the relationship between mobility device use and homebound trajectories. Clarke (2014) found that having stairs at the entryway doubled the odds of reporting difficulty going outside alone for older adults who use a walker. Clarke studied self-reported difficulty with going outside, not the frequency of going outside, which may have caused our inconsistent findings. Moreover, use of mobility device and features of the immediate built environment are probably adaptations to difficulty going outside, which is unlikely in itself to affect future homebound trajectories. In addition, environmental modifications may have occurred as older adults experienced more difficulty going outside during the follow-up, which were not assessed in this study.

Our finding of the three distinctive homebound trajectories has implications for policy and practice aimed at promoting aging in place. Homebound state often marks the transition from community living to an institutionalized setting (Qiu et al., 2010). For the estimated 3 million older adults in a chronic homebound state, public policy and program should focus on providing formal support to assist their daily activities (e.g., home care) and family caregiver support services, so that they may stay safely in their homes for as long as they wish. Nonskilled in-home care services and family support services are already allowed as supplemental benefits for Medicare Advantage plans in 2019, although the uptake and implementation of these benefits have been reported to be slow. As more plans offer these benefits, future studies should evaluate whether increased coverage of support services helps older adults in a chronic homebound state remain community living. The estimated 9 million older adults who will experience the onset of homebound at some point in late life are prime candidates for public health programs aimed at reducing the burden of disability. Risk factors including being Hispanic, social isolation, current or past smoker, IADL limitations, dementia, and use of mobility device, if confirmed by more studies, can be used to develop a simple risk assessment tool. Most of these risk factors are already included in routine data collected by most health providers, which allows the implementation of such tool for providers to communicate to patients about their risks and to devise a plan of action. Whether addressing these risk factors will

change a person's expected homebound trajectory remains to be examined.

The present study has several limitations. Measures were self-reported and subject to recall bias and reporting errors. NHATS used proxies when sample persons were not available and administered questions relating to more subjective items such as depression to proxies. A previous study found that proxies tended to report more dysfunction symptoms than self-responses (Williams et al., 2006). This overreporting of dysfunction may have occurred in the present study, which could overestimate prevalence of depression, cognitive impairment, and homebound state. Nevertheless, we included an indicator of proxy response in estimating risk factors associated with homebound trajectories, a method commonly used in previous studies to adjust for proxy bias (Skolarus et al., 2010). Moreover, homebound status was assessed based on the frequency of going out in the last month. The nature of homebound state was not assessed. It is unknown if the state of homebound was voluntary (e.g., one is physically capable of going out often but chooses not to) or involuntary (e.g., one wishes to go out more frequently but could not due to illness or other barriers) due to skip patterns of the survey questions. The epidemiology, causes, and potential remedies of involuntary homebound state probably differ from those of voluntary homebound state.

Conclusions

Changes in homebound status among community-dwelling older adults follow three distinct trajectories over a 7-year period. Social isolation is an important and potentially modifiable risk factor for progressing to homebound state. Future studies should further examine the role of social isolation and social support to unpack their complex relationship with outdoor mobility.

Supplementary Material

Supplementary data are available at *The Gerontologist* online.

Funding

This work was supported by a grant from the National Institutes of Health, University of Michigan Older Americans Independence Center Research Education Core (AG024824).

Conflict of Interest

None reported.

References

- Brinkman, S., Voortman, T., Kieft-de Jong, J. C., van Rooij, F. J. A., Ikram, M. A., Rivadeneira, F.,...Schoufour, J. D. (2018). The association between lifestyle and overall health, using the frailty index. *Archives of Gerontology and Geriatrics*, 76, 85–91. doi:10.1016/j.archger.2018.02.006
- Choi, N. G., Hegel, M. T., Marinucci, M. L., Sirrianni, L., & Bruce, M. L. (2012). Association between participant-identified problems and depression severity in problem-solving therapy for low-income homebound older adults. *International Journal of Geriatric Psychiatry*, 27, 491–499. doi:10.1002/gps.2741
- Clarke, P. J. (2014). The role of the built environment and assistive devices for outdoor mobility in later life. *The Journals of Gerontology Series B: Psychological Sciences and Social Sciences*, 69(Suppl 1), S8–S15. doi:10.1093/geronb/gbu121
- Cohen-Mansfield, J., Shmotkin, D., & Hazan, H. (2010). The effect of homebound status on older persons. *Journal of the American Geriatrics Society*, 58, 2358–2362. doi:10.1111/j.1532-5415.2010.03172.x
- Cohen-Mansfield, J., Shmotkin, D., & Hazan, H. (2012). Homebound older persons: Prevalence, characteristics, and longitudinal predictors. *Archives of Gerontology and Geriatrics*, 54, 55–60. doi:10.1016/j.archger.2011.02.016
- De-Rosende Celeiro, I., Santos-Del-Riego, S., & Muñiz García, J. (2017). Homebound status among middle-aged and older adults with disabilities in ADLs and its associations with clinical, functional, and environmental factors. *Disability and Health Journal*, 10, 145–151. doi:10.1016/j.dhjo.2016.06.006
- Fujita, K., Fujiwara, Y., Chaves, P. H. M., Motohashi, Y., & Shinkai, S. (2006). Frequency of going outdoors as a good predictors for incident disability of physical function as well as disability recovery in community-dwelling older adults in rural Japan. *Journal of Epidemiology*, 16, 261–270. doi:10.2188/jea.16.261
- Hamazaki, Y., Morikawa, Y., Morimoto, S., & Nakagawa, H. (2016). Difference in the impact of homebound status on functional decline between independent older men and women: A 2 year follow-up study. *Japan Journal of Nursing Science*, 13, 265–275. doi:10.1111/jjns.12109
- Harada, K., Lee, S., Park, H., Shimada, H., Makizako, H., Doi, T.,... Suzuki, T. (2016). Going outdoors and cognitive function among community-dwelling older adults: Moderating role of physical function. *Geriatrics & Gerontology International*, 16, 65–73. doi:10.1111/ggi.12437
- Haviland, A. M., Jones, B. L., & Nagin, D. S. (2011). Group-based trajectory modeling extended to account for nonrandom participant attrition. *Sociological Methods and Research*, 40, 367–390. doi:10.1177/0049124111400041
- Herr, M., Latouche, A., & Ankri, J. (2013). Homebound status increases death risk within two years in the elderly: Results from a national longitudinal survey. *Archives of Gerontology and Geriatrics*, 56, 258–264. doi:10.1016/j.archger.2012.10.006
- Hirai, H., Kondo, N., Sasaki, R., Iwamuro, S., Masuno, K., Ohtsuka, R.,...Sakata, K. (2015). Distance to retail stores and risk of being homebound among older adults in a city severely affected by the 2011 Great East Japan Earthquake. *Age and Ageing*, 44, 478–484. doi:10.1093/ageing/afu146
- Jones, B. L., & Nagin, D. S. (2007). Advances in group-based trajectory modeling and an SAS procedure for estimating them. *Sociological Methods and Research*, 35, 542–571. doi:10.1177/0049124106292364
- Kasper, J. D., & Freedman, V. A. (2018). *National Health and Aging Trends Study user guide: Rounds 1–7 final release*. Baltimore,

- MD: Johns Hopkins University School of Public Health. Retrieved from www.NHATS.org
- Kasper, J. D., Freedman, V. A., & Spillman, B. C. (2013). *Classification of persons by dementia status in the National Health and Aging Trends Study*. Technical Paper 5. Baltimore, MD: Johns Hopkins University School of Public Health. Retrieved from www.NHATS.org
- Kobayashi, L. C., & Steptoe, A. (2018). Social isolation, loneliness, and health behaviors at older ages: Longitudinal cohort study. *Annals of Behavioral Medicine*, *52*, 582–593. doi:10.1093/abm/kax033
- Kroenke, K., Spitzer, R. L., Williams, J. B., & Löwe, B. (2009). An ultra-brief screening scale for anxiety and depression: The PHQ-4. *Psychosomatics*, *50*, 613–621. doi:10.1176/appi.psy.50.6.613
- Kroenke, K., Spitzer, R. L., Williams, J. B., & Löwe, B. (2010). The patient health questionnaire somatic, anxiety, and depressive symptom scales: A systematic review. *General Hospital Psychiatry*, *32*, 345–359. doi:10.1016/j.genhosppsych.2010.03.006
- Leff, B., Carlson, C. M., Saliba, D., & Ritchie, C. (2015). The invisible homebound: Setting quality-of-care standards for home-based primary and palliative care. *Health Affairs (Project Hope)*, *34*, 21–29. doi:10.1377/hlthaff.2014.1008
- Locher, J. L., Ritchie, C. S., Roth, D. L., Baker, P. S., Bodner, E. V., & Allman, R. M. (2005). Social isolation, support, and capital and nutritional risk in an older sample: Ethnic and gender differences. *Social Science & Medicine*, *60*, 747–761. doi:10.1016/j.socscimed.2004.06.023
- Musich, S., Wang, S. S., Hawkins, K., & Yeh, C. S. (2015). Homebound older adults: Prevalence, characteristics, health care utilization and quality of care. *Geriatric Nursing*, *36*, 445–450. doi:10.1016/j.gerinurse.2015.06.013
- Nagin, D. (2005). *Group-based modeling of development*. Cambridge, MA: Harvard University Press.
- Negron-Blanco, L., de Pedro-Cuesta, J., Almazán, J., Rodríguez-Blázquez, C., Franco, E., & Damián, J.; DISCAP-ARAGON Research Group. (2016). Prevalence of and factors associated with homebound status among adults in urban and rural Spanish populations. *BMC Public Health*, *16*, 574. doi:10.1186/s12889-016-3270-z
- Ornstein, K. A., Leff, B., Covinsky, K. E., Ritchie, C. S., Federman, A. D., Roberts, L., ... Szanton, S. L. (2015). Epidemiology of the homebound population in the United States. *JAMA Internal Medicine*, *175*, 1180–1186. doi:10.1001/jamainternmed.2015.1849
- Perissinotto, C. M., & Covinsky, K. E. (2014). Living alone, socially isolated or lonely – What are we measuring? *Journal of General Internal Medicine*, *29*, 1429–1431. doi:10.1007/s11606-014-2977-8
- Pohl, J. S., Cochrane, B. B., Schepp, K. G., & Woods, N. F. (2017). Measuring social isolation in the National Health and Aging Trends Study. *Research in Gerontological Nursing*, *10*, 277–287. doi:10.3928/19404921-20171002-01
- Qiu, W. Q., Dean, M., Liu, T., George, L., Gann, M., Cohen, J., & Bruce, M. L. (2010). Physical and mental health of homebound older adults: An overlooked population. *Journal of the American Geriatrics Society*, *58*, 2423–2428. doi:10.1111/j.1532-5415.2010.03161.x
- Satariano, W. (2006). *Epidemiology of aging: An ecological approach* (pp. 39–78). Burlington, MA: Jones & Bartlett Learning.
- Skolarus, L. E., Sánchez, B. N., Morgenstern, L. B., Garcia, N. M., Smith, M. A., Brown, D. L., & Lisabeth, L. D. (2010). Validity of proxies and correction for proxy use when evaluating social determinants of health in stroke patients. *Stroke*, *41*, 510–515. doi:10.1161/STROKEAHA.109.571703
- Smith, A. R., Chen, C., Clarke, P., & Gallagher, N. A. (2016). Trajectories of outdoor mobility in vulnerable community-dwelling elderly: The role of individual and environmental factors. *Journal of Aging and Health*, *28*, 796–811. doi:10.1177/0898264315611665
- Teo, A. R., Choi, H., & Valenstein, M. (2013). Social relationships and depression: Ten-year follow-up from a nationally representative study. *PLoS One*, *8*, e62396. doi:10.1371/journal.pone.0062396
- Williams, L. S., Bakas, T., Brizendine, E., Plue, L., Tu, W., Hendrie, H., & Kroenke, K. (2006). How valid are family proxy assessments of stroke patients' health-related quality of life? *Stroke*, *37*, 2081–2085. doi:10.1161/01.STR.0000230583.10311.9f
- Xiang, X., An, R., & Oh, H. (2018). The bidirectional relationship between depressive symptoms and homebound status among older adults. *The Journals of Gerontology, Series B: Psychological Sciences and Social Sciences*. doi:10.1093/geronb/gbx180
- Zimmer, Z., Martin, L. G., Nagin, D. S., & Jones, B. L. (2012). Modeling disability trajectories and mortality of the oldest-old in China. *Demography*, *49*, 291–314. doi:10.1007/s13524-011-0075-7