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Trajectories of General Health Status and Depressive Symptoms among Persons with Cognitive Impairment in the United States

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Abstract

Objectives—To identify and examine heterogeneous trajectories of general health status (GHS) and depressive symptoms (DS) among persons with cognitive impairment (PCIs)

Methods—We use group-based trajectory models to study 2,361 PCIs for GHS and 1,927 PCIs for DS from the National Health and Aging Trends Survey 2011–18, and apply multinomial logistic regressions to predict identified latent trajectory group memberships using individual characteristics

Results—For both GHS and DS, there were six groups of PCIs with distinct trajectories over a seven-year period. More than 40% PCIs experienced sharp declines in GHS, and 35.5% experienced persistently poor GHS. There was greater heterogeneity in DS trajectories with 55% PCIs experiencing improvement, 16.4% experiencing persistently high DS, and 30.5% experiencing deterioration

Discussion—The GHS trajectories illustrate the heavy burden of poor and declining health among PCIs. Further research is needed to understand the factors underlying stable or improving DS despite declining GHS

Keywords

Cognitive Aging; Health Disparities; Depression; Alzheimer's disease

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Introduction

More than 20% of those aged 65 and older in the United States currently suffer from cognitive impairment. Cognitive impairment, encompassing the diagnoses of mild cognitive impairment (MCI) and dementia, has become a major public health concern due to accelerated population aging, and has an immense personal, emotional, and financial toll (Patterson, 2018). Because cognitive impairment can develop, persist, and worsen over a span of 15–25 years, it is important to study health trajectories (i.e., an individual's changes in health outcomes over time) among persons with cognitive impairment (hereafter "PCIs") to understand its dynamic and long-term consequences. General health status (i.e., self- or proxy-reported health) and depressive symptoms are particularly essential components of physical and mental health. Previous studies have demonstrated that cognitive impairment is associated with depressive symptoms and poor general health status (Diniz et al., 2013; Livingston et al., 2020; Lyketsos et al., 2002; Polyakova et al., 2014; Prince et al., 2014). However, less work has examined population-based trajectories of general health status and depressive symptoms among PCIs in the US. The limited number of studies that examined trajectories of general health status and depressive symptoms tended to use data outside of the US, and exclusively focused on persons with dementia (Barca et al., 2017; Ydstebø et al., 2018). Initial evidence has shown that persons with MCI are more likely to develop depressive symptoms and anxiety (Ma, 2020). Despite some evidence documenting that persons with MCI tend to experience faster declines in everyday physical functioning compared to those without (Wadley et al., 2007), previous studies examining trajectories of general health status and depressive symptoms among PCIs rarely considered persons with MCI.

This study examines population-based trajectories of general health status and depressive symptoms among PCIs with dementia or MCI, using a group-based trajectory modeling (GBTM) approach. We choose this approach over alternative approaches to modeling trajectories for both methodological and theoretical reasons. Popular approaches to modeling trajectories such as the growth curve modeling assume that individual trajectories are variations of an average trajectory of a population. By contrast, GBTM relaxes this assumption by assuming that the population is composed of qualitatively distinct subgroups which are not identifiable based on observed characteristics (Howard & Hoffman, 2018). The assumption of GBTM is also more consistent with the gerontological tradition of group-based theorizing. For example, past literature has theorized the need to identify different symptom profiles and their underlying structures among depressed older adults (Hybels et al., 2011). Several previous studies used GBTM to study self-rated health and depressive symptoms in non-PCI populations and discovered substantial heterogeneity (Ayyagari et al., 2012; Choi et al., 2012; Hong et al., 2009; Xiang, 2020), which motivates the use of GBTM for studying these health outcomes of PCIs. Considering that our knowledge on the heterogeneity of health trajectories among PCIs is currently limited, GBTM is particularly useful to identify clusters/groups of PCIs with similar health trajectories, visualize the generalized trajectory for each group, and identify the corresponding risk factors. As a "person-centered approach," GBTM can help address heterogeneity of individual health trajectories by grouping those with similar trajectories together (Howard & Hoffman, 2018).

Based on previous studies documenting heterogeneous trajectories of self-rated health and depressive symptoms in the US (Ayyagari et al., 2012; Hybels et al., 2011) and the interaction between cognitive impairment and other health outcomes (Qiu et al., 2020), we hypothesize the existence of multiple qualitatively distinct latent groups. In addition, based on existing literature documenting that age, race/ethnicity, sex, SES, social support, health behaviors, and health conditions moderate the relationship between cognitive impairment and other health outcomes (Livingston et al., 2020), we hypothesize that these factors will be associated with trajectory group memberships. Specifically, older individuals are more likely to have fast-deteriorating health trajectories (Ayyagari et al., 2012). Based on theories of structural racism and sexism, people of color and women are socioeconomically more disadvantaged than non-Hispanic Whites and men, and they may experience further discrimination in the medical system (Feagin & Bennefield, 2014). Individuals with low SES tend to have limited access to high-quality medical resources, and lack protections from exposure to harmful environments and events (Feagin & Bennefield, 2014). Health decline among PCIs is decelerated by social support (Tough et al., 2017) and accelerated by risky health behaviors (Akasaki et al., 2019). Individuals with multiple chronic conditions tend to have worse general health status and depressive symptoms (Ward et al., 2014), and PCIs with more severe cognitive impairment are at greater risk for worse baseline health (Barnes, 2015). These characteristics are also consistent with the ecological model of aging developed by Satariano (2006), in which the following domains are specified to affect health outcomes over the life course: 1) demographic, 2) socioeconomic status (SES), 3) social environment (e.g., social capital, living arrangements, social networks, and social support), 4) physical environment, 5) health behaviors, 6) psychosocial conditions (e.g., self-efficacy, social control, and sense of coherence), and 7) health conditions (e.g., biological fitness, disease and comorbidities). We note, nonetheless, that the ecological model does not explicitly include policy; particularly in localized contexts like the US, wherein policies like insurance are left up to individual states, we also considered the need to include other covariates which are based on less regularized implementation. Throughout the paper, we return to the importance of considering the localized environment, and caveat our findings about insurance coverage with the need to consider further locally disaggregated analyses.

Methods

Data and Measures

Our data come from the National Health and Aging Trends Study (NHATS) collected annually in 2011–18. NHATS follows a nationally representative sample of Medicare beneficiaries aged 65 or older in the US in a panel study, making the data conducive for trajectory analyses. This sample is particularly apt for studying the general aging population in the US, given 96% of all adults 65 years and older are enrolled in Medicare (Lohr, 1990). In the first round, 8,245 sampled persons were home interviewed. When a sampled person could not respond, a proxy respondent, typically a relative or a caregiver, was interviewed. In the fifth round, a refreshment sample of 4,182 respondents was added to restore the first round sample size by age and race (Kasper & Freedman, 2020). Respondents were contacted in each round until death, and over 85% of all living sample persons responded in all follow-up waves (Kasper & Freedman, 2020). All observations of PCIs who met our

criteria, outlined in the following paragraph, were included in our sample, even if these PCIs were lost in later follow-up periods.

We constructed our sample using the following inclusion criteria. The first was the presence of cognitive impairment. To account for measurement error, we included individuals who had cognitive impairment for at least two waves (Freedman et al., 2018). In order to model trajectories, the second criterion was the presence of at least two rounds of follow-up with valid health outcomes after the first observation with cognitive impairment. A flow chart in Appendix Figure S1 shows the numbers of observations excluded at each step. Our final sample includes 2,361 individuals for analysis of general health status and 1,927 for depressive symptoms.

Cognitive Impairment—PCIs are defined as individuals meeting NHATS criteria for having either dementia or MCI. Dementia was classified in three ways: 1) a report, either from the sampled person or a proxy respondent, that the sampled person had dementia or Alzheimer's disease, 2) a score of two or higher on the AD8 questionnaire reported by the proxy respondent, or 3) a cognitive tests score ≤ 1.5 standard deviations below the mean in at least two cognitive domains out of three (i.e., memory, orientation, and executive functioning). The classification of MCI was based on the cognitive tests and was defined by a score of ≤ 1.5 standard deviations below the mean in one domain. Detailed documentation can be found on NHATS' website (https://www.nhats.org/researcher/nhats).

Health Outcomes—General health status was assessed by asking respondents to categorize their general health status from 1 (*excellent*) to 5 (*poor*). Approximately 29.53% of 11,535 person-year observations for general health status were reported by a proxy respondent (at the baseline, the percentage of reports by a proxy was 16.14%, see Table 1). Proxy-reported health predicts quality of life and survival well when self-rated health is unavailable (Ayalon & Covinsky, 2009). Following existing studies on self-rated health trajectories (Miller & Wolinsky, 2007; Wolinsky et al., 2008), we adopted Diehr's recoding strategy to transform general health status to a 0–95 scale (*excellent* = 95, *very good* = 90, *good* = 80, *fair* = 30, *poor* = 15, and 0 for *the deceased or nursing home residents*) (Diehr et al., 2001). These values were determined using logistic functions to reflect estimated probabilities of future health, where 0 is dead and 100 is perfect health (Diehr et al., 2001). This recoding strategy is a simple transformation to include participants who died (1,006 PCIs) or were in nursing homes (659 PCIs) in the evaluation of general health status, which also allows us to avoid survival biases when examining disparities in health trajectories between two sociodemographic groups.

We measured depressive symptoms using the Patient Health Questionnaire-4 (PHQ-4) (Kroenke et al., 2009). NHATS contains four questions to assess depressive symptoms. Respondents were asked: "Over the last month, how often have you 1) had little interest or pleasure in doing things; 2) felt down, depressed, or hopeless; 3) felt nervous, anxious, or on edge; 4) been unable to stop or control worrying?" For each question, respondents were given a point ranging from 0 (*not at all*) to 3 (*nearly every day*). We summed up the points and created a final score ranging from 0–12. The Cronbach's alpha for this summary measure is 0.76, indicating acceptable internal consistency (Tavakol & Dennick,

2011). Existing studies have shown that family members' perceptions can broadly capture the severity of an individual's depressive symptoms (Heisel et al., 2011). 20% of 9,276 person-year observations for depressive symptoms were reported by a proxy respondent.

Predictors of Trajectory Group Membership—We selected sociodemographic and health characteristics based on existing studies of risk factors for general health status and depressive symptoms (Ayyagari et al., 2012; Bennett & Thomas, 2014; Hammen, 2018): age, sex (female = 1), race/ethnicity (non-Hispanic White, hereafter "White"; non-Hispanic Black, hereafter "Black"; non-Hispanic Other, hereafter "Other"; and Hispanic), educational attainment (less than high school, high school graduate, beyond high school), number of siblings (0, 1–3, or 3+), number of children (0, 1–3, or 3+), enrollment in Medicare Part D, Medicaid, or Tricare (enrolled = 1, some may enroll in more than one option), number of comorbidities (0–3, 4+), marital status ("never married", "married or living with a partner", or "separated, divorced, or widowed"), vigorous activity (participated in vigorous physical activity recently = 1), smoking status (smoking regularly = 1), self-report (self-reported instead of reporting by a proxy = 1), and MCI (MCI instead of dementia = 1, as defined in the Methods section). NHATS asked about the following chronic conditions besides dementia: heart attack, heart disease, hypertension, arthritis, osteoporosis, diabetes, lung disease, stroke, and cancer. Since over half of our sample had fewer than four comorbidities (70.87%), we created a dummy indicator of having four or more comorbidities in line with past studies (Keeney et al., 2019). Among these characteristics, educational attainment and enrollment in Medicare Part D, Medicaid, or Tricare are indicators of SES. Number of siblings, number of children, and marital status are indicators of potential social support. Vigorous activity and smoking status are indicators of health behaviors. Self-reporting and MCI are indicators of the severity of an individual's cognitive impairment. Table 1 shows descriptive statistics.

Statistical Analyses

We applied GBTM techniques to identify heterogeneous health trajectories of PCIs. Other techniques like mixed effects models or growth curve models assume that individual trajectories are variations around a mean population trajectory (Wattmo et al., 2013; Wilson et al., 2011). By contrast, GBTMs and growth mixture models (GMMs) assume there are multiple unobserved subgroups with qualitatively distinct trajectory patterns in a population (Nagin & Odgers, 2010) and assume homogeneity conditional on trajectory group membership (Nagin, 2015). Each individual's probability of belonging to one of these latent groups can be approximated.

We used the first observation of cognitive impairment as the baseline for each participant. The first observation of cognitive impairment was in the first round (or the fifth round for the refreshment sample) for most PCIs (67.5% for the general health status and 64.6% for the depressive symptoms sample); the remainder of the cohort developed cognitive impairment in later rounds. Years since the first observation of cognitive impairment was used as the time variable. We modeled general health status using a censored normal distribution and depressive symptoms using a zero-inflated Poisson distribution (Ayyagari et al., 2012; Bennett & Thomas, 2014). We included linear, quadratic, and cubic terms in the models and

fitted models with varying numbers of latent groups. We selected the best fitted model based on the Bayesian information criterion (BIC) and diagnostic statistics, such as the average posterior probability (AvePP) and the odds of correction classification (OCC). Our model selection results and model diagnostics are shown in Appendix Table S1 and Appendix Table S4, respectively. A BIC closer to 0, an AvePP greater than 0.7, and an OCC greater than 5 are indicative of good model fit (Nagin, 2015). Model selection results for both health outcomes show that the BIC is best with six groups, and the model diagnosis results indicate good model fit. Each participant was assigned to the latent group with the highest posterior probability. All analyses were performed using the 'traj' package in Stata 15 (Jones & Nagin, 2013).

We applied multinomial logistic regressions to examine the association between a variety of individual characteristics and group membership. We performed multiple imputation by chained equations using the Stata package 'ice' to impute missing values in the independent variables (Royston & White, 2011). Regression coefficients from ten imputed datasets were then combined using the Rubin's rule (Rubin, 2004) using Stata package "mim."

Results

General Health Status

We identified six latent groups as the optimal model for general health status. 22.2% of PCIs were in Group 1, 10.8% in Group 2, 7.5% in Group 3, 8.5% in Group 4, 15.4% in Group 5, and 35.5% in Group 6. Their estimated trajectories are shown in Figure 1. The estimated trajectory parameters capturing baseline health and the speed of health decline are shown in Appendix Table S2. Groups 1–4 had the highest baseline values that indicate *good* health. Among these four groups, Group 1 ("high start, stable") had relatively stable general health status over time (e.g., the coefficients of the linear and quadratic terms of the trajectory were small in Appendix Table S2), indicating a healthy aging trajectory. Groups 2–4 experienced fast decline in general health status at different stages over time, dropping from *good* to *poor* health. Group 4 ("high start, early sharp decrease") experienced a rapid health decline within the second year since the first observation of cognitive impairment. Group 3 ("high start, late sharp decrease") experienced a similar decline within the third year since the first observation of cognitive impairment. The health decline was relatively more gradual for Group 2 ("high start, fast decrease"), which happened over the course of the period between the third and the sixth year. Approximately one year after their general health status dropped to *poor*, Groups 2–4 experienced a further health decline: Almost all persons died or ended up in nursing homes. Group 5 ("medium start, late decrease") had a baseline value between *good* and *fair*. It had a relatively stable general health status for the first four years but then started to decline quickly around the fifth year. By the end of the seventh year, the general health status for Group 5 dropped to *poor*. Group 6 ("low start, stable") had the lowest baseline value slightly above *fair* health. The general health status remained relatively stable over time, with a slight decline to *fair* health starting from the second year.

Appendix Table S5 shows the baseline characteristics for each of the latent groups. In the multinomial logistic regression analysis, we selected Group 1 ("high start, stable") as the reference category (Table 2). In general, PCIs who had dementia, a proxy report, at least

four comorbidities, or who smoked regularly were less likely to be in Group 1 (“high start, stable”), whereas PCIs who had higher than high school education were more likely to be in this group. In addition, compared to being in Group 1, PCIs who were not married/with a partner were more likely to be in Group 2 (“high start, fast decrease”); PCIs who had no siblings or more than three siblings were more likely to be in Group 3 (“high start, late sharp decrease”); PCIs who were male or Hispanic, who had no siblings or more than three siblings, or who did not participate in vigorous activities were more likely to be in Group 5 (“medium start, late decrease”); PCIs who were male, Black or Hispanic, who had below high school education, who did not participate in vigorous activities were more likely to be in Group 6 (“low start, stable”).

Depressive Symptoms

Six groups for depressive symptoms were identified. 14.5% of PCIs were in Group 1, 16.8% in Group 2, 16.6% in Group 3, 13.7% in Group 4, 22.0% in Group 5, and 16.4% in Group 6. A visual presentation of the trajectory for each latent group and full model results describing the baseline depressive symptoms and the speed of change are shown in Figure 2 and Appendix Table S3, respectively. Group 1 (“low start, stable”) had little indication of depressive symptoms at baseline, and the score remained relatively stable over time. Group 2 (“low start, gradual increase”) had relatively low depressive symptoms at baseline with gradual increases in depressive symptoms over time (“gradual” here indicates a faster speed than “slight” but a slower speed than “sharp”). By the end of the seventh year, the depression score increased from 0.5 to 3.5. Group 3 (“low start, slight decrease”) had relatively low baseline depressive symptoms, but the score was higher than Groups 1–2. The score decreased slightly over time, from 2 to 1 by the end of the seventh year. Group 4 (“low start, sharp changes”) had a comparable baseline score as Group 3 (“low start, slight decrease”). However, Group 4 experienced a sharp increase in depressive symptoms until the seventh year, and a slight decrease afterwards. By the end of the sixth year, the score was as high as 6.5. Group 5 (“medium start, gradual decrease”) had a score of depressive symptoms at a baseline of 4, which declined gradually over time to 2 at the end of the seventh year. Group 6 (“high start, slight decrease”) had a high level of depressive symptoms at the baseline with a score of 6.5. The score declined slightly over time to 6 at the end of the seventh year.

Appendix Table S6 shows the baseline characteristics for each of the latent groups. We used Group 1, representing stably low depressive symptoms, as our reference category in the multinomial logistic regression analysis (Table 3). In general, PCIs who were females, or who had dementia, a proxy report, or at least four comorbidities were less likely to be in Group 1 (“low start, stable”) whereas PCIs with higher than high school education were more likely to be in this group. In addition, compared to being in Group 1 (“low start, stable”), non-Hispanic Others were more likely to be in Group 2 (“low start, gradual increase”); PCIs who did not have Medicare Part D or who had no siblings or more than three siblings were more likely to be in Group 3 (“low start, slight decrease”); PCIs who were non-Hispanic Others or who had below high school education were more likely to be in Group 4 (“low start, sharp changes”); PCIs who did not participate in vigorous activities

were more likely to be in Group 5 (“medium start, gradual decrease”); Hispanics were more likely to be in Group 6 (“high start, slight decrease”).

Discussion

Using population-based data, we performed group-based trajectory modeling to examine trajectories of general health status and depressive symptoms among PCIs. For general health status, we identified six latent groups: one with a high baseline value and little change over time, one with a low baseline value and little change over time, and four with high baseline values and fast declines in different times after the first observation of cognitive impairment. For depressive symptoms, we also identified six latent groups: one with a low baseline value and little change over time, three with different baseline values but declines over time, and two with relatively low baseline values and increases over time. The results demonstrate that many of the factors associated with poorer health in cross-sectional studies, such as less education (Bjelland et al., 2008) and higher numbers of comorbidities (Taylor et al., 2020), also apply to trajectories of general health status and depressive symptoms. However, contrary to our hypotheses, we generally did not find strong evidence for social support (i.e., measured as numbers of siblings and children as well as married/living with a partner in this study) or health insurance being associated with trajectory group memberships. Nonetheless, we caveat these findings. For social support, we find that PCIs having 1–3 siblings were less likely to be in Group 3 (“high start, late sharp decrease”) and 5 (“medium start, late decrease”) for general health, and Group 3 (“low start, slight decrease”) for depressive symptoms. These results provide some suggestive evidence on the health benefits of having siblings. The lack of associations between number of children or marital status and trajectory group membership may be driven by the varying quality of the relationship between PCIs and their family members. For health insurance, since many insurance policies, such as Medicaid, are handled differently by state, we might not fully capture the effect of insurance on trajectory group memberships.

Our trajectory analysis adds to the existing literature in several ways. First, our study demonstrates that more than 40% of all older PCIs—i.e., Groups 2 (“high start, fast decrease”), 3 (“high start, late sharp decrease”), 4 (“high start, early sharp decrease”), or 5 (“medium start, late decrease”)—in the US experienced sharp declines in general health status, and 35.5% experienced persistently poor health over a seven-year time period. Although comparable studies examining the general populations of US older adults are lacking, this finding provides a marked contrast to a study of Dutch community-dwelling older adults regardless of cognitive impairment status, which found four stable trajectories of self-rated health (Feenstra et al., 2020). The finding suggests that decline of physical health is more common among PCIs compared to a general older population. In addition, the shape of these trajectories provides new evidence suggesting a negatively synergistic interaction between cognitive and physical decline, resulting in many persons belonging to trajectories of rapidly declining health. There are likely to be profound implications of these rapid declines for PCIs, caregivers, and the health system that require further investigation. This is particularly important in light of the fact that many insurance policies, such as Medicaid, have disparate implementations based upon the state of residence: Understanding policies, particularly those related to services that depend on regions and locales, may reveal

areas that might require additional targeted interventions for PCIs of rapid decline. In one previous study examining a nationally representative 5% sample of Medicare beneficiaries, dementia was associated with a three-fold increase in total expenditures for each specific type of Medicare service, with hospitalization accounting for over all of costs (Bynum et al., 2004). A more detailed understanding of the clinical factors contributing to the steep slopes of decline has the potential to yield new insights into how best to manage PCIs with multiple chronic illness and cognitive impairment (Snowden et al., 2017). Further, understanding how these clinical factors interact with specific elements of other healthcare systems can provide future insight into where expenditures should be targeted.

Second, although all PCIs experienced either declines in or persistently poor general health status, there was greater heterogeneity in depressive symptoms trajectories with three groups —namely, Groups 3 (“low start, slight decrease”), 5 (“medium start, gradual decrease”), and 6 (“high start, slight decrease”)—experiencing improvement in these symptoms. These results suggest the potential for resilience in mental health in the face of declining physical health. Future studies are needed to better understand the reasons behind this phenomenon. Though many studies have looked at resilience in PCIs’ caregivers (Bailey et al., 2013; Gaugler et al., 2007), less work has been done on resilience in PCIs themselves and whether their resilience and their caregivers’ are related, which our research would indicate is a place that necessitates further evaluation.

In addition, the heterogeneity in depressive symptoms trajectories in the current study is greater than found in a previous study examining general populations of US older adults. Xiang and Cheng (2019) found only single trajectories of improvement and decline, as compared to the current study in which we identified two groups with different starting values and speeds of change for each of the increasing and decreasing groups. The greater heterogeneity observed in our study suggests that PCIs may have more diverse mental health trajectories compared to non-PCIs. Despite the existence of trajectories with improvement, larger proportions of PCIs were in trajectories with persistently high or worsening depressive symptoms as compared to Xiang and Cheng (2019). The two groups with increasing trajectories of depressive symptoms identified in this study account for 30.5% PCIs and the group with persistently high depressive symptoms accounts for 16.4% PCIs. By contrast, Xiang and Cheng (2019) identified only 7.9% individuals with increasing depressive symptoms, and 8.9% with persistently high depressive symptoms. These results confirm previous evidence on the substantial mental health burden of cognitive impairment (Diniz et al., 2013).

Finally, our findings add to the literature on the predictors of poor health. Prior studies have provided conflicting data regarding the association between race/ethnicity and general health status trajectories (Ferraro & Kelley-Moore, 2001; Liang et al., 2010; McDonough & Berglund, 2003; Yao & Robert, 2008). Our findings among PCIs are more consistent with Liang et al. (2010), which focused on middle-aged and older adults regardless of cognitive impairment status. They found that both Blacks and Hispanics had lower baselines/intercepts of self-rated health, but only Hispanics had significantly faster-declining slopes of self-rated health trajectories compared to Whites. Similarly, we find that 1) Blacks were more likely than Whites to be in latent groups with low baselines, but no significant differences were

found in terms of being in latent groups with different speeds of declines; 2) Compared to Whites, Hispanics were more likely to be in latent groups with both low baselines and faster declines. Future studies are needed to better understand these racial/ethnic disparities. For example, why Hispanics were more likely to have fast declines in general health needs further investigation, as our finding is consistent with previous evidence showing that Hispanics had faster chronic disease accumulation than Whites and Blacks (Quiñones et al., 2019).

This study has some limitations. First, the results of this observational study do not imply a causal effect of cognitive impairment on general health status and depressive symptoms trajectories. Second, due to data limitations, we were not able to examine some theoretically important characteristics, such as living arrangements, in predicting trajectory group membership. Third, because health information was unavailable for individuals in nursing homes and 26% of these people ended up dying, we assigned 0 to those individuals' general health status. However, death and institutionalization are theoretically different, and future studies need to design a coding strategy to distinguish them in trajectory analysis of general health status. Fourth, although there is evidence supporting the validity of proxy-reported health and depressive symptoms (Ayalon & Covinsky, 2009; Heisel et al., 2011), self-reports are preferable, especially for depressive symptoms. Since persons with severe cognitive impairment may have difficulties accurately reporting their own general health status and depressive symptoms, new evaluation methods are needed. Finally, we find that despite having relatively low baseline values, non-Hispanic Others, including American Indians, Asians, and Pacific Islanders, etc., experienced faster increasing depressive symptoms over time compared to Whites. However, this racial/ethnic group is extremely heterogeneous, and sample sizes limited our ability to disaggregate this group. There is a need to oversample participants from these racial/ethnic groups in national surveys to better understand the observed patterns.

To summarize, for both general health status and depressive symptoms, we use a nationally representative sample of Medicare beneficiaries to show that there are six groups of PCIs with distinct trajectories over a seven-year period. Since Medicare beneficiaries make up 96% of adults in the US over the age of 65, our study reveals patterns that can inform policies at a national level. From our analyses, we find that more than 40% of all older PCIs in the US experienced sharp declines in general health status, and 35.5% experienced persistently poor health. By contrast, we observe greater heterogeneity in depressive symptoms trajectories with 55% PCIs experiencing improvement, 16.4% experiencing persistently high depressive symptoms, and 30.5% experiencing deterioration. The high percentages of PCIs in groups with health deterioration or persistently poor health call for additional efforts on reducing the physical and mental health burden among PCIs. Specifically, evidence-based treatments could be designed based on these identified trajectory groups. PCIs who are women, people of color, and who smoke regularly or have multiple comorbidities are prime candidates for such prevention efforts. Future research is needed to examine the reasons behind the differences in health trajectories among PCIs by race/ethnicity, sex, smoking behaviors, and comorbidity. This would build upon prior research that would indicate that marginalization and discrimination on the basis of identities, such as race/ethnicity or sex, are present (if not exacerbated) within healthcare

systems (Feagin & Bennefield, 2014), and that other health factors/behaviors are often interactional (Akasaki et al., 2019).

Future studies may also consider separately examining persons with dementia and persons with various types of MCI (e.g., amnestic, non-amnestic): Since our study focused on moving beyond studying strictly to those with dementia and instead expanding to also include those with MCI, we realize we might not be capturing the full heterogeneity of health trajectories within the group of adults with MCI. Understanding the needs of different types of MCI can allow for even further targeted preventative interventions at the outset of initial diagnosis. Finally, studies are needed to better understand why some PCIs experienced improvement in mental health despite deterioration in physical health. This is an area that has been explored in the field of health resiliency particularly for caregivers, but needs to also be addressed for PCIs themselves.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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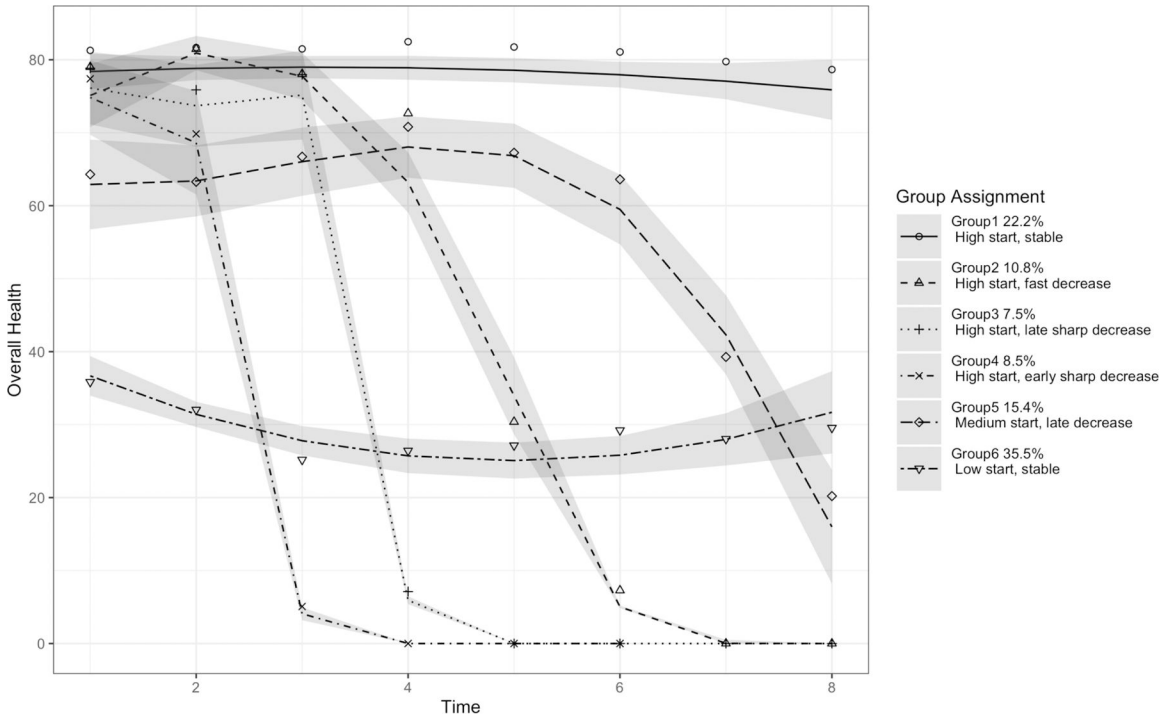

Figure 1.
General health status trajectories for individuals with cognitive impairment

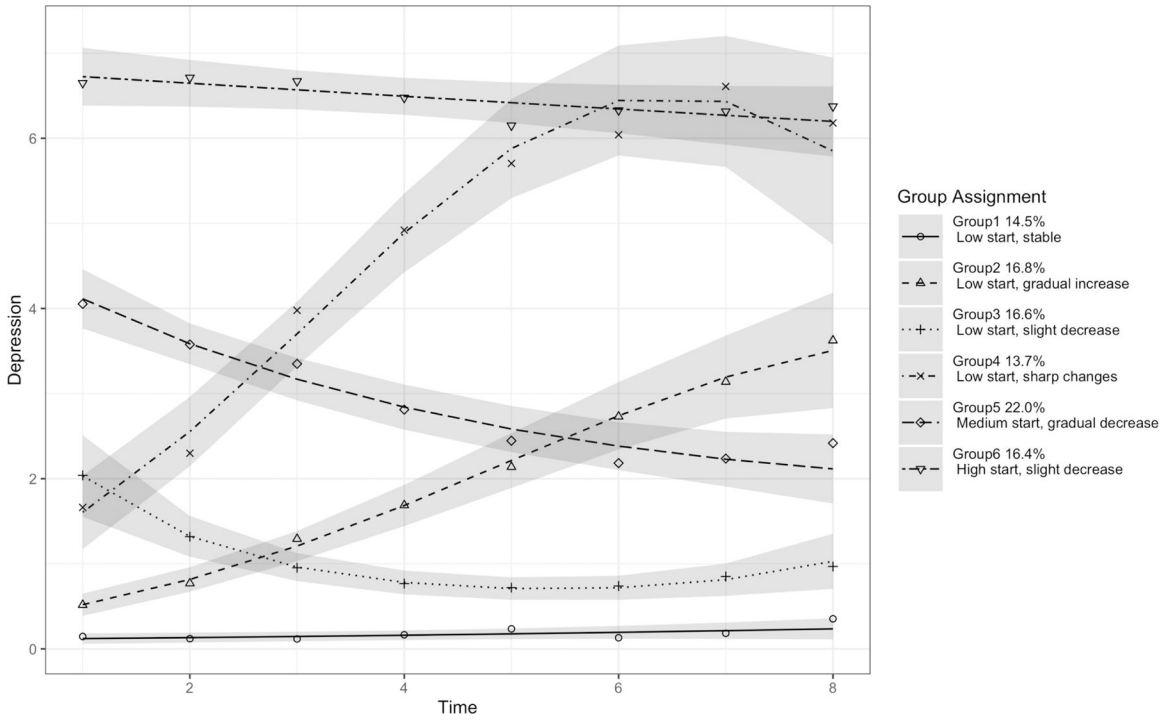

Figure 2.
Depressive symptoms trajectories for individuals with cognitive impairment

Table 1.

Baseline characteristics for individuals with cognitive impairment

	N	Mean (SD)/ %	Missing rate
Female	2361	60.23%	0.00%
Age	2361	81.73 (7.75)	0.00%
Race/Ethnicity	2320		1.74%
Non-Hispanic Black		29.61%	
Non-Hispanic White		57.24%	
Hispanic		9.44%	
Other		3.71%	
Educational attainment	2310		2.16%
Less than high school		42.99%	
High school		25.41%	
Beyond high school		31.60%	
Number of siblings	2342		0.80%
0		28.52%	
1–3		50.73%	
3+		20.75%	
Number of children	2361		0.00%
0		9.57%	
1–3		54.55%	
3+		35.87%	
Medicare Part D	2170	70.05%	8.09%
Medicaid	2239	27.11%	5.17%
Tricare	2284	4.47%	3.26%
Number of comorbidities	2310		2.16%
0–3		70.87%	
4+		29.13%	
Marital status	2357		0.17%
Married/living with a partner		37.04%	
Separated, divorced, or widowed		57.91%	
Never married		5.05%	
Vigorous activity	2358	21.20%	0.13%
Smoking regularly	1801	45.92%	23.72%
Self-report	2361	83.86%	0.00%
MCI	2361	35.49%	0.00%

Note: Mean (SD) for continuous variables and % for categorical variables.

Table 2.

Risk factors of general health trajectories among individuals with cognitive impairment (Relative Risk Ratios and 95% Confidence Interval)

	Group 2 High start, fast decrease	Group 3 High start, late sharp decrease	Group 4 High start, early sharp decrease	Group 5 Medium start, late decrease	Group 6 Low start, stable
Female	0.90 (0.60, 1.34)	0.64 (0.41, 1.01)	0.74 (0.50, 1.10)	0.72 * (0.52, 0.99)	0.68 ** (0.52, 0.90)
Age	1.07 (0.70, 1.64)	1.39 (0.84, 2.32)	0.80 (0.54, 1.19)	1.33 (0.94, 1.89)	0.98 (0.74, 1.30)
Age squared	1.00 (1.00, 1.00)	1.00 (1.00, 1.00)	1.00 (1.00, 1.00)	1.00 (1.00, 1.00)	1.00 (1.00, 1.00)
Race/Ethnicity (Ref. White)					
Black	0.65 (0.40, 1.04)	1.09 (0.67, 1.78)	0.92 (0.59, 1.43)	1.33 (0.95, 1.87)	1.56 ** (1.16, 2.09)
Other	0.97 (0.38, 2.45)	1.01 (0.35, 2.95)	0.71 (0.25, 2.05)	1.11 (0.53, 2.31)	1.21 (0.65, 2.28)
Hispanic	1.01 (0.45, 2.30)	1.04 (0.40, 2.76)	1.07 (0.46, 2.48)	2.66 *** (1.55, 4.56)	3.23 *** (2.00, 5.23)
Educational attainment (Ref. < High school)					
High school	0.90 (0.56, 1.47)	1.12 (0.68, 1.84)	0.93 (0.60, 1.45)	0.81 (0.57, 1.16)	0.65 ** (0.48, 0.89)
> High school	1.24 (0.80, 1.92)	0.78 (0.48, 1.28)	0.63 * (0.41, 0.96)	0.57 ** (0.40, 0.81)	0.40 *** (0.30, 0.55)
Number of siblings (Ref. 0)					
1–3	0.84 (0.56, 1.26)	0.53 ** (0.34, 0.83)	0.71 (0.49, 1.04)	0.70 * (0.50, 0.98)	0.80 (0.60, 1.07)
3+	1.02 (0.58, 1.81)	1.01 (0.56, 1.82)	0.65 (0.36, 1.17)	0.92 (0.60, 1.41)	0.96 (0.67, 1.40)
Number of children (Ref. 0)					
1–3	1.16 (0.62, 2.16)	0.88 (0.46, 1.69)	1.12 (0.62, 2.04)	1.22 (0.74, 2.01)	1.34 (0.87, 2.08)
3+	0.92 (0.48, 1.78)	0.50 (0.25, 1.02)	0.63 (0.33, 1.19)	0.77 (0.46, 1.29)	1.04 (0.66, 1.64)
Medicare Part D	0.99 (0.67, 1.47)	0.80 (0.52, 1.22)	1.20 (0.81, 1.77)	1.01 (0.73, 1.38)	0.90 (0.70, 1.17)
Medicaid	0.98 (0.59, 1.63)	1.14 (0.66, 1.97)	0.75 (0.46, 1.23)	0.99 (0.69, 1.43)	1.17 (0.86, 1.59)
Tricare	0.68 (0.28, 1.61)	0.67 (0.24, 1.85)	0.98 (0.43, 2.25)	0.80 (0.41, 1.55)	0.87 (0.50, 1.52)
4+ comorbidities	1.13 (0.71, 1.81)	2.69 *** (1.73, 4.20)	1.88 ** (1.24, 2.85)	2.05 *** (1.46, 2.90)	5.10 *** (3.84, 6.77)
Marital status (Ref. Separated, divorced, or widowed)					
Married/living with a partner	1.72 ** (1.14, 2.60)	0.92 (0.57, 1.49)	1.20 (0.79, 1.82)	1.02 (0.74, 1.41)	1.26 (0.95, 1.66)
Never married	2.06 (0.90, 4.71)	0.75 (0.27, 2.08)	0.94 (0.38, 2.36)	0.58 (0.28, 1.19)	0.84 (0.48, 1.49)
Vigorous activity	0.85 (0.57, 1.25)	0.64 (0.40, 1.04)	0.68 (0.45, 1.02)	0.64 ** (0.46, 0.88)	0.46 *** (0.34, 0.61)
Smoke regularly	0.92 (0.61, 1.40)	2.06 ** (1.22, 3.46)	1.53 * (1.07, 2.19)	0.93 (0.63, 1.36)	1.41 * (1.01, 1.95)
Self-report	0.73 (0.44, 1.23)	0.58 (0.33, 1.01)	0.52 ** (0.33, 0.83)	0.60 * (0.39, 0.92)	0.62 * (0.43, 0.91)
MCI	0.55 ** (0.38, 0.80)	0.60 * (0.40, 0.92)	0.29 *** (0.19, 0.44)	0.70 * (0.52, 0.93)	0.51 *** (0.40, 0.66)

Note:

* p<0.05

** p<0.01

*** p<0.001.

Reference group is Group 1 (High start, stable). Total N = 2,361. Number of individuals in each group: Group 1 (N=599), Group 2 (N=191), Group 3 (N=145), Group 4 (N=221), Group 5 (N=364), Group 6 (N=841).

Table 3.

Risk factors of depressive symptoms trajectories among individuals with cognitive impairment (Relative Risk Ratios and 95% Confidence Interval)

	Group 2 Low start, gradual increase	Group 3 Low start, slight decrease	Group 4 Low start, sharp changes	Group 5 Medium start, gradual decrease	Group 6 High start, slight decrease
Female	1.15 (0.78, 1.68)	1.50 * (1.03, 2.20)	1.75 ** (1.17, 2.63)	2.14 *** (1.49, 3.09)	2.23 *** (1.48, 3.34)
Age	1.29 (0.86, 1.93)	1.20 (0.80, 1.80)	1.01 (0.67, 1.52)	1.11 (0.76, 1.61)	1.04 (0.69, 1.58)
Age squared	1.00 (1.00, 1.00)	1.00 (1.00, 1.00)	1.00 (1.00, 1.00)	1.00 (1.00, 1.00)	1.00 (1.00, 1.00)
Race/Ethnicity (Ref. White)					
Black	1.34 (0.88, 2.04)	1.24 (0.81, 1.90)	1.10 (0.70, 1.73)	1.10 (0.73, 1.66)	1.18 (0.76, 1.85)
Other	3.25 * (1.12, 9.43)	2.88 (0.98, 8.40)	3.20 * (1.05, 9.74)	2.34 (0.82, 6.70)	1.94 (0.61, 6.13)
Hispanic	0.99 (0.51, 1.93)	1.02 (0.53, 1.96)	1.17 (0.59, 2.31)	1.17 (0.64, 2.15)	2.09 * (1.11, 3.93)
Educational attainment (Ref. < High school)					
High school	0.64 (0.40, 1.00)	0.82 (0.52, 1.28)	0.60 * (0.37, 0.95)	0.65 (0.43, 1.00)	0.66 (0.42, 1.05)
> High school	0.67 (0.44, 1.02)	0.70 (0.46, 1.09)	0.50 ** (0.32, 0.79)	0.62 * (0.41, 0.93)	0.45 ** (0.28, 0.72)
Number of siblings (Ref. 0)					
1–3	0.86 (0.57, 1.29)	0.64 * (0.43, 0.97)	0.81 (0.53, 1.24)	0.74 (0.50, 1.09)	0.74 (0.48, 1.14)
3+	0.82 (0.48, 1.39)	0.84 (0.50, 1.41)	0.74 (0.42, 1.29)	1.00 (0.61, 1.63)	0.81 (0.47, 1.40)
Number of children (Ref. 0)					
1–3	0.85 (0.45, 1.59)	0.61 (0.33, 1.12)	0.78 (0.41, 1.48)	0.64 (0.35, 1.16)	0.77 (0.39, 1.52)
3+	0.76 (0.40, 1.48)	0.73 (0.38, 1.39)	0.65 (0.33, 1.29)	0.69 (0.37, 1.27)	0.86 (0.43, 1.73)
Medicare Part D	0.90 (0.62, 1.29)	0.66 * (0.46, 0.94)	0.74 (0.50, 1.09)	0.95 (0.66, 1.37)	1.02 (0.68, 1.52)
Medicaid	1.06 (0.66, 1.70)	1.10 (0.69, 1.76)	0.98 (0.60, 1.59)	1.41 (0.91, 2.18)	1.54 (0.97, 2.44)
Tricare	1.19 (0.59, 2.39)	0.51 (0.22, 1.16)	0.51 (0.19, 1.36)	1.21 (0.60, 2.44)	0.86 (0.36, 2.06)
4+ comorbidities	1.26 (0.82, 1.95)	1.50 (0.98, 2.30)	1.81 ** (1.17, 2.81)	2.91 *** (1.98, 4.28)	4.83 *** (3.21, 7.26)
Marital status (Ref. Separated, divorced, or widowed)					
Married/living with a partner	0.70 (0.48, 1.03)	0.80 (0.54, 1.18)	0.90 (0.59, 1.35)	0.77 (0.53, 1.11)	1.09 (0.72, 1.63)
Never married	0.65 (0.29, 1.48)	0.62 (0.28, 1.41)	0.94 (0.41, 2.13)	0.46 (0.21, 1.01)	0.51 (0.21, 1.22)
Vigorous activity	1.14 (0.79, 1.64)	0.86 (0.59, 1.26)	0.88 (0.59, 1.33)	0.68 * (0.47, 0.99)	0.76 (0.50, 1.16)
Smoke regularly	1.03 (0.66, 1.60)	1.05 (0.71, 1.55)	1.25 (0.82, 1.92)	1.27 (0.88, 1.84)	1.30 (0.83, 2.04)
Self-report	0.84 (0.45, 1.59)	0.52 * (0.28, 0.95)	0.60 (0.33, 1.12)	0.50 * (0.28, 0.89)	0.44 ** (0.25, 0.80)
MCI	0.68 * (0.49, 0.95)	1.06 (0.76, 1.49)	0.45 *** (0.31, 0.65)	0.59 ** (0.43, 0.81)	0.36 *** (0.25, 0.52)

Note:

* p<0.05

** p<0.01

*** p<0.001.

Reference group is Group 1 (Low start, stable). Total N = 1,927. N in each group: Group 1 (N=295), Group 2 (N=317), Group 3 (N=309), Group 4 (N=258), Group 5 (N=438), Group 6 (N=310).