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Trajectories of Disability and Long-Term Care Utilization After Acute Health Events

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ABSTRACT

Hip fractures, strokes, and heart attacks are common acute health events that can lead to long-term disability, care utilization, and unmet needs. However, such impacts, especially in the long term, are not fully understood. Using data from the Health and Retirement Study, 1992–2018, this study examines the long-term trajectories of individuals suffering such health shocks, comparing with individuals not experiencing health shocks. Hip fracture, stroke, and heart attack are confirmed to have severe implications for disability. In most cases of stroke and heart attack, informal caregivers provide the daily support needed by survivors, whereas following hip fracture, nursing home care is more relevant. These health shocks put individuals on worse trajectories of disability, care utilization, and unmet needs. There is no long-term recovery or convergence with individuals who do not suffer shocks. Unmet need is prevalent, even pre-shock and among individuals who do not experience health shocks, emphasizing the importance of preventative care measures. These findings support policy action to ensure hospitalized individuals, especially those aged 50 and above, receive rehabilitative services and other post-acute care. Furthermore, hospitalization is an event that requires the detection and addressing of unmet care needs beyond the short run.

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Event study; formal home care; health shock; informal care; limitations in activities of daily living; nursing home care; unmet need

Introduction

Hip fracture, stroke, and heart attack are examples of acute life-threatening events that are increasingly common. Worldwide in 2019, there were an estimated 14.2 million incident hip fractures, 12.2 million incident strokes, and 21.2 million incident cases of ischemic heart disease (which typically manifests as heart attack). Incidence is also growing, with 93, 70, and 80% increases since 1990, respectively (Feigin et al., 2021; Safiri et al., 2022; Wu et al., 2021). After

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neonatal disorders, ischemic heart disease and stroke are the second and third leading causes of death and disability combined (i.e., lost Disability-Adjusted Life Years) in the world (Vos et al., 2020). Hip fracture, stroke, and heart attack impose large health and long-term care (LTC) costs, as the majority of survivors are left with long-lasting impairments that push them into needing long-term support in their daily activities, like bathing and dressing (Bishu et al., 2020; Braithwaite et al., 2003; Luengo-Fernandez et al., 2020).

While the risk factors for hip fracture, stroke, or heart attack usually build up over the life course – unhealthy diet, low physical activity, smoking, drinking—, these events are sudden. Hip fractures are cracks or breaks in the top of the thigh bone (femur), close to the hip joint, caused by a fall or injury. Strokes occur when the blood supply to part of the brain is stopped because of a blood clot (ischemic stroke), or when a weakened blood vessel supplying part of the brain bursts (hemorrhagic stroke). A heart attack (myocardial infarction) is also usually caused by a blood clot blocking the supply of blood to the heart. Because these are acute, unexpected events, researchers usually consider them to be exogenous health shocks.

In the Economics literature, stroke, heart attack, and accidental injuries or falls have been used as sources of exogenous variation to identify the effects of health on income, wealth, and labor market outcomes (Cheng et al., 2019; Coile, 2004; Coile & Milligan, 2009; Dobkin et al., 2018; García-Gómez et al., 2013; Giaquinto et al., 2022; Jones et al., 2020; Lenhart, 2019; McGeary, 2009; Tanaka, 2021; Trevisan & Zantomio, 2016; Van Houtven & Coe, 2010). Some studies also consider medical expenditure or healthcare use post-health shock, but none look into the effects of health shocks on LTC utilization (Cheng et al., 2019; Dobkin et al., 2018; Lenhart, 2019). This strand of literature usually relies on data from large population-based surveys, such as the Health and Retirement Study (HRS) that we use in the present paper (Coile, 2004; Coile & Milligan, 2009; Dobkin et al., 2018; McGeary, 2009; Tanaka, 2021; Van Houtven & Coe, 2010).

This paper relates to a second strand of literature that includes retrospective cohort studies following patients through their discharge destinations (home, skilled nursing or rehabilitation facilities, LTC facilities) after hospitalization due to acute events like stroke or hip fracture (Amador et al., 2007; Buntin et al., 2010; Gaughan et al., 2017; Gosman-Hedström & Claesson, 2005; Harrison et al., 2017; Oliva-Moreno et al., 2018; Stein et al., 2015; Torbica et al., 2015; Van Der Burg et al., 2020; Wodchis et al., 2021). The length of follow-up in these studies is usually short, stopping at six or twelve months, so the focus is on post-acute care rather than actual LTC. The cohorts are sometimes small (e.g., admissions to a single hospital over some period of time) and limited to a specific condition, but some studies consider nationally representative cohorts (Buntin et al., 2010; Gaughan et al., 2017; Oliva-Moreno et al., 2018; Torbica et al., 2015; Van Der Burg et al., 2020; Wodchis et al., 2021).

In the US, formal support for people limited in their activities of daily living (ADL: personal hygiene, dressing, toileting, transferring, and eating) is paid for in a variety of ways, with very incomplete LTC insurance coverage. Medicare insurance, available for 96% of Americans age 65 and above (65 million older adults; CMS, 2023), covers post-acute facility and home-based skilled care for a limited period of time, typically following hospital admission. Medicare does not cover ongoing help with ADL; i.e., it does not cover LTC. LTC is funded primarily through Medicaid, Veterans benefits, private insurance, and out-of-pocket spending. Medicaid dollars account for more than 50% of LTC spending, but Medicaid is only available to low-income individuals. Only 11% of older adults, covered by Medicare, also have Medicaid (7.2 million older adults; Medicaid.gov, n.d..). With an additional 10% of older adults covered by private LTC insurance policies (McKnights Senior Living, 2022), and an additional small proportion covered by Veterans benefits (ASPE, 2021), nearly three-fourths of older adults in the US have no LTC insurance and must pay for such services out-of-pocket. With no universal LTC insurance coverage, informal care is the modal form of LTC. Around three-fourths of older adults with functional disability receive informal care (Van Houtven et al., 2020). Over time, formal LTC has been moving from nursing homes to patients' homes, with care provided in institutions representing almost 90% of Medicaid LTC spending in 1990, compared to less than 50% today (Kaye et al., 2010; Werner & Konetzka, 2022).

In this context, and given the high and growing incidence and costs associated with hip fractures, strokes, and heart attacks also in the US, knowledge of the long-run trajectories of need and utilization of LTC by individuals who suffer and survive such shocks is essential (Heidenreich et al., 2011; Ovbiagele et al., 2013; Schwartz et al., 2020). This includes recognizing that each shock has potentially different implications in terms of survival, disability, and LTC utilization. Such knowledge may guide policymaking to mitigate the burden on individuals, the health system, and the LTC system. Policy answers might involve more prevention, enhanced coverage and benefits, not only regarding LTC, but also post-acute care, to interrupt adverse trajectories and prevent further events.

The present study brings new knowledge by documenting and distinguishing between the long-run impacts of first-ever incidences of hip fractures, strokes, and heart attacks on disability, LTC utilization, and unmet need, based on a large representative sample of the 50+ population in the US. Focusing on first-ever incidences, combined with longitudinal analyses that account for individual fixed effects, and matched comparison groups, allows us to estimate causal effects and compare the trajectories of individuals who suffer these types of acute health events with those of similar individuals who never experience such events.

Methods

Data source

We use data from the Health and Retirement Study (HRS), a panel of older adults representative of the 50+ population in the US, conducted every two years since 1992 (14 waves until 2018). We use the RAND longitudinal file, February 2021 release. We obtain additional information to construct the health shock and (in/)formal home help variables from the original data files.

Outcome measures

We consider **six binary outcomes**. The first is reporting **any ADL limitation**, a common measure of disability following acute health events like the ones considered here (Carmo et al., 2015; De Leon et al., 2005; Dhamoon et al., 2017; Dyer et al., 2016; Levine et al., 2014). The second is **living in a nursing home**. For this outcome, when individuals die, we can consider one final observation by using information from the exit interviews with relatives, specifically whether the deceased individual had moved to a nursing home since the previous wave. Third, individuals with any ADL limitation living in the community may receive **formal or informal support**. Informal care use is defined as receiving help with any ADL from any relative or unpaid non-relative. Formal home care use is defined as receiving help with any ADL from an organization, employee of an institution, paid helper, or professional. This information is retrieved from the original datafiles. We construct one binary indicator taking value one if the individual receives any ADL support at home (formal or informal). Fourth and fifth, we look separately at **formal home support** and **informal home support**. Sixth and last, **unmet need** is defined as living in the community and having any reported ADL limitation for which neither formal nor informal home support is received (Kemper et al., 2008).

The definition of disability must reflect a need for assistance in the aftermath of a shock, and the definition of unmet need must reflect a gap in assistance needed. We explore what disability and unmet need, according to the definitions above, entail in terms of health status, based on an array of health indices constructed by RAND and available in the RAND longitudinal file, capturing functional limitations, mental health, and health conditions (Table A1 in the Appendix). These descriptive statistics confirm that individuals who report any ADL limitation are in poorer health condition, compared to individuals who do not report ADL limitations, and alarmingly, that individuals who report any unmet need are in poorer health condition than those who have their needs met by formal or informal support.

HRS data include information on ADL limitations since the beginning (i.e., 1992). However, we can only derive unmet need from wave 2 onwards, nursing home residence status from wave 3 onwards, and we are able to distinguish between formal and informal home help only from wave 3 onwards, as well.

Health shocks

The first-ever **hip fracture** is identified from the question *Have you ever fractured your hip?*, asked the first time individuals join HRS, or *Have you fractured your hip since the previous wave?*, for subsequent observations. Only respondents who are at least 65 years old are asked about hip fractures. The question was not included in wave 1 (1992), and only for part of the sample in wave 2 (AHEAD cohort).

Similarly, first-time HRS respondents are asked if a doctor ever told them that they had a **stroke**, and recurrent respondents are asked if a doctor told them that they had a stroke since the previous wave. Since wave 3, transient ischemic attacks (TIA) are recorded separately. TIAs are "mild strokes," when the blockage in blood supply to the brain is brief and there is no permanent damage, so we exclude them.

Regarding **heart attack**, there are two separate questions: whether the respondent suffered a heart attack since the previous wave (i.e., new heart attack), and whether a doctor ever told them that they had a heart attack. However, the latter is only available from wave 10 (2010) onwards. So, to identify the first-ever heart attack, we consider the first time the individual reports a new heart attack. Then, if the individual answered positively to the question "Has a doctor ever told you that you had a heart attack" in a previous wave, we exclude them. Because this information is not always available, it is possible that we incorrectly count some heart attacks as first-ever heart attacks in early waves.

The implication of including (likely, very few) TIAs before wave 3, or heart attacks that are not first-ever occurrences before wave 10, may be an attenuation bias, meaning that we underestimate the impacts of the shocks.

Study design

First, for each of the three health shocks (hip fracture, stroke, heart attack), we construct a longitudinal dataset with time centered around the wave in which the individual reports the first-ever occurrence of the shock (t_0). Individuals must also be observed in the wave prior to the first-ever occurrence of the shock (t_{-1}), otherwise they are excluded (Figure 1). These individuals constitute the *treatment groups*.

To create the comparison groups, first we identify all individuals in HRS who never suffer a health shock of the type under consideration. Our goal is to define a group of comparison individuals similar to treatment group individuals in t_{-1}. However, t(our measure of time relative to the acute event) is not defined when individuals don't suffer a health shock. To solve this, we apply coarsened exact matching in the following manner. First, we stratify treatment group observations in t_{-1}, and all observations of individuals who don't suffer a shock, according to age (5-year intervals), gender, race/ethnicity (white, black, Hispanic, other), whether they have any mobility limitation, whether they have any health condition, whether they were ever a smoker, whether they are overweight or obese, whether they have any health insurance, and whether they are observed or not in each of the following four waves. Then, survey wave by survey wave, we match observations from the two groups (k2k matching, meaning that if an observation in the treatment group has more than one viable match, only one is selected, at random). This process is done survey wave by survey wave to allow for sequentially excluding individuals already matched, such that individuals in the comparison group are not repeated. Lastly, when a comparison group individual is matched, t is set at t_{-1}. Note that by matching on whether individuals are observed or not in the following four waves, we require that comparison and treatment group individuals have the same observation pattern up to four waves post-shock (e.g.,

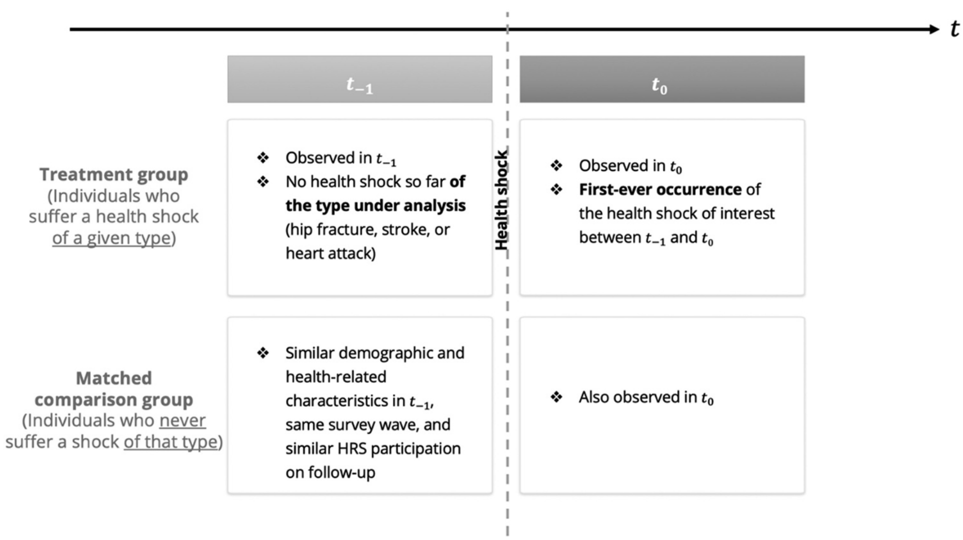

Figure 1. Study design.
Note: Predicted likelihoods with 95% prediction intervals, and pre/post-shock linear trends. Black: treatment group (people who experience their first-ever hip fracture, stroke, or heart attack between t_{-1} and t_0). Gray: comparison group (people who never experience the health shock considered). Standard errors are adjusted for multiple observations of the same individual, heteroskedasticity, and serial correlation.

a treatment group individual who survives for only one wave is matched to a comparison individual that also survives for only one wave). In conjunction with the health-related variables, this should help mitigate any selection bias.

For the remainder of the text, "time" is relative to the date of the acute health event, and a "wave" corresponds to a time interval of two years.

In addition to matching pre-shock, we take advantage of the longitudinal dimension of the data and control for individual fixed effects, effectively ruling out confounding from time-invariant observed or unobserved individual characteristics (e.g., age at the time of the shock and even lifestyle, to some extent – please see Statistical Analyses).

Sample

We identify in the data 1,341, 3,228, and 2,410 first-ever incidences of hip fracture, stroke, and heart attack, respectively (same as the numbers of individuals; Table 1). About 90% of those have exact matches among individuals who do not suffer shocks, based on the variables listed in the previous section.

Table 2 shows summary statistics for all outcomes and health shocks in the full treatment group (i.e., pre-matching), and in the matched treatment and comparison groups, separating between the period before t_0 and the period from t_0 onwards. The matching variables – all measured in t_{-1}— are described in Table A2 in the Appendix, comparing the treatment group pre- and post-matching.

Statistical analyses

For each outcome and health shock, we perform an *event study*, using fixed effects linear regression. We estimate the following model:

Table 1. Numbers of observations over time, by type of health shock.

t=	−4	−3	−2	−1	0	1	2	3	4	5	6	7	Total
Hip fracture (all)	972	1,073	1,211	1,341	1,341	1,138	742	476	303	180	112	63	8,952
Hip fracture (matched)	886	977	1,098	1,215	1,215	1,041	670	436	287	170	107	62	8,164
No hip fracture (matched)	853	954	1,087	1,215	1,215	1,041	670	436	307	205	130	78	8,191
Stroke (all)	1,975	2,323	2,713	3,228	3,228	2,736	1,927	1,401	935	644	435	276	21,821
Stroke (matched)	1,762	2,055	2,391	2,849	2,849	2,432	1,745	1,285	872	601	407	257	19,505
No stroke (matched)	1,761	2,064	2,388	2,849	2,849	2,432	1,745	1,285	985	704	512	375	19,949
Heart attack (all)	1,089	1,408	1,849	2,410	2,410	2,189	1,727	1,411	1,153	938	677	483	17,744
Heart attack (matched)	988	1,279	1,677	2,171	2,171	2,005	1,601	1,320	1,083	880	638	457	16,270
No heart attack (matched)	1,004	1,298	1,681	2,171	2,171	2,005	1,601	1,320	1,101	943	716	528	16,539

Notes: Initial sample sizes after applying the selection criteria; final numbers of observations vary by outcome, depending on the number of missing values. The total number of individuals corresponds to the number of observations in t_{-1} or t_0 (in gray shade), as individuals must appear in both waves.

Table 2. Summary statistics for all outcomes in the treatment and comparison groups, before and from t_0 onwards (proportions).

	Before				After			
	Treatment pre-matching	Matched treatment	Matched comparison	t-statistic	Treatment pre-matching	Matched treatment	Matched comparison	t-statistic
Hip fracture								
Any ADL limitation	0.305	0.304	0.226	**8.01**	0.610	0.600	0.368	**19.49**
Living in a nursing home	0.031	0.030	0.019	**2.98**	0.270	0.263	0.148	**12.97**
Any formal/informal support	0.126	0.123	0.079	**6.64**	0.264	0.255	0.145	**11.35**
Any informal support	0.122	0.120	0.070	**7.49**	0.225	0.216	0.124	**10.17**
Any formal support	0.016	0.016	0.016	0.02	0.072	0.068	0.034	**6.43**
Unmet need	0.213	0.215	0.168	**5.41**	0.273	0.277	0.214	**6.00**
Stroke								
Any ADL limitation	0.234	0.229	0.180	**8.20**	0.501	0.492	0.283	**29.99**
Living in a nursing home	0.015	0.014	0.014	0.13	0.175	0.170	0.084	**19.04**
Any formal/informal support	0.087	0.084	0.058	**6.65**	0.234	0.226	0.109	**21.83**
Any informal support	0.086	0.083	0.057	**6.42**	0.216	0.208	0.098	**21.12**
Any formal support	0.012	0.010	0.007	**2.45**	0.046	0.044	0.021	**8.84**
Unmet need	0.174	0.172	0.138	**6.20**	0.254	0.253	0.187	**10.95**
Heart attack								
Any ADL limitation	0.216	0.210	0.177	**4.64**	0.342	0.335	0.258	**11.55**
Living in a nursing home	0.011	0.010	0.012	−0.95	0.085	0.083	0.069	**3.66**
Any formal/informal support	0.080	0.077	0.061	**3.43**	0.151	0.147	0.093	**11.31**
Any informal support	0.084	0.081	0.064	**3.17**	0.141	0.137	0.088	**10.65**
Any formal support	0.006	0.006	0.004	0.92	0.026	0.025	0.014	**5.74**
Unmet need	0.163	0.160	0.138	**3.28**	0.219	0.217	0.176	**7.05**

Notes: Bold denotes statistically significant differences between matched treatment and comparison groups at 5% significance.

$$y_{it} = \alpha_0 + \left(\sum_{t=-4}^{-2} \beta_t T_t + \sum_{t=0}^{7} \beta_t T_t\right) + \left(\sum_{t=-4}^{-2} \delta_t T_t S_i + \sum_{t=0}^{7} \delta_t T_t S_i\right) + W_{it} + \mu_i + \varepsilon_{it} \tag{1}$$

Where y_{it} is one of the outcomes of individual i in time t, T_t are the time indicators, S_i indicates if the individual belongs to the treatment ($S_i = 1$) or comparison group ($S_i = 0$), μ_i are individual fixed effects, W_{it} are survey wave indicators, α_0 is the constant term, and ε_{it} is the random error term. The omitted (reference) time period is the one before the health shock occurs, t_{-1}. So, $\beta_0$gives the average change in the likelihood of any ADL limitation, for example, between t_{-1} and t_0, for the comparison group; β_1 gives the change between t_{-1} and t_1, and so on. For the treatment group ($S_i = 1$), $\beta_0 + \delta_0$ gives the average change in the likelihood of any ADL limitation, for example, between t_{-1} (the wave before the shock) and t_0 (the wave immediately after), $\beta_1 + \delta_1$ gives the change between t_{-1} and t_1, and so on.

As we observe fewer and fewer individuals the further we get from the moment of the shock (Table 1), we limit the observation window to eight waves (sixteen years) after the health shock ($t_0$to t_7). We include four waves until the shock ($t_{-4}$to t_{-1}), to compare prior trends between individuals who eventually experience a health shock (i.e., treatment group) and individuals who never do (i.e., comparison group).

We use the model specified above to compute predicted likelihoods, $\hat{y}_{it}$, with 95% prediction intervals, for treatment and comparison groups separately. Then, we can plot the typical trajectory of individuals until and after they suffer the first-ever incidence of the health shock under consideration, or the trajectory of individuals who never suffer a shock. Those trajectories take into account differences between individuals that remain constant over time (captured by the individual fixed effects, μ_i), and contextual factors affecting all individuals in a given survey year (captured in the wave fixed effects, W_{it}). For example, gender, age at the time of the shock and, to a large extent, socioeconomic background or lifestyle are captured by the individual fixed effects and do not influence the estimated trajectories. The economic environment or current medical practice in a given survey year are accounted for by the wave fixed effects. The wave fixed effects also capture changes in sample composition due to the HRS design.

The estimated trajectories are, however, affected by individual-specific aspects that change over time, such as health (e.g., development of new comorbidities or incidence of other health shocks). For instance, having a stroke increases the risk of a second stroke or heart attack. That second health shock will affect disability and LTC utilization, but (part of) those effects can be attributed to the first-ever stroke. Our choice to estimate total rather than partial effects comes with the limitation that in the long run, the estimated trajectories may suffer from confounding (i.e., endogeneity). Nevertheless, in the short run, because we consider first-ever incidences of acute, unexpected, health events, include a comparison group, and control for individual heterogeneity via fixed effects, we believe the estimates reflect the causal impacts of the initial shock.

Results

Main results

Figure 2 shows the estimated trajectories in the likelihoods of any ADL limitation, nursing home living, (in/)formal home support, and unmet need, for individuals experiencing hip fracture, stroke, or heart attack, and their respective comparison groups, made of similar individuals who do not experience that type of shock. Three general observations are first, that the trajectories are positively sloped, reflecting increasing disability and LTC needs as individuals age. Second, individuals who experience acute events display worse trajectories in the aftermath than individuals in the comparison group. Note that up to t_{-1}, the trajectories of treatment and comparison individuals are statistically similar, which provides reassurance regarding the exogeneity of acute health events like these. Third, acute events mainly cause upward parallel shifts in the trajectories, suggesting permanent impacts of health shocks (no convergence with the trajectories of individuals who do not suffer acute events in the long run, with few exceptions).

Zooming in on the immediate impacts of health shocks, and *vis-à-vis* the comparison group (i.e., $\hat{\delta}_0$; Table A3 the Appendix), the first-ever hip fracture, stroke, or heart attack increases the likelihood of any ADL limitation by 19, 17, and 4 percentage points (pp), respectively, on average. The increases in the likelihood of living in a nursing home following hip fracture, stroke, or heart attack amount to 11, 7, and 2 pp. The increases in the likelihood of receiving long-term support at home (formal or informal) amount to 7, 9, and 3 pp, respectively. It is mostly informal caregivers that are stepping in (+4, 8, and 3 pp), with smaller changes in the likelihoods of formal home support (+4, 2, and 2 pp, respectively).

Regarding the overall trajectories and despite the previous general observations, there are important differences across outcomes and depending on the type of health shock considered. After the immediate impacts of hip fractures on disability and (in/)formal home support, the trajectories of hip fracture survivors eventually converge with those of individuals who do not experience this type of acute event. Only the impact on the likelihood of living in a nursing home is sustained in the long run, with the trajectories of the two

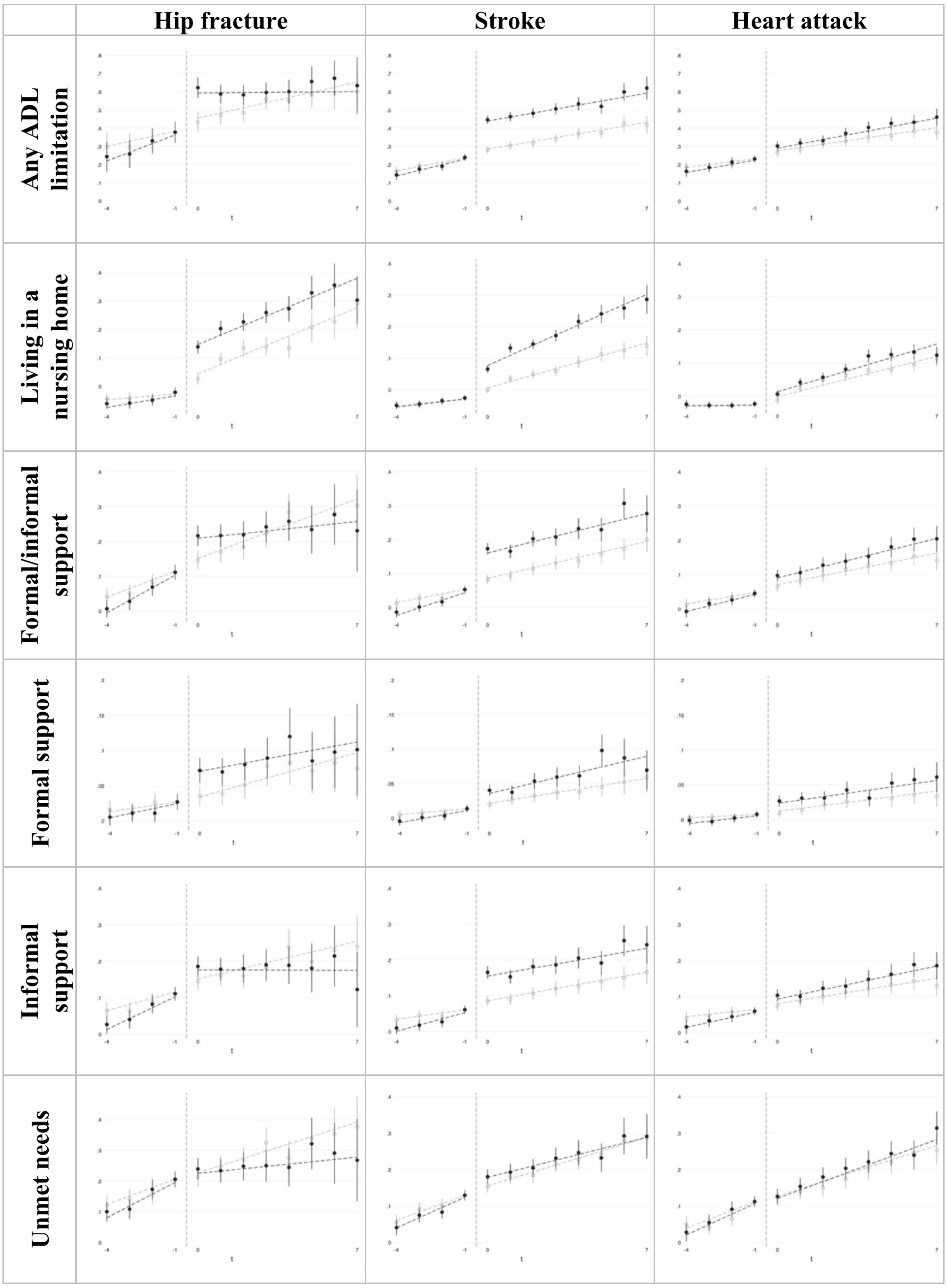

Figure 2. Estimated trajectories in the likelihoods of any ADL limitation, nursing home living, (in/) formal home support, and unmet need ($\hat{y}_{it}$) by type of health shock.

Notes: Predicted likelihoods with 95% prediction intervals, and pre/post-shock linear trends. Black: treatment group (people who experience their first-ever hip fracture, stroke, or heart attack between t_{-1} and t_0). Gray: comparison group (people who never experience the health shock considered). Standard errors are adjusted for multiple observations of the same individual, heteroskedasticity, and serial correlation.

groups remaining separate and parallel. Strokes cause not only an upward shift but also a steeper slope in the trajectories of nursing home living and formal home support.

Compared to the other outcomes, trajectories of unmet needs in the community (i.e., having any ADL limitation for which neither formal nor informal home support is received) behave distinctly in several regards. First, the trajectories of treatment and comparison individuals are statistically similar, for any type of shock. Second, the trajectories are not significantly altered by a health shock, except in the case of stroke (+3 pp). Third, the prevalence of unmet needs is meaningful, even in the comparison group and even before health shocks take place (at least 10%).

Sensitivity checks

The linear probability model was preferred for computational ease and because there isn't an obvious way to obtain predictions and their respective standard errors from a logit model with individual fixed effects. To isolate the effect of the choice of functional form, we compare the linear and logit models estimated without individual fixed effects. They give identical marginal effects for any time indicator T_t, any outcome, and any shock (available upon request).

We also consider a balanced panel including all individuals observed in time periods t_{-1} to t_3 (five time periods to ensure a reasonable number of observations, focusing on the post-shock period). In general, trajectories are attenuated in the balanced panel, although only significantly so in the cases of living in a nursing home (all shocks) and any ADL limitation (stroke). This is expected because the balanced panel does not include the individuals in worse health after the shock, as they do not survive for very long. Those in worse health are more often institutionalized after the shock, so the impacts of excluding them are unsurprisingly more visible when looking at the likelihood of living in a nursing home (please see Figure A1 in the Appendix).

Discussion

Using data from a large population-based survey, we show that health shocks such as hip fracture, stroke, and heart attack have severe implications for disability. In most cases of stroke and heart attack, it is informal caregivers that provide the daily support needed by survivors, in the short to medium run. Following hip fracture, nursing home care is more relevant than home support, in the short or long run. Although it is difficult to discern health shocks' severity in HRS data, this support mix is consistent with what we know about the consequences of the different health shocks and most available evidence on LTC preferences. In particular, we know that people generally prefer (informal) home-based support, but they prefer residential care when needs are extensive

(Guo et al., 2015; Lehnert et al., 2019; Wolff et al., 2008). Yet, we would benefit from more knowledge on the specific needs and preferences of individuals experiencing these kinds of acute health events.

Looking at the long run (up to sixteen years post-shock) is a key contribution of this study. By doing so and by documenting also the trajectories of individuals who do not experience acute health events, we show that health shocks generally put individuals in worse trajectories from which there is no recovery or convergence with individuals who do not suffer shocks. This stresses that preventing hip fractures, strokes, and heart attacks is critical. Furthermore, our results show that each shock has different implications in terms of disability, LTC utilization, and unmet need. Future research as well as policymaking must consider differentiating between acute events.

Importantly, we document meaningful levels of unmet needs, increasing throughout the entire observation window, with up to 20% of individuals reporting any unmet need even before suffering a health shock. Unmet needs are prevalent even among individuals who do not experience shocks. We need to make additional efforts to identify and address unmet needs. The formal interactions with the healthcare system that result from acute health events like these (i.e., hospitalization) can be leveraged to identify such cases – we can establish or improve mechanisms to follow individuals after their health shock and ensure that they get the support they need. This could require insurance redesign, not only in terms of LTC benefits, but also post-acute care ones, i.e., Medicare (with changes to public insurance potentially influencing changes in private health insurance). Enhanced post-acute care post-discharge could interrupt adverse health trajectories, and together with improved LTC benefits, could address unmet needs and prevent further acute events. To be viable, any such changes may require prioritization or targeting, for example of common and costly acute events like the ones we consider here. For this, more research may be needed that contemplates a wider range of health conditions and distinguishes between specific population groups. Further research is also needed to learn how the institutional/home-based support mix could better serve these populations, including before acute events take place (Bannenberg et al., 2021).

Limitations

The interval between two HRS waves is two years. Therefore, for some individuals observed in t_0 (the wave after the shock), the health shock is very recent, while for others, almost two years have passed, providing more time for adaptation. For this reason, the estimated short-run impacts of the health shocks on disability and LTC utilization may be underestimated. Assuming this larger time gap between the health shock and the first observation post-shock affects few individuals and has a limited impact, our short-run effects likely have a close-to-causal interpretation, as the health shocks considered are acute and unexpected. However, the longer run trajectories are likely to reflect other health changes besides the first-ever hip fracture, stroke, or heart attack. Moreover, our measure of nursing home care captures individuals living in a nursing home at the time of the survey. For a few individuals observed in t_0 who suffered their health shock recently, the nursing home stay may not be permanent (i.e., post-acute rather than LTC). This may cause an overestimation of the impacts of the health shocks on nursing home care, but only in t_0, and looking at the trajectories in nursing home care after t_0, this does not seem to be a concern. The two-year gap between waves also implies that we miss not only individuals who do not survive the shock, but also and importantly in our context, individuals who survive the shock but do not endure long enough to be observed again. Potentially, those individuals experienced significant disability impacts and used LTC before passing. This selection of the fittest may cause our impacts to be underestimated (in a similar fashion to the attenuated trajectories observed in the balanced panel). Overall, the low frequency of HRS likely implies that our estimated impacts of hip fractures, strokes, and heart attacks are conservative.

Conclusion

With upwards of 300,000 hip fractures, 600,000 first strokes, and 600,000 first heart attacks occurring annually in the US, these are common health shocks. This study relies on a large population-based survey to document the disability and LTC utilization trajectories of individuals who suffer such shocks and compare them with the trajectories of individuals who do not experience such acute events. Health care planners and policy makers may take this descriptive evidence to help design specific care strategies for survivors of these common shocks. Crucially, we follow individuals for up to sixteen years following the shocks, shedding light on their long run consequences for disability, which are substantial. This knowledge was missing and sets the ground for further research, for example on how these trajectories depend on key modifiable risk factors, or how they can be altered by policy or health care interventions. Our results can also be used as inputs for cost-of-illness studies interested in estimating the long run costs of hip fractures, strokes, and heart attacks.

Key points

- Causal, representative evidence of severe short run impacts of common health shocks
- Much worse long-run trajectories of disability, long-term care use, and unmet need
- Meaningful levels of unmet needs even before health shocks
- Need for insurance redesign addressing post-hospitalization care needs
- Preventive efforts could negate adverse trajectories and address unmet care needs

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Appendix

Table A1. Health status by ADL limitations and unmet need, after acute events.

	No ADL limitations	Any ADL limitation	t-statistic	No unmet need	Any unmet need	t-statistic
Hip fracture						
Mobility (0–5)	1.43	3.81	**47.25**	2.65	3.54	**12.69**
Large muscle (0–4)	1.52	2.75	**30.74**	2.11	2.72	**12.32**
Activities of daily living (0–5)	0.00	2.89	**67.87**	1.60	2.18	**8.32**
Gross motor skills (0–4)	0.42	3.30	**61.98**	2.01	2.67	**8.91**
Fine motor skills (0–3)	0.07	1.35	**44.55**	0.79	1.03	**6.02**
Instrumental activities of daily living (0–5)	0.36	2.56	**41.29**	1.76	1.56	**−2.67**
CES-D depression scale (0–8)	1.53	2.86	**16.05**	1.90	2.84	**10.30**
Mental status (0–15)	11.88	10.46	**−10.82**	11.15	11.19	0.29
Cognition score (0–35)	19.57	16.78	**−11.83**	18.20	18.07	−0.51
Health conditions (0–8)	2.58	3.28	**13.15**	2.95	3.16	**3.49**
Stroke						
Mobility (0–5)	1.27	3.67	**81.06**	2.15	3.44	**30.28**
Large muscle (0–4)	1.39	2.81	**59.16**	1.86	2.85	**32.40**
Activities of daily living (0–5)	0.00	2.72	**119.34**	1.09	2.16	**26.98**
Gross motor skills (0–4)	0.37	3.06	**103.53**	1.44	2.60	**27.24**
Fine motor skills (0–3)	0.08	1.39	**83.15**	0.62	1.12	**21.41**
Instrumental activities of daily living (0–5)	0.36	2.38	**68.45**	1.32	1.54	**5.54**
CES-D depression scale (0–8)	1.54	3.11	**31.82**	1.82	3.16	**24.22**
Mental status (0–15)	12.05	10.52	**−18.64**	11.54	11.03	**−5.43**
Cognition score (0–35)	20.13	17.15	**−19.71**	19.18	18.03	**−6.76**
Health conditions (0–8)	3.66	4.32	**23.82**	3.88	4.32	**13.30**
Heart attack						
Mobility (0–5)	1.24	3.54	**76.97**	1.63	3.42	**44.91**
Large muscle (0–4)	1.31	2.84	**59.91**	1.54	2.85	**41.19**
Activities of daily living (0–5)	0.00	2.28	**124.14**	0.44	1.98	**51.07**
Gross motor skills (0–4)	0.35	2.77	**106.43**	0.80	2.52	**49.65**
Fine motor skills (0–3)	0.06	1.14	**85.62**	0.27	1.01	**41.84**
Instrumental activities of daily living (0–5)	0.21	1.81	**65.18**	0.60	1.29	**20.90**
CES-D depression scale (0–8)	1.55	3.32	**35.59**	1.73	3.33	**28.54**
Mental status (0–15)	12.55	11.08	**−19.41**	12.32	11.35	**−11.56**
Cognition score (0–35)	21.07	18.08	**−20.55**	20.61	18.64	**−12.05**
Health conditions (0–8)	3.18	4.21	**36.31**	3.37	4.12	**22.21**

Notes: Only observations in the treatment group (pre-matching) after the shock. Bold denotes statistically significant differences at the 1% level. In parentheses are the theoretical minimum and maximum values. With the exceptions of mental status and cognition score, higher values denote poorer health. For details on the indices, see RAND HRS Longitudinal File 2018 (V1) Documentation.

Table A2. Summary statistics for the matching variables.

	Hip fracture		Stroke		Heart attack	
	Pre-matching	Matched	Pre-matching	Matched	Pre-matching	Matched
Age	78.91	78.53	72.14	72.10	68.28	68.18
Female	0.743	0.745	0.562	0.571	0.463	0.472
Race/ethnicity						
White	0.789	0.818	0.705	0.747	0.740	0.778
Black	0.113	0.106	0.192	0.171	0.148	0.141
Hispanic	0.087	0.069	0.084	0.069	0.090	0.070
Other	0.011	0.007	0.018	0.012	0.022	0.010
Any mobility limitation	0.732	0.738	0.643	0.647	0.616	0.611
Any health condition	0.925	0.941	0.919	0.934	0.907	0.916
Ever smoked	0.524	0.519	0.613	0.618	0.687	0.687
BMI ≥25	0.443	0.456	0.631	0.647	0.682	0.692
Any health insurance	0.979	0.983	0.946	0.957	0.928	0.943
Observed in $t = 0$	1.000	1.000	1.000	1.000	1.000	1.000
Observed in $t = 1$	0.849	0.857	0.848	0.854	0.908	0.924
Observed in $t = 2$	0.553	0.551	0.597	0.612	0.717	0.737
Observed in $t = 3$	0.355	0.359	0.434	0.451	0.585	0.608
# observations	1,341	**1,215**	3,228	**2,849**	2,410	**2,171**

Notes: Measured in *t*-1. Given that coarsened exact matching was performed, the summary statistics for the comparison group are identical to those for the matched treatment group.

Table A3. Results of the event studies (estimated coefficients $\hat{\beta}_t$ and $\hat{\delta}_t$).

	Any ADL limitation	Living in a nursing home	Any formal/informal support	Any informal support	Any formal support	Unmet need
Hip fracture						
Comparison group (*t*=)						
−4	−0.080***	0.221***	−0.123***	−0.080*	−0.026	−0.135**
	(0.019)	(0.038)	(0.047)	(0.044)	(0.032)	(0.059)
−3	−0.080***	0.142***	−0.095***	−0.069**	−0.024	−0.096**
	(0.017)	(0.026)	(0.032)	(0.030)	(0.021)	(0.041)
−2	−0.054***	0.058***	−0.046**	−0.033*	−0.006	−0.066***
	(0.014)	(0.014)	(0.018)	(0.017)	(0.012)	(0.024)
−1 (ref.)						
0	0.057***	−0.034***	0.052***	0.045***	0.013	0.024
	(0.014)	(0.013)	(0.017)	(0.017)	(0.011)	(0.023)
1	0.094***	−0.044*	0.093***	0.072**	0.022	0.073*
	(0.019)	(0.026)	(0.032)	(0.030)	(0.021)	(0.040)
2	0.108***	−0.088**	0.124***	0.082*	0.040	0.113*
	(0.023)	(0.038)	(0.047)	(0.044)	(0.032)	(0.058)
3	0.181***	−0.164***	0.181***	0.117**	0.072	0.185**
	(0.030)	(0.050)	(0.064)	(0.059)	(0.044)	(0.078)
4	0.173***	−0.248***	0.260***	0.184**	0.081	0.152
	(0.036)	(0.061)	(0.080)	(0.075)	(0.054)	(0.097)
5	0.206***	−0.258***	0.236**	0.155*	0.075	0.232**
	(0.042)	(0.076)	(0.093)	(0.088)	(0.062)	(0.116)
6	0.216***	−0.318***	0.292***	0.199*	0.092	0.264*
	(0.054)	(0.089)	(0.110)	(0.103)	(0.073)	(0.137)
7	0.224***	−0.336***	0.332***	0.220*	0.089	0.304*
	(0.062)	(0.105)	(0.124)	(0.116)	(0.083)	(0.156)
Treatment group (*t*=)						
−4	−0.054**	−0.017	−0.034**	−0.038**	−0.011	−0.020
	(0.023)	(0.011)	(0.016)	(0.016)	(0.008)	(0.022)
−3	−0.040*	−0.018*	−0.023	−0.025	−0.003	−0.034
	(0.021)	(0.011)	(0.016)	(0.016)	(0.007)	(0.021)
−2	0.007	−0.005	−0.014	−0.007	−0.015**	0.016
	(0.020)	(0.009)	(0.015)	(0.015)	(0.007)	(0.020)
−1 (ref.)						
0	0.189***	0.113***	0.070***	0.041**	0.036***	0.026
	(0.020)	(0.013)	(0.017)	(0.017)	(0.010)	(0.021)
1	0.117***	0.107***	0.047**	0.018	0.031***	−0.012
	(0.025)	(0.017)	(0.021)	(0.020)	(0.011)	(0.025)
2	0.097***	0.092***	0.036	0.020	0.029**	−0.021
	(0.030)	(0.021)	(0.025)	(0.024)	(0.014)	(0.029)
3	0.038	0.120***	0.019	0.007	0.011	−0.075**
	(0.036)	(0.026)	(0.030)	(0.029)	(0.019)	(0.036)
4	0.051	0.137***	−0.027	−0.050	0.037	−0.031
	(0.043)	(0.029)	(0.038)	(0.035)	(0.025)	(0.040)
5	0.073	0.121***	−0.009	−0.018	0.014	−0.017
	(0.056)	(0.040)	(0.045)	(0.043)	(0.026)	(0.053)
6	0.081	0.128**	−0.004	−0.017	0.015	−0.063
	(0.067)	(0.051)	(0.057)	(0.054)	(0.033)	(0.065)
7	0.032	0.012	−0.073	−0.118*	0.027	−0.109
	(0.094)	(0.062)	(0.075)	(0.067)	(0.040)	(0.084)
N	14,992	15,571	14,903	14,194	14,194	14,950
Stroke						
Comparison group (*t*=)						
−4	−0.077***	0.149***	0.029	0.039	−0.000	−0.092***
	(0.010)	(0.018)	(0.027)	(0.026)	(0.015)	(0.034)
−3	−0.047***	0.091***	0.022	0.029	−0.001	−0.049**
	(0.009)	(0.013)	(0.019)	(0.018)	(0.010)	(0.023)
−2	−0.046***	0.044***	−0.002	0.005	−0.003	−0.033**
	(0.008)	(0.007)	(0.010)	(0.010)	(0.006)	(0.014)

(*Continued*)

Table A3. (Continued).

	Any ADL limitation	Living in a nursing home	Any formal/informal support	Any informal support	Any formal support	Unmet need
−1 (ref.)						
0	0.042***	−0.032***	0.007	0.002	0.003	0.030**
	(0.008)	(0.006)	(0.010)	(0.010)	(0.005)	(0.013)
1	0.065***	−0.051***	−0.007	−0.017	0.007	0.064***
	(0.010)	(0.012)	(0.018)	(0.017)	(0.010)	(0.023)
2	0.078***	−0.094***	−0.010	−0.023	0.010	0.073**
	(0.011)	(0.018)	(0.026)	(0.026)	(0.015)	(0.033)
3	0.103***	−0.140***	−0.016	−0.032	0.012	0.112**
	(0.013)	(0.023)	(0.035)	(0.034)	(0.019)	(0.044)
4	0.131***	−0.168***	−0.033	−0.048	0.009	0.127**
	(0.015)	(0.029)	(0.043)	(0.042)	(0.024)	(0.054)
5	0.135***	−0.200***	−0.036	−0.058	0.014	0.148**
	(0.018)	(0.036)	(0.052)	(0.051)	(0.029)	(0.065)
6	0.187***	−0.244***	−0.045	−0.071	0.018	0.193**
	(0.022)	(0.041)	(0.061)	(0.059)	(0.034)	(0.076)
7	0.178***	−0.286***	−0.041	−0.077	0.022	0.206**
	(0.025)	(0.047)	(0.069)	(0.068)	(0.039)	(0.086)
Treatment group (*t*=)						
−4	−0.019	−0.004	−0.026**	−0.022**	−0.009*	−0.015
	(0.014)	(0.007)	(0.010)	(0.011)	(0.005)	(0.014)
−3	−0.017	0.002	−0.026***	−0.027***	−0.006	−0.018
	(0.013)	(0.006)	(0.009)	(0.010)	(0.004)	(0.013)
−2	−0.003	0.004	−0.010	−0.016*	−0.005	−0.019
	(0.012)	(0.005)	(0.009)	(0.009)	(0.004)	(0.012)
−1 (ref.)						
0	0.165***	0.067***	0.090***	0.080***	0.020***	0.026**
	(0.012)	(0.007)	(0.010)	(0.010)	(0.005)	(0.013)
1	0.159***	0.097***	0.073***	0.063***	0.011*	0.011
	(0.015)	(0.010)	(0.012)	(0.012)	(0.006)	(0.015)
2	0.164***	0.096***	0.089***	0.075***	0.021***	0.020
	(0.017)	(0.011)	(0.014)	(0.014)	(0.007)	(0.016)
3	0.164***	0.112***	0.077***	0.066***	0.022**	0.013
	(0.020)	(0.013)	(0.016)	(0.016)	(0.009)	(0.020)
4	0.163***	0.128***	0.095***	0.078***	0.024**	0.019
	(0.023)	(0.016)	(0.019)	(0.019)	(0.010)	(0.022)
5	0.145***	0.128***	0.071***	0.051**	0.053***	−0.010
	(0.027)	(0.020)	(0.022)	(0.022)	(0.014)	(0.025)
6	0.173***	0.135***	0.135***	0.104***	0.035**	0.011
	(0.032)	(0.023)	(0.028)	(0.027)	(0.016)	(0.031)
7	0.203***	0.147***	0.077**	0.076**	0.010	0.003
	(0.040)	(0.028)	(0.033)	(0.031)	(0.018)	(0.037)
N	36,772	36,948	35,965	34,232	34,232	36,155
Heart attack						
Comparison group (*t*=)						
−4	−0.043***	0.120***	0.019	0.030	0.004	−0.028
	(0.013)	(0.021)	(0.035)	(0.035)	(0.019)	(0.046)
−3	−0.046***	0.078***	0.011	0.021	0.002	−0.045
	(0.011)	(0.015)	(0.024)	(0.024)	(0.013)	(0.031)
	−0.031***	0.037***	0.007	0.015	−0.004	−0.036**
	(0.009)	(0.008)	(0.013)	(0.014)	(0.007)	(0.017)
−1 (ref.)						
0	0.036***	−0.029***	0.003	−0.001	−0.002	−0.002
	(0.009)	(0.008)	(0.013)	(0.013)	(0.006)	(0.017)
1	0.052***	−0.033**	0.001	−0.005	0.000	0.005
	(0.010)	(0.014)	(0.023)	(0.023)	(0.012)	(0.030)
2	0.084***	−0.047**	0.002	−0.009	0.005	0.003
	(0.012)	(0.021)	(0.034)	(0.034)	(0.019)	(0.045)
3	0.098***	−0.075***	0.002	−0.013	0.007	0.014

(*Continued*)

Table A3. (Continued).

	Any ADL limitation	Living in a nursing home	Any formal/informal support	Any informal support	Any formal support	Unmet need
	(0.014)	(0.027)	(0.045)	(0.046)	(0.025)	(0.059)
4	0.121***	−0.098***	−0.005	−0.021	0.007	0.032
	(0.015)	(0.034)	(0.057)	(0.057)	(0.031)	(0.074)
5	0.128***	−0.136***	−0.014	−0.027	0.004	0.038
	(0.016)	(0.041)	(0.068)	(0.068)	(0.037)	(0.088)
6	0.152***	−0.161***	−0.010	−0.031	0.007	0.052
	(0.019)	(0.048)	(0.079)	(0.080)	(0.043)	(0.103)
7	0.146***	−0.183***	−0.041	−0.061	0.001	0.047
	(0.021)	(0.054)	(0.090)	(0.090)	(0.049)	(0.118)
Treatment group (*t*=)						
−4	−0.025	−0.001	−0.020	−0.024*	−0.004	−0.022
	(0.018)	(0.008)	(0.012)	(0.014)	(0.004)	(0.018)
−3	−0.001	−0.003	−0.007	−0.014	−0.006	0.011
	(0.016)	(0.007)	(0.011)	(0.012)	(0.004)	(0.016)
−2	0.014	−0.002	−0.009	−0.014	0.002	0.026*
	(0.014)	(0.005)	(0.010)	(0.011)	(0.004)	(0.014)
−1 (ref.)						
0	0.036***	0.019***	0.032***	0.028***	0.018***	0.004
	(0.013)	(0.006)	(0.010)	(0.010)	(0.004)	(0.014)
1	0.036**	0.018**	0.025**	0.013	0.017***	0.013
	(0.015)	(0.008)	(0.012)	(0.012)	(0.005)	(0.015)
2	0.018	0.007	0.030**	0.024*	0.009	0.029*
	(0.017)	(0.010)	(0.013)	(0.013)	(0.006)	(0.017)
3	0.043**	0.019*	0.023*	0.016	0.016**	0.030*
	(0.019)	(0.012)	(0.014)	(0.014)	(0.007)	(0.018)
4	0.052**	0.043***	0.028*	0.027*	0.001	0.018
	(0.020)	(0.014)	(0.016)	(0.016)	(0.007)	(0.019)
5	0.068***	0.044***	0.047***	0.030*	0.022**	0.023
	(0.022)	(0.015)	(0.017)	(0.017)	(0.009)	(0.021)
6	0.050*	0.037**	0.049**	0.045**	0.022**	−0.007
	(0.026)	(0.017)	(0.021)	(0.021)	(0.011)	(0.025)
7	0.084***	0.010	0.064***	0.055**	0.028**	0.061**
	(0.030)	(0.019)	(0.022)	(0.022)	(0.012)	(0.029)
N	30,663	29,731	29,544	27,569	27,569	29,730

Notes: **p* < .1, ***p* < .05, ****p* < .01. Standard errors are adjusted for multiple observations of the same individual, heteroskedasticity, and serial correlation

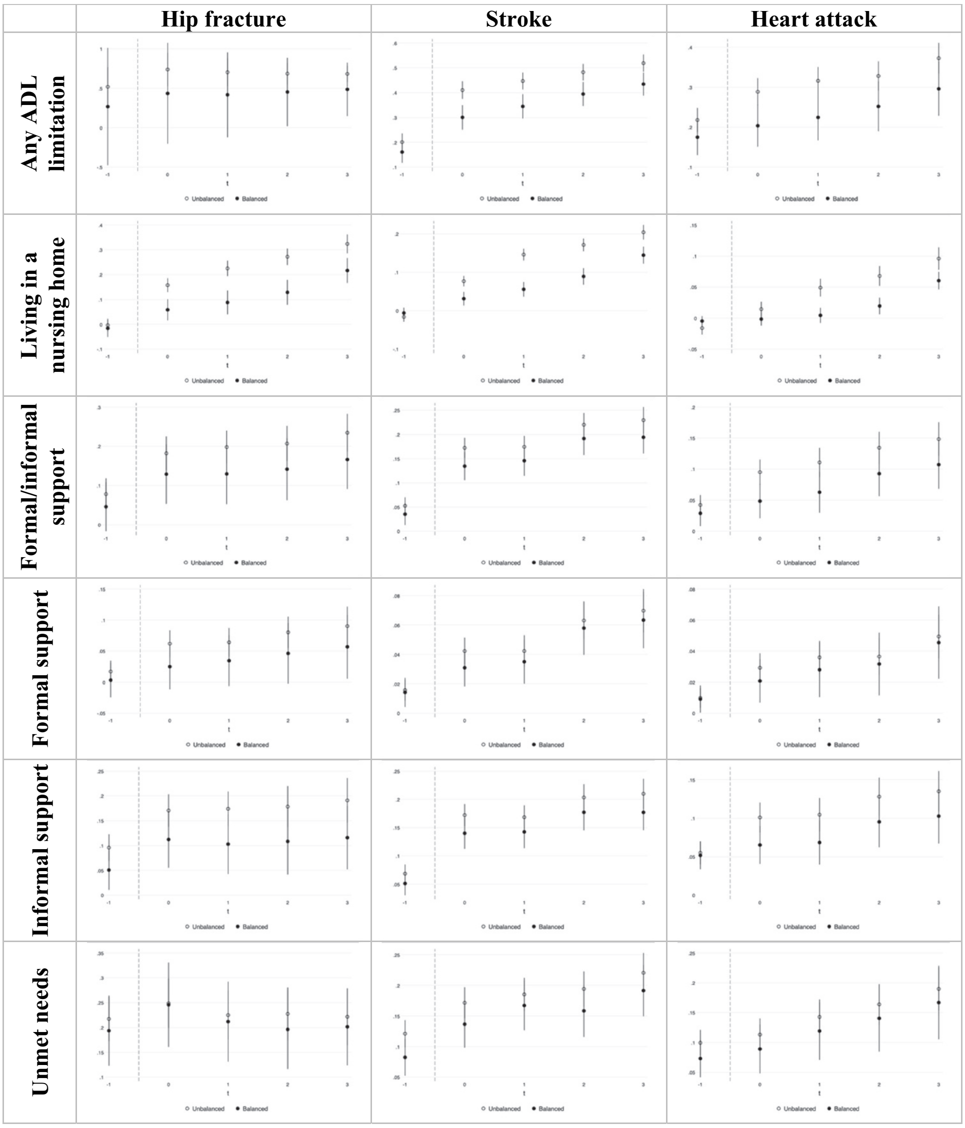

Figure A1. Sensitivity check: balanced panel.

Note: Comparison groups not shown, to facilitate visualization. Predicted likelihoods with 95% prediction intervals. Standard errors are adjusted for multiple observations of the same individual, heteroskedasticity, and serial correlation.