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Activities of Daily Living (ADL) Trajectories Surrounding Acute Hospitalization of Long-stay Nursing Home Residents

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Abstract

OBJECTIVES—To explore patterns of change in nursing home residents' activities of daily living (ADLs), particularly surrounding acute hospital stays.

DESIGN—Longitudinal study using Medicare and Minimum Data Set (MDS) assessments

SETTING—National sample of long-stay nursing home residents

PARTICIPANTS—We identified 40,128 residents who were hospitalized for the seven most common inpatient diagnoses. Each hospital admission was at least 90 days after any prior hospitalization and had at least two preceding MDS assessments.

MEASUREMENTS—We represented residents' ADL function with the MDS ADL-Long form score, a simple sum of seven self-care variables coded from 0 (independent) to 4 (totally dependent). Scores ranged from 0 to 28; higher scores indicated greater impairment. We jointly estimated a linear mixed model describing ADL trajectories with mortality and hospital readmission.

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RESULTS—Before hospitalization, the most common trajectory represented stability (53.7%), with 27.5% of residents worsening and 18.8% improving. ADL function after hospital discharge was most often characterized by stability (43.1%) or worsening (39.2%). Mortality (20.3%) was higher for those with worsening pre-hospital ADL function (28.9%) compared to those with stable (19.1%) or improving (11.3%) trajectories. Hospital diagnosis was associated with both the amount of ADL worsening and the rate of subsequent ADL change. Most residents with the best initial function continued to worsen after hospital discharge. Cognitive impairment was associated with poorer ADL function and accelerated worsening of ADLs.

CONCLUSION—For many long-stay nursing home residents acute hospitalization is accompanied by substantial and sustained ADL worsening. Thus, acute hospitalization presents an opportunity to revisit care goals; our results can help inform decision-making.

Keywords

nursing homes; activities of daily living; hospitalization; Minimum Data Set

INTRODUCTION

Independence in Activities of Daily Living (ADLs)—basic personal care activities such as dressing, eating, and moving about—is positively associated with quality of life.[1,2] Conversely, ADL impairments are strongly associated with poorer physical health,[3] hospital admission,[4,5] increased cost,[6] and death.[3,4,7–11] Thus, a resident's ADL status and likely pattern of change over time, or trajectory, are important considerations for determining care priorities. Because hospitalization is often associated with at least a transient decline in ADL,[12–18] residents' pre-hospital ADL trajectories may act as "vital signs" that help determine appropriate care plans both in the hospital and following discharge.[19]

Many nursing home residents are long-stay residents with low potential for returning home;[20,21] their care needs and ADL status will likely change over time. Over six months, 15 to 25 percent of long-stay residents may be hospitalized.[22–24] Residents' medical conditions can contribute to ADL decline,[5,25] as might complications associated with hospitalization due to prolonged immobilization, iatrogenic problems, sensory deprivation, and decreased nutritional intake.[12,13] Hospitalization can result in pressure sores, infections, and delirium,[12,15,26,27] and may increase the risk of subsequent cognitive and functional decline.[17]

For some, hospitalization marks a very poor prognosis. For example, individuals with severe dementia who are hospitalized for pneumonia or a hip fracture have very high 6-month mortality.[28] For others, return from the hospital might suggest physical therapy and rehabilitation. Despite the potential value of ADL trajectories, relatively few studies have explored ADL change in nursing home residents, particularly as they are influenced by hospitalization.[29,30]

Most previous research has considered change in ADL between two fixed time points (e.g., baseline and 90 days), often dichotomizing change as declined or not.[15,16,31–33] Depending on the span between time points and whether they encompass an acute event, substantial ADL changes could be missed. Although several studies report an association between ADL decline and hospitalization, most used such a before-and-after comparison. It is unclear whether residents' ADL function was declining prior to hospitalization, and how much recovery, if any, followed hospital discharge. Moreover, existing information provides little insight into the functional prognosis of residents returning to a nursing home following hospitalization.

Kurella Tamura and colleagues examined ADL trajectories of nursing home residents before and after initiating dialysis.[34] Pre-dialysis ADL scores were characterized by a slight worsening. In the three months following dialysis initiation, median ADL scores for survivors worsened; only 13% of residents maintained their pre-dialysis function. A random-effects model showed accelerating ADL decline surrounding dialysis initiation, followed by stabilization between months 1 and 4 and continued worsening after month 4. We aimed to use a similar approach in a broader sample of nursing home residents.

To better understand the ADL trajectories of residents who returned to a nursing home after a hospitalization, we examined ADL trajectories of long-stay nursing home residents before and after acute hospitalization to determine the effect of pre-hospital ADL trajectories on post-hospital outcomes, and to determine how resident characteristics and diagnosis influence this relationship. We hypothesized residents with worsening ADL trajectories before hospital admission would be more likely to die or exhibit worsening ADL trajectories following hospitalization than those with stable or improving trajectories. We further hypothesized that residents with good ADL function prior to hospitalization would return to their pre-hospital level more rapidly following hospital discharge than residents with poorer baseline function.

METHODS

Analytic Cohort

We obtained Minimum Data Set (MDS) assessments and Medicare inpatient records from the Centers for Medicare and Medicaid Services to assemble a cohort of long-stay residents who had an acute hospitalization (Figure 1). We excluded residents less than 67 years of age as of January 1, 2006; residents with any health maintenance organization membership during 2006–2007 (because health maintenance organizations do not report hospital data); residents not appearing in the beneficiary summary files for 2006–2007; residents with date discrepancies (e.g., multiple dates of death); residents lacking Part A coverage for either year; and residents with more than 15 acute hospitalizations in 2006 and 2007.

We included each resident’s first stay in an acute care hospital of 30 or fewer days in length and having at least two preceding MDS assessments with ADL data, one of which was within the 30 days preceding hospitalization to help define the trajectory before hospitalization. Because hospitalization is associated with substantial ADL change, we only included hospital stays that were 90 days or more from any prior stay to minimize the effect of the prior hospital stay. To allow for six months of MDS assessments before and after hospitalization, we included stays with admission date on or after July 1, 2006 discharged before July 1, 2007. Because our focus was on post-hospital outcomes, we excluded residents who died in the hospital. We additionally required that residents reside in one facility for all included assessments.

We included all of a resident’s MDS assessments during the six months before and after hospitalization except those occurring before a preceding hospital stay or following a subsequent stay. MDS assessments typically occur quarterly with at least one full (more detailed) assessment occurring annually. Additional assessments may occur when a resident has a substantial change in condition or receives Medicare-paid skilled nursing care; timing and number of post-hospital assessments differ by state. The longitudinal ADL record for each resident was terminated at 180 days of follow-up or at time of death or hospital readmission if either event occurred within the 180-day window. We also excluded multiple MDS assessments from the same day, assessments with target dates before 2006, and “impossible” assessments dated in the middle of long hospital stays. We excluded hospital stays when a subsequent stay occurred within 1 day of discharge.

The multi-level Clinical Classification Software (available at http://www.hcup-us.ahrq.gov/toolssoftware/ccs/ccs.jsp) was used to group primary hospital diagnoses into categories. Because we wanted to compare the effects of specific hospital diagnoses on post-hospital ADL trajectories, we included residents with the seven most common hospital diagnoses – pneumonia, septicemia, congestive heart failure, hip fracture, renal failure, stroke, and urinary tract infection. These diagnoses accounted for 51.6% of the sample and included both chronic and acute conditions, common infections, and conditions often associated with rehabilitation. As additional diagnoses occur in diminishing frequency while adding to model complexity, we excluded them.

Outcome Variable

ADL function was measured using the MDS ADL-Long form score,[35] a simple sum of seven self-care variables (bed mobility, self-transfer, locomotion on unit, dressing, eating, toileting and personal hygiene) from section G of MDS 2.0. The weighted kappas for the 7 component activities were above 0.75, indicating excellent reliability.[35] Internal consistency of the scale is also high (alpha = 0.94).[35] Item scores varied from 0=independence to 4=total dependence. Item scores of 8 (activity did not occur during the entire week), were recoded to 4 prior to summing. The total score ranged from 0 to 28, with 0 indicating complete independence and 28 indicating complete dependence in all 7 activities.

We defined deteriorating ADL function as a gain of 3 or more points per year; conversely, losing 3 or more points per year delineated improvement.[16] Change of three points or more represents a substantial change in assistance, denoting an increase or decrease in the need for cueing or supervision of three ADL activities or the addition or loss of physical assistance for one activity. We calculated the Cognitive Performance Scale (CPS) score at the time of the first MDS assessment.[36] The CPS is a 0–6 scale where 0 indicates intact cognition and 6 represents severe impairment.

Resident Characteristics

MDS records and beneficiary summary files were used to determine residents' demographic characteristics. When sources disagreed, the beneficiary summary file prevailed. The earliest date a diagnosis was assigned to a resident was derived by combining data from Medicare claims, MDS assessments, and the Chronic Condition Warehouse data furnished by the Centers for Medicare and Medicaid Services. This date of earliest diagnosis was used to determine diagnoses present at the time of hospital admission, which we used to calculate the Charlson Index.[43]

Statistical Analysis

All analyses were performed in SAS v9.3 (SAS Institute Inc., Cary, NC). Our overall strategy was to determine how ADL trajectory was modified by hospital diagnosis and length of stay. Because MDS assessments are typically performed on a quarterly basis, we measured time in fractions of quarters before hospital admission or following discharge, with baseline covariates measured at the earliest included pre-hospital assessment. We modeled ADL trajectories using a linear mixed-effects model. Separate covariance structures allowed the person-specific random slopes and intercepts to vary over pre- and post-hospital periods.

Loss to follow-up due to death or hospital readmission is a significant feature of this cohort. Death and readmission represent potentially non-random selection mechanisms limiting the estimation of trajectories to "healthy survivors."[37] Simultaneously modeling the longitudinal outcome (ADL) and the time to drop-out can limit the biasing effects of non-random drop out.[38,39] We therefore jointly modeled ADL trajectory, survival time, and time to readmission.[40] Death and readmission were each modeled with a separate log-normal regression. The event-time models shared a subject-specific intercept and slope for post-hospital ADL. Model fitting was done with the NLMIXED procedure. A more detailed description of the model appears in the Appendix. Parameter estimates were used to determine expected trajectories for groups of patients with specific characteristics.

Prior research has found associations between ADL change and baseline ADL function,[15,16,41] prior ADL loss,[19] cognition,[14,41,42] and acute illness indicators.[15,16] We balanced our desire to include important covariates with their availability on quarterly MDS forms and an overall strategy of model parsimony. To explore the effects of good, moderately impaired, and severely impaired baseline ADL function, we divided residents' initial ADL scores into three categories (0–4, 5–23, 24–28). Resident's initial ADL category, age, gender, Charlson Comorbidity Index[43] (based on pre-hospital diagnoses), and baseline CPS[36] were included as covariates during both pre- and post-hospital time periods. Primary hospital diagnosis and length of stay were included as covariates only during the post-hospital time period. We interacted initial ADL category, CPS, length of stay, and primary hospital diagnosis with time to determine their effect on the rate of change in ADL score. The ADL and CPS interactions were included across both time periods, while hospital diagnosis and length of stay interacted with time following hospital discharge.

To evaluate the effects of pre-hospital slope on post-hospital outcomes, we characterized residents' person-specific predicted slopes as worsening, stable or improving. Chi-square analysis was used to determine whether pre-hospital slope was associated with 30-day mortality or readmission.

RESULTS

Of an initial cohort of slightly over 2 million long-stay residents we identified 97,880 residents meeting initial selection criteria (Figure 1). Of these, we excluded 47,390 (48.4%) residents who were not hospitalized for one of the included diagnoses, 5883 (6.0%) who died in the hospital, and 4019 (4.1%) assessed in multiple facilities. We also excluded 126 residents (0.1%) who lacked any follow-up data and 334 residents (0.3%) with erratic and seemingly implausible ADL patterns, leaving 40,128 (41.0%) long-stay residents who survived hospitalization.

Most (70.5%) residents were women, 51.5% were age 85 years or older, 84.6% were White and 10.9% were Black (Table 1). Demographic characteristics were similar to those of the initial sample of 2,050,461 long-stay residents, in which 71.3% were women, 85.0% were White and 9.9% were Black. A smaller proportion of all long-stay residents (45.8%) were age 85 years or older. Residents least impaired at baseline (ADL score <5) were most likely to have no or mild cognitive impairment (70.9%), while those with severely impaired ADL function usually had moderately impaired (41.6%) or severely impaired (46.8%) cognition. Median number of MDS assessments both before and after hospitalization was 2 (mean = 2.8 pre-hospital and 2.5 post-hospital).

Using person-specific predicted slopes, the most common pre-hospital ADL trajectory represented stability (53.7%); 27.5% of residents had a worsening trajectory and 18.8% were improving. Pre-hospital ADL trajectory was associated with baseline ADL score. Residents with the best pre-hospital ADL score had the highest proportion of worsening trajectories (61.4%) compared to those who were moderately (31.1%) or severely impaired (2.4%).

The most common comorbidities before hospital admission included diabetes (38.7%), congestive heart failure (32.6%) and chronic obstructive pulmonary disease (31.2%). Most residents (60.4%) had a Charlson Index[43] of 2 or higher. Hospital admission was usually due to infection, most commonly pneumonia (33.5%), septicemia (17.0%) and urinary tract infections (15.4%). Compared to residents with low to intermediate baseline ADLs, infections were more prevalent among residents with severely impaired baseline ADL function. Conversely, congestive heart failure, hip fracture, renal failure and stroke were relatively more common among residents with less ADL impairment.

Mortality (20.3%) and readmission (19.6%) were common in the 30 days following hospital discharge (Table 2). Using person-specific predicted ADL slopes, mortality was higher for those with worsening pre-hospital function (28.9%) compared to those with stable (19.1%) or improving (11.3%) ADLs ($P<.0001$). Readmission varied less, affecting 18.5% of residents with worsening pre-hospital ADL function and approximately 20% of residents who were improving or stable before hospitalization ($P = .0014$). Following hospital discharge, stable trajectories were the most common (43.1%), followed by worsening (39.2%) and improving (17.7%) trajectories.

Parameter estimates for the mixed model are shown in Table 3a. “Factors that affect ADL level” are the main effect estimates that represent the change in ADL score associated with that variable (intercepts). “Factors that affect the rate of change” are estimates of a variable’s interactions with time (slopes). Several factors were associated with ADL score, including female gender and CPS. Both pre- and post-hospital, each point increase in CPS was associated with an ADL score that was .94 points worse. CPS was also associated with the rate of ADL change; for each point increase in CPS, ADL score worsened .24 points per quarter, or .96 points per year. High or low baseline ADL scores were also associated with the rate of change in ADL. The overall mean ADL score improved at the rate of −.41 point per quarter (−1.6 points per year). In addition to the overall mean, good initial ADL function was associated with a 1.39-point worsening in ADL score per quarter, while poor baseline function was associated with a −1.09 point change (improvement) per quarter. Given the other variables in the model, age did not appear to be importantly associated with ADL score ($P = .86$).

Primary hospital diagnosis and length of stay were associated with both a change in post-hospital ADL score and a change in the rate of post-hospital ADL recovery. On average, hip fracture added 7.65 points to the ADL score, followed by stroke (6.53), renal failure (3.41), septicemia (2.97), urinary tract infection (2.75), pneumonia (2.74), and congestive heart failure (2.64). Only hip fracture was associated with ADL improvement following hospital discharge (−1.39 points per quarter). The remaining diagnoses were associated with worsening post-hospital ADLs.

The combined effects of diagnosis and baseline ADL on resident ADL trajectories are only possible to present on particular resident populations due to the interaction terms in the model. Figure 2 present the expected ADL trajectories based on the model presented in Table 3 for residents with two diagnoses, hip fracture and pneumonia. Residents with modal characteristics were used for the illustration: age > 85, female, moderate baseline ADL impairment, moderate cognitive impairment (CPS=3), Charlson Index=2, and a 5-day hospital stay. The y-axis has been reversed so that worsening scores visually appear to decline. In the pre-hospital period, ADL function worsens slowly. Because the hospital diagnosis is not present during the pre-hospital period, the pre-hospital trajectories are identical for both diagnoses. Surrounding the acute hospitalization, ADL function worsens precipitously, with the amount of change equal to the diagnosis-specific intercepts in Table 3a. The effect of this substantial change in ADL score over a short period in time is a trajectory that appears discontinuous. For example, hip fracture is associated with a 7.65-point change and pneumonia, 2.74 points. Following hospital discharge, residents who had a hip fracture improve, while residents who were hospitalized for pneumonia (and the other diagnoses) continue to worsen. Because each additional point on the CPS scale both shifts the ADL score upward and increases the slope of the trajectory, compared with residents with good cognition, residents with poor cognition have poorer ADL function at all times as well as relatively worsening function over time (not illustrated).

Many of the same factors were associated with readmission and mortality (Table 3b). Time was log-transformed for these time-to-event models, therefore the parameter estimates were exponentiated and are interpreted as multiplicative factors (values greater than 1 indicate longer time to event). For example, women were less likely to be readmitted and had lower mortality (24% longer time to readmission and 15% longer time to death) than men. Age lengthened time to readmission, but residents over 85 years of age had a higher death rate (26% fewer days to death) than younger residents. Residents with higher CPS were slightly less likely to be readmitted and more likely to die. Relative to hip fracture, residents with other hospital diagnoses were more likely to be readmitted, as were residents with higher Charlson scores and longer length of stay. Septicemia and stroke were associated with higher mortality than congestive heart failure, while hip fracture and urinary tract infection were associated with lower mortality.

DISCUSSION

We examined ADL trajectories of a cohort of long-stay nursing home residents surrounding an acute hospitalization. Overall, ADL function worsened between pre-hospital and post-hospital assessments, and for most residents the post-hospital trajectory continued this trend. Trajectories differed depending on pre-hospital ADL score, cognition, and primary hospital diagnosis. Residents with significant cognitive impairment had worse ADL trajectories following hospitalization than residents with better cognition. Understanding the more limited potential for recovery of residents with significant cognitive impairment is important in helping families and facilities develop meaningful care plans for these residents, including decisions about limiting aggressive treatment.

We were surprised to see that on average, residents with good baseline function did not improve after acute hospitalization. Except for residents hospitalized for hip fracture, these residents worsened following hospital discharge, causing us to reject our hypothesis that they would return to baseline ADL level more quickly than more impaired residents. As shown in Table 1, among residents with good initial ADL function, 61% had declining trajectories before hospitalization. Thus, their higher probability of decline after hospitalization continued their pre-hospital trend. These higher functioning residents' initially declining trajectories perhaps reflect that in many cases they had some limitations in areas other than ADL function that led to long-term nursing home care.

Primary hospital diagnosis had a strong effect on both the shift in ADL score upon hospitalization and the rate of change in ADL score following hospital discharge. Residents hospitalized for hip fracture or stroke, conditions often associated with a need for rehabilitation, exhibited the largest change in ADL score, worsening more than six points on the 28-point scale immediately following hospitalization. Residents hospitalized for congestive heart failure had the smallest change in ADL score. Longer hospital stays, likely a proxy for severity of the acute illness, were also associated with worse post-hospital ADL scores. After jointly modeling ADL trajectories with mortality and readmission, only the group of residents with poor initial function exhibited any post-hospital ADL recovery, and the recovery rate for most diagnoses was modest.

Few other studies have used mixed models to study ADL trajectories of nursing home residents. McConnell et al.[42] used MDS data to study ADL trajectories of residents in a facility one year or longer. They excluded residents with severe cognitive impairment (CPS = 6) or complete eating dependency at admission. Representing ADL as a sum of five items to form a 0 to 20 scale, mean ADL score increased 0.07 per month, indicating a slow worsening. In contrast, we found a mean pre-hospital slope of −0.41 per quarter (−0.14 per month), indicating slow improvement. This likely represents a cohort difference. We did not exclude residents with severe cognitive impairment or complete eating dependency; if they survived, these residents could only remain stable or improve. Further, pre-hospital trajectories in our data were free of intervening hospital stays that would also tend to be associated with worsening ADL.

Consistent with our results, among older adults admitted to a nursing home with disability following an acute hospitalization, Gill[44] found that recovering pre-hospital function was unlikely. In addition to better gross motor coordination and manual dexterity, Gill found that intact cognition and stable weight were associated with recovery. Acute events and hospitalization among older adults appear to be periods of substantial change. Recognizing these outcomes following hospitalization should prompt practitioners to consider potential changes in care priorities following these events.

Our study has several strengths but also some limitations. We analyzed a large, national cohort of long-stay nursing home residents. We linked nursing home assessments to Medicare data, which provided more information on diagnoses than is available in the MDS. The timing of MDS assessments and hospital stays required us to exclude many potential participants to allow for sufficient data for meaningful analysis. As future acute hospitalizations are unknown at the time of assessment, limiting the sample to residents with an assessment in the 30 days before hospital admission did not likely bias our sample. Moreover, excluding residents who were hospitalized less than 90 days prior to the study admission likely biased our results towards the positive side, if anything. Therefore, from the perspective of care planning following an acute hospitalization, our findings may provide helpful guidance towards considering more of a palliative approach for residents with an extremely poor prognosis for meaningful recovery. While we restricted our cohort to those hospitalized for the seven most common hospital diagnoses, these represented over 50% of hospitalized residents and included both chronic and acute conditions.

CONCLUSION

We found that baseline ADL status, impaired cognition, female gender, comorbid burden, hospital length of stay, and hospital diagnosis were associated with ADL decline in nursing home residents. As well, each resident’s pre-hospital ADL trajectory was associated with mortality and readmission, indicating that ADL trajectory is associated with other important outcomes. Finally, consistent with work in other settings, significant cognitive impairment bodes poorly for recovery from acute events. Cognitive status and ADL trajectory prior to an acute illness are important considerations for prioritizing care goals for residents admitted to the hospital and on their return to the nursing home if they survive.

This first step in modeling suggests several areas for future study. In particular, investigating the effects of facility organizational structure and care delivery on residents’ ADL trajectories is a logical next step. For example, do residents with hip fracture in facilities with on-site physical therapy do better than residents of facilities without these services? As well, specifically examining the effects of multiple hospitalizations has important implications for care priorities. Further work should examine the effects of prospective efforts to reduce hospitalizations (e.g., INTERACT II[45]) in terms of the functional status of residents. Finally, future work should prospectively evaluate whether providing information on likely functional outcomes leads to better or even different care decisions. Knowing potential outcomes could help patients and families make clear decisions about shifting care goals. Our study lays the foundation for a line of research using expected functional outcomes to inform care decisions.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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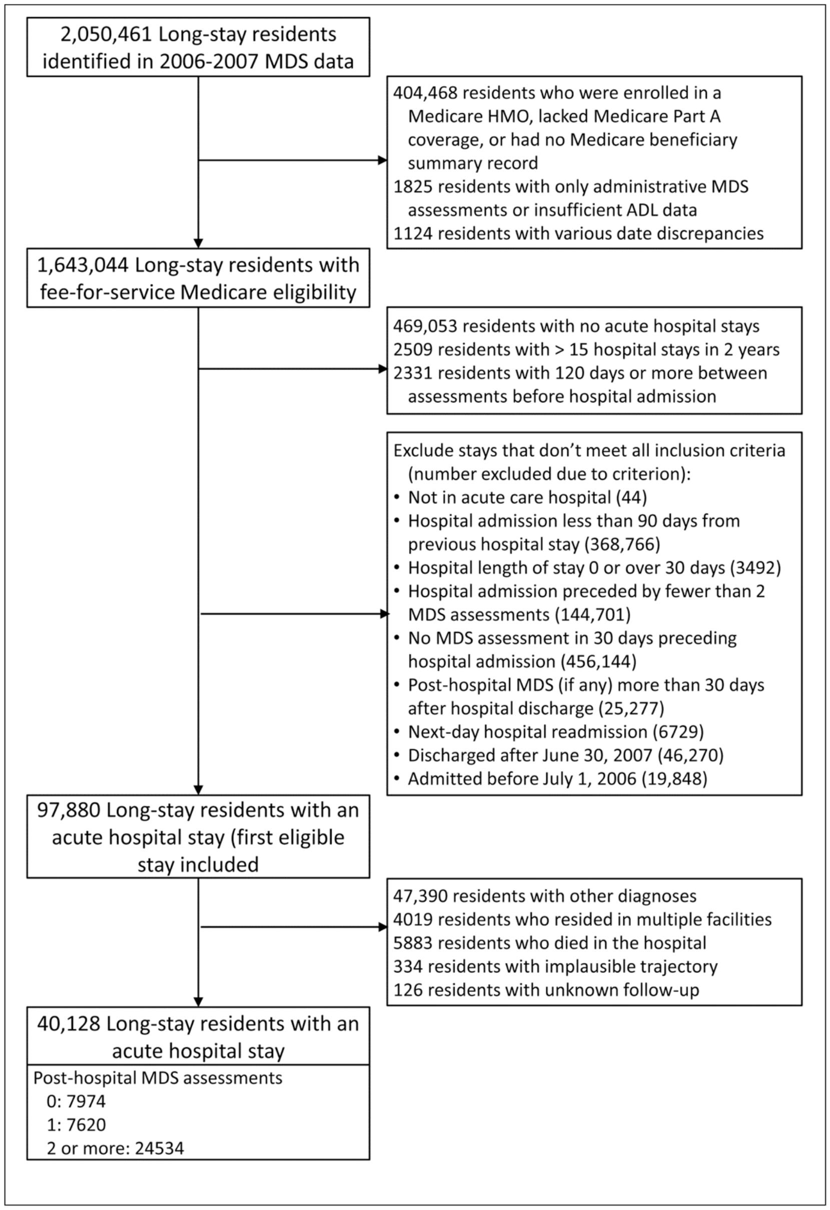

Figure 1.

Flow diagram showing derivation of cohort of long-stay nursing home residents.

MDS = Minimum Data Set

ADL = activities of daily living

HMO = health maintenance organization

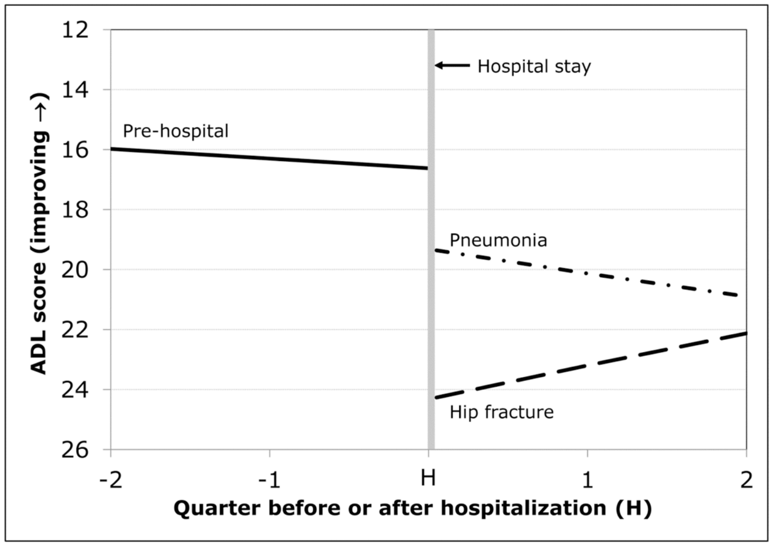

Figure 2.

Average ADL trajectories predicted by regression model (Table 3a) for nursing home residents hospitalized for hip fracture or pneumonia. Because the primary hospital diagnosis is not present before the acute event, the pre-hospital trajectory is identical for the two diagnoses. The slow pre-hospital worsening in ADL function is followed by precipitous worsening surrounding the acute hospitalization. The amount of worsening varies by diagnosis and is equal to the intercepts in Table 3a – hip fracture was associated with a 7.65-point change and pneumonia was associated with a 2.74-point change. On average, hip fracture patients improve following hospital discharge while residents hospitalized for pneumonia (and the other diagnoses) continue to worsen. For purposes of illustration, the modal characteristics of the population were used for other resident characteristics: age > 85, female, moderately impaired cognition (Cognitive Performance Scale=3), moderate baseline ADL impairment (baseline ADL 5–23), Charlson Comorbidity Index=2, and hospital length of stay=5 days.

ADL = activities of daily living

Table 1

Characteristics of Long-stay Nursing Home Residents with an MDS[a] Assessment within 30 Days of Hospital Admission, Grouped by Baseline ADL[b] Score [Number (Percentage)].

Characteristic	Baseline ADL impairment score			
	Not/mildly impaired, 0–4 (N=3480)	Moderately impaired, 5–23 (N=27,931)	Severely impaired, 24–28 (N=8717)	Total (N=40,128)
Demographics				
Female sex	2423 (69.6)	19,652 (70.4)	6226 (71.4)	28,301 (70.5)
Age 85 or older	1738 (49.9)	14,839 (53.1)	4080 (46.8)	20,657 (51.5)
Race[c]				
Asian/Pacific Islander	19 (0.6)	231 (0.8)	159 (1.8)	409 (1.0)
Black	240 (6.9)	2592 (9.3)	1542 (17.7)	4374 (10.9)
Hispanic	94 (2.7)	719 (2.6)	429 (4.9)	1242 (3.1)
North American native	14 (0.4)	105 (0.4)	30 (0.3)	149 (0.4)
White	3104 (89.4)	24,228 (86.9)	6547 (75.2)	33,879 (84.6)
Cognitive Performance Scale (CPS)				
Not/mildly impaired, CPS 0–2	2468 (70.9)	11,913 (42.6)	1008 (11.6)	15,389 (38.4)
Moderately impaired, CPS 3–4	982 (28.2)	13,726 (49.1)	3625 (41.6)	18,333 (45.7)
Severely impaired, CPS 5–6	30 (0.9)	2292 (8.2)	4084 (46.8)	6406 (16.0)
Diagnoses prior to hospital admission				
Alzheimer's or other dementia	1901 (54.6)	17,726 (63.5)	6797 (78.0)	26,424 (65.8)
Acute myocardial infarction	143 (4.1)	1133 (4.1)	236 (2.7)	1512 (3.8)
Cancer	227 (6.5)	1929 (6.9)	471 (5.4)	2627 (6.6)
Chronic kidney disease	756 (21.7)	7142 (25.6)	2039 (23.4)	9937 (24.8)
Congestive heart failure	1180 (33.9)	9543 (34.2)	2373 (27.2)	13,096 (32.6)
Chronic Obstructive Pulmonary Disease	1288 (37.0)	8988 (32.2)	2235 (25.6)	12,511 (31.2)
Diabetes	1241 (35.7)	10,796 (38.6)	3489 (40.0)	15,526 (38.7)
Hip fracture	221 (6.4)	2871 (10.3)	702 (8.0)	3794 (9.4)
Stroke/Transient Ischemic Attack	543 (15.6)	7026 (25.2)	3010 (34.5)	10,579 (26.4)
Charlson Index				
0	546 (15.7)	3746 (13.4)	1164 (13.4)	5456 (13.6)
1	941 (27.0)	7158 (25.6)	2333 (26.8)	10,432 (26.0)

Characteristic	Baseline ADL impairment score: Not/mildly impaired, 0–4 (N=3480)	Moderately impaired, 5–23 (N=27,931)	Severely impaired, 24–28 (N=8717)	Total (N=40,128)
2 or more	1993 (57.3)	17,027 (61.0)	5220 (59.9)	24,240 (60.4)
Hospital admissions in prior year				
0	2284 (65.6)	13,421 (48.1)	4023 (46.2)	19,728 (49.2)
1	706 (20.3)	7397 (26.5)	2207 (25.3)	10,310 (25.7)
2 or more	490 (14.1)	7113 (25.5)	2487 (28.5)	10,090 (28.5)
MDS assessments before hospital admission				
Two	2453 (70.5)	15,224 (54.5)	5008 (57.4)	22,685 (56.5)
Three	830 (23.8)	6565 (23.5)	1826 (21.0)	9221 (23.0)
Four or more	197 (5.7)	6142 (22.0)	1883 (21.6)	8222 (20.5)
MDS assessments following hospital discharge				
None	481 (13.8)	4872 (17.4)	2621 (30.1)	7974 (19.9)
One	559 (16.1)	5299 (19.0)	1762 (20.2)	7620 (19.0)
Two or more	2440 (70.1)	17,760 (63.6)	4334 (49.7)	24,534 (61.1)
Person-specific pre-hospital ADL slope				
Improving	37 (1.1)	5575 (20.0)	1938 (22.2)	7550 (18.8)
Stable	1306 (37.5)	13,679 (49.0)	6570 (75.4)	21,555 (53.7)
Worsening	2137 (61.4)	8677 (31.1)	209 (2.4)	11,023 (27.5)
Hospital diagnosis				
Congestive heart failure	604 (17.4)	3433 (12.3)	468 (5.4)	4505 (11.2)
Hip fracture	657 (18.9)	3107 (11.1)	210 (2.4)	3974 (9.9)
Pneumonia	1081 (31.1)	8991 (32.2)	3358 (38.5)	13,430 (33.5)
Renal failure	274 (7.9)	2101 (7.5)	516 (5.9)	2891 (7.2)
Septicemia	327 (9.4)	4292 (15.4)	2182 (25.0)	6801 (17.0)
Stroke	249 (7.2)	1763 (6.3)	322 (3.7)	2334 (5.8)
Urinary tract infection	288 (8.3)	4244 (15.2)	1661 (19.0)	6193 (15.4)

[a]MDS = Minimum Data Set

[b]ADL = Activities of Daily Living

[c]Race/ethnicity was missing for 75 residents. Version 2 of the MDS does not permit choosing multiple categories and does not separately consider Hispanic ethnicity.

Table 2

Outcomes Following Hospital Discharge for Long-stay Nursing Home Residents[a] [Number (Column percent)].

	Person-specific pre-hospital ADL[b] slope				
Post-discharge outcome	**Improving (N=7550)**	**Stable (N=21,555)**	**Worsening (N=11,023)**	**Total (N=40,128)**	***P*-value[c]**
Readmission within 30 days	1512 (20.0)	4333 (20.1)	2036 (18.5)	7881 (19.6)	.0014
Death within 30 days	853 (11.3)	4122 (19.1)	3188 (28.9)	8163 (20.3)	<.0001
Person-specific post-hospital ADL slope[d]					<.0001
Improving	2626 (34.8)	3100 (14.4)	1376 (12.5)	7102 (17.7)	
Stable	3381 (44.8)	10,984 (51.0)	2911 (26.4)	17,276 (43.1)	
Worsening	1543 (20.4)	7471 (34.7)	6736 (61.1)	15,750 (39.2)	

[a] 40,128 residents who survived their hospital stay and were not lost to follow-up.

[b] ADL = Activities of Daily Living

[c] *P*-value for chi-square test of outcomes by pre-hospital person-specific slopes.

[d] The model calculates a predicted value for all residents. Residents who have no post-hospital ADL data are assigned the group mean slope for individuals with their characteristics (gender, baseline ADL, diagnosis, etc.).

Table 3a

Parameter Estimates for the ADL[a] Trajectory Portion of the Joint Model (N = 40,128 subjects).

Variable[b]	Parameter estimate (95% CI)	*P*-value
Baseline ADL level (intercept)	13.5 (13.4 – 13.6)	<0.001
Factors that affect ADL level (intercept) across both time periods		
Female	0.17 (0.09 – 0.26)	<0.001
Age > 85	−0.01 (−0.08 – 0.07)	0.86
Charlson Comorbidity Index[c]	0.05 (0.03 – 0.08)	<0.001
Cognitive Performance Scale	0.94 (0.92 – 0.97)	<0.001
Baseline ADL score ≤ 4	−9.92 (−10.1 – −9.76)	<0.001
Baseline ADL score ≥ 24	7.26 (7.15 – 7.36)	<0.001
Factors that affect the rate of change in ADL (slope) across both time periods		
Time (fractions of quarters)	−0.41 (−0.46 – −0.36)	<0.001
Cognitive Performance Scale	0.24 (0.23 – 0.26)	<0.001
Baseline ADL score ≤ 4	1.39 (1.31 – 1.47)	<0.001
Baseline ADL score ≥ 24	−1.09 (−1.14 – −1.04)	<0.001
Factors that affect ADL level following hospital discharge (intercept)		
Hip fracture	7.65 (7.50 – 7.79)	<0.001
Stroke	6.53 (6.33 – 6.73)	<0.001
Renal failure	3.41 (3.23 – 3.59)	<0.001
Septicemia	2.97 (2.85 – 3.10)	<0.001
Urinary tract infection	2.75 (2.62 – 2.87)	<0.001
Pneumonia	2.74 (2.65 – 2.83)	<0.001
Congestive heart failure	2.64 (2.49 – 2.79)	<0.001
Hospital length of stay[d]	0.17 (0.16 – 0.18)	<0.001
Factors that affect the rate of change in ADL following hospital discharge (slope)		
Hip fracture	−1.39 (−1.52 – −1.27)	<0.001
Stroke	0.89 (0.72 – 1.05)	<0.001
Renal failure	0.58 (0.42 – 0.74)	<0.001
Septicemia	0.78 (0.68 – 0.89)	<0.001
Urinary tract infection	0.35 (0.24 – 0.46)	<0.001
Pneumonia	0.45 (0.37 – 0.53)	<0.001
Congestive heart failure	0.33 (0.20 – 0.47)	<0.001
Hospital length of stay	−0.01 (−0.02 – 0.01)	0.33

[a]ADL = Activities of Daily Living

[b]Main effect estimates are shown as “factors that affect ADL level” and time interactions are “factors that affect the rate of change.” For example, each point increase in Cognitive Performance Score was associated with an ADL score that was 0.94 points worse (higher) and also an ADL score that worsened 0.24 points per quarter, or 0.96 points per year.

[c]Capped at a maximum score of 6.

[d]Per day, centered on median of 5 days

Table 3b

Parameter Estimates for the Log-normal Regressions for Event Times Portion of the Joint Model.

	Time to death		Time to readmission	
Effect	**Multiplicative effects[a] (95% CI)**	***P*-value**	**Multiplicative effects (95% CI)**	***P*-value**
Intercept	14.0 (12.0 – 16.2)	<0.001	13.7 (11.8 – 15.9)	<0.001
Female	1.15 (1.08 – 1.21)	<0.001	1.24 (1.15 – 1.34)	<0.001
Age > 85	0.74 (0.70 – 0.77)	<0.001	1.35 (1.26 – 1.45)	<0.001
Cognitive Performance Scale	0.76 (0.75 – 0.77)	<0.001	1.03 (1.00 – 1.05)	0.016
Pneumonia	1.04 (0.92 – 1.17)	0.54	0.50 (0.44 – 0.57)	<0.001
Septicemia	0.75 (0.66 – 0.86)	<0.001	0.49 (0.43 – 0.56)	<0.001
Congestive heart failure	Reference		0.28 (0.24 – 0.32)	<0.001
Hip fracture	1.98 (1.68 – 2.33)	<0.001	Reference	
Urinary tract infection	1.85 (1.62 – 2.13)	<0.001	0.40 (0.35 – 0.46)	<0.001
Renal failure	0.90 (0.76 – 1.06)	0.20	0.54 (0.45 – 0.64)	<0.001
Stroke	0.33 (0.28 – 0.40)	<0.001	0.80 (0.67 – 0.97)	0.021
Charlson Comorbidity Index	0.97 (0.96 – 0.99)	<0.001	0.82 (0.80 – 0.84)	<0.001
Hospital length of stay	0.98 (0.97 – 0.98)	<0.001	0.95 (0.94 – 0.96)	<0.001

[a]Because time was log-transformed, the parameter estimates were exponentiated and are interpreted as multiplicative factors on the time to event. For example, holding the other variables constant, time to readmission in quarters would be 1.24 times longer for a female resident than for a male resident (readmission would be delayed).