Potentially Avoidable Hospitalizations among People at Different Activity of Daily Living Limitation Stages

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Objective. To determine whether higher activity of daily living (ADL) limitation stages are associated with increased risk of hospitalization, particularly for ambulatory care sensitive (ACS) conditions.

Data Source. Secondary data analysis, including 8,815 beneficiaries from 2005 to 2006 Medicare Current Beneficiary Survey (MCBS).

Study Design. ADL limitation stages (0-IV) were determined at the end of 2005. Hospitalization rates were calculated for 2006 and age adjusted using direct standardization. Multivariate negative binomial regression, adjusting for baseline demographic and health characteristics, with the outcome hospitalization count was performed to estimate the adjusted rate ratio of ACS and non-ACS hospitalizations for beneficiaries with ADL stages > 0 compared to beneficiaries without limitations.

Data Collection. Baseline ADL stage and health conditions were assessed using 2005 MCBS data and count of hospitalization determined using 2006 MCBS data.

Principal Findings. Referenced to stage 0, the adjusted rate ratios (95 percent confidence interval) for stage I to stage IV ranged from 1.9 (1.4–2.5) to 4.1 (2.2–7.8) for ACS hospitalizations compared with from 1.6 (1.3–1.9) to 1.8 (1.4–2.5) for non-ACS hospitalizations.

Conclusions. Hospitalization rates for ACS conditions increased more dramatically with ADL limitation stage than did rates for non-ACS conditions. Adults with ADL limitations appear particularly vulnerable to potentially preventable hospitalizations for conditions typically manageable in ambulatory settings.

Key Words. Ambulatory care, hospitalization, primary health care, health services accessibility, disabled persons

While worse health outcomes in people with disabilities have been traditionally attributed to their underlying conditions, they may also be the result of disparities (Krahn, Walker, and Correa-De-Araujo 2015). Persons with disabilities may have increased trouble accessing health care because of cost (Lee,

Hasnain-Wynia, and Lau 2012) or transportation issues (Henning-Smith et al. 2013). Once at the primary care setting, they may encounter further barriers such as inaccessible examination tables, lack of transfer aides, or accessible weight scales (Mudrick et al. 2012; Stillman et al. 2014). Furthermore, communication barriers, inadequate time, and provider training may affect the quality of care received by people with disabilities in primary care (Bachman et al. 2006; Morrison, George, and Mosqueda 2008; Brown et al. 2010; Sharby, Martire, and Iversen 2015).

Healthy People 2020 recognized that people with disabilities commonly experience difficulties or delays in getting needed health care (US Department of Health and Human Services 2010b). Thus, in 2011, the Centers for Disease Control and Prevention (CDC) added persons with disabilities to its list of vulnerable populations (CDC 2011), and the Agency for Healthcare Research and Quality (AHRQ) designated people with disabilities as a priority population (Butler et al. 2012). The CDC seeks to reduce disparities between the most and least vulnerable populations and has studied ambulatory care-sensitive hospitalization as one potential disparity indicator (CDC 2011).

Ambulatory care-sensitive (ACS) conditions are defined as conditions “for which good outpatient care can potentially prevent the need for hospitalization or for which early intervention can prevent complications or more severe disease” (AHRQ 2011). Research links high ACS hospitalizations rates to ambulatory care service access problems and to underuse of needed care (Millman 1993). Endorsed by the Institute of Medicine (IOM) and by the national quality forum (Millman 1993; IOM of the National Academies 2012), lists of these conditions have been used as indicators of potentially avoidable hospitalizations in the United States and other countries (Brown et al. 2001; Caminal et al. 2004). The U.S. Patient Protection and Affordable Care Act of

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2010 used ACS hospitalizations as an example in the section mandating the reporting of care quality measures by Accountable Care Organizations. (United States Congress 2010). Reducing excess ACS hospitalizations across vulnerable populations could have huge implications for enhancing quality of life and reducing health care costs.

Prior research has demonstrated that persons with African American and Hispanic race or ethnicity (Laditka 2003), low income (CDC 2011), and less education (Laditka 2003; Roos et al. 2005) are at higher risk of ACS hospitalizations. Given that people with disabilities can have difficulty in accessing ambulatory care, they may also be at higher risk for ACS hospitalizations. Although some studies on ACS hospitalizations adjust for disability (Culler, Parchman, and Przybylski 1998; Laditka 2003), there is a paucity of studies on ACS hospitalizations among people with disabilities. Activity of Daily Living (ADL) staging is an approach to measure disability that specifies four clinically meaningful patterns of increasing difficulty with self-care skills (Stineman et al. 2011, 2014). No previous research has investigated associations between increasing stages of ADL limitation and rates of ACS hospitalization.

Our underlying conceptual model, based on literature review, recognizes that people with disabilities may have increased difficulties in accessing care. With acute illness, the need to rely on others for transportation or to arrange special transportation may lead to delayed presentation and worsening of acute conditions, thus resulting in an acute ACS hospitalization. For chronic conditions, difficulty accessing ambulatory care and barriers faced in primary care may lead to suboptimal management of chronic ACS conditions resulting in increased risk of hospitalization for uncontrolled exacerbations of the chronic ACS conditions and/or for ACS condition complications (Figure 1).

ACS hospitalization has become a proxy indicator of poor access to effective outpatient care. Timely, appropriate, and coordinated outpatient care can help successfully manage chronic ACS conditions, thus potentially preventing excess hospitalizations for these conditions (Yoon et al. 2013; van Loenen et al. 2014; O'Malley, Reschovsky, and Saiontz-Martinez 2015; Sundmacher and Kopetsch 2015). People with ADL limitations have greater health care needs while suffering from worse access to care (Gulley, Rasch, and Chan 2011). Such disparities may lead to excess potentially avoidable ACS hospitalizations. Thus, we hypothesize that people with ADL limitations have higher rates of ACS hospitalizations and that these rates increase as ADL limitation stage increases.

We address four questions: Is the prevalence for known socioeconomic and health-related risk factors for ACS hospitalizations higher among people

Figure 1: Hypothetical Ambulatory Care–Sensitive Condition Pathways

Notes. ACS hospitalizations are considered a proxy for poor access to primary care. Accessibility challenges were derived from literature review and are meant to illustrate how we would expect ACS hospitalizations to increase with ADL limitation stage.

at higher ADL limitation stages? How do age-standardized potentially preventable hospitalization rates differ among those at different stages of limitation compared with those without ADL limitations? Is there an independent association between higher stage and ACS hospitalization rates after adjustment for baseline demographic and health characteristics? Do associations between stage of limitation and hospitalization differ for ACS and non-

ACS-related causes? Understanding stage-specific baseline ACS hospitalization rates is a first step in planning the development of targeted interventions to reduce any related disparities and thus to reducing gaps in health care quality for Medicare beneficiaries with disabilities.

METHODS

Data and Measures

The Medicare Current Beneficiary Survey (MCBS) draws its sample from the Medicare enrollment file and is representative of the Medicare population (Centers for Medicare and Medicaid Services 2006; Kautter et al. 2006; US Department of Health and Human Services 2010a). The MCBS combines survey data with information from Medicare administrative files and other sources such as the Minimum Data Set (MDS) for beneficiaries in facilities. The 2006 MCBS Cost and Use sample ($n = 11,984$) consists of three independent panels which entered the survey in different years (2003, 2004, and 2005). Their cumulative response rates in 2006 were 65.7, 70.6, and 74.5 percent, respectively (Center for Medicare and Medicaid Services 2009). The MCBS adjusts survey weights to account for nonresponse (Kautter et al. 2006) and the oversampling of people under 65 years and 80 years or above. We limited the sample to those who participated in the fall 2005 Health Status and Functioning interview ($n = 11,227$), which we used to determine baseline functional status. In addition, interview data on health conditions along with 2005 claim data determined baseline presence of an ACS condition and presence of a neuropsychiatric condition. Similar to others (Culler, Parchman, and Przybylski 1998), we excluded those ($n = 2,394$) in Medicare Health Maintenance Organizations (HMOs) because HMOs are not required to submit claims for payment. Our determination of whether a hospitalization was ACS condition-related relied on claims files, which were frequently missing for those in HMOs. We excluded an additional 18 participants missing ADL ($n = 15$) and/or marital status ($n = 3$), leaving a final sample of 8,815 beneficiaries. The Institutional Review Board at the University of Pennsylvania approved this study.

ACS Condition and Non-ACS Condition-Related Hospitalizations

The main outcome was the count of potentially preventable hospitalization(s) for acute or chronic ACS conditions from January 1 to December 31, 2006. To determine whether a hospitalization was ACS condition related, we applied

the AHRQ technical specifications (Version 4.3) (AHRQ 2011) for ACS hospitalizations to the 2006 hospital claim files provided with the MCBS data. *International Classification of Disease*, 9th revision, diagnostic and procedure codes were applied to define ACS-related hospitalizations. Hospitalizations related to acute ACS conditions (dehydration, urinary tract infections, and pneumonia) were combined with those for chronic ACS conditions (diabetes short-term and long-term complications, uncontrolled diabetes, diabetes-related lower extremity amputation, asthma in younger adults, chronic obstructive pulmonary disease [COPD]/asthma in older adults, hypertension, congestive heart failure, and angina without procedures). We compared ACS to non-ACS-related hospitalization (non-ACS) over the same time period.

Activities of Daily Living Staging

ADL limitation, expressed as five hierarchical and mutually exclusive stages, was the primary exposure. We chose stages to measure ADL limitation based on the IOM's recommendation to use International Classification of Functioning, Disability and Health (ICF)-based disability measurement (World Health Organization 2001). ADL stages differentiate among people with no activity limitations (stage 0) through total limitations in all ADLs (stage IV). Initially derived in the Second Longitudinal Study of Aging II dataset and shown to be associated with a variety of outcomes (Henry-Sanchez et al. 2012; Stineman et al. 2012a,b; Schüssler-Fiorenza et al. 2013), stages were re-derived for the MCBS population (Stineman et al. 2014). Definitions for stages 0, I, II, and IV conform to an ontological order of expected patterns of difficulty documented in the literature (Katz et al. 1963; Lawton and Brody 1969; Linacre et al. 1994; Saliba et al. 2000) and are defined by the specific ADLs a person is able to do (Table 1). Stage III is the exception in that it is defined by difficulty in eating or toileting (typically impaired at more advanced levels of disability), but the specific ADL a person at stage III can do is not explicitly defined.

Stage assignment was determined for the end of 2005, using respondent answers to the MCBS Health Status and Functioning questionnaire. The introduction of the section specifies that the interview would like to know about any difficulty doing each activity by oneself and without special equipment. The survey asks, "Because of a health or physical problem, do you (or sample person if proxy interview) have *any* difficulty with the following?" The questions cover six ADLs: bathing or showering, dressing, eating, getting in and out of bed or chairs, walking, and using the toilet. Responses can be "yes"

Table 1: Activity of Daily Living (ADL) Stage Definitions with Estimated Prevalence in Fee-for-Service Medicare Population

<i>Stages of ADL Limitation</i>	<i>ADL Threshold Definition: Individual Must Be Able to Do without Difficulty</i>	<i>Raw N</i>	<i>Weighted N in Millions (%)</i>
0—None	All ADLs*	5,592	19.6 (66.0)
I—Mild	Eat, toilet, dress, bathe/shower	1,369	4.7 (15.7)
II—Moderate	Eat, toilet	805	2.5 (8.5)
III—Severe/other†	At least one ADL but has difficulty with eating and/or toileting	663	1.9 (6.5)
IV—Total	Nothing—has difficulty with all ADLs	386	1.0 (3.2)

*The six ADLs assessed are walking, getting in and out of bed and chairs, dressing, bathing/show-
ering, toileting, and eating.

†Stage III differs from the other stages in that it is not defined by the specific ADLs an individual
can do without difficulty.

(counted as a limitation), “no” (no limitation), or “does not do.” A “does not do” response is followed with the question, “Is this because of a *health* or *physical* problem?” An affirmative answer counts as a limitation and “no” as no limitation. Facility-dwelling participants are not interviewed directly, and their ADL questions are phrased differently. For each facility ADL question, we counted participants reported to be independent without need of an assistive device as having “no difficulty” and those requiring an assistive device, supervision, assistance, or not doing the ADL as having “difficulty.”

Baseline Demographic and Health Conditions

We included age (21–64, 65–79, ≥80), sex, race or ethnic group (non-Hispanic white, non-Hispanic black, Hispanic, other), high school graduation (yes, no), marital status (married, not married), facility residence such as rest home or continuing care retirement community (yes, no), personal income in 2005 (<\$15,000, \$15,000–\$29,000, ≥\$30,000), dual Medicaid/Medicare eligibility (yes, no), and preexisting health conditions. We determined preexisting health conditions using a combination of 2005 MCBS health survey and 2005 Medicare claims data. The inclusion of both data sources was intended to increase diagnostic sensitivity (Pressley et al. 2003; Ostbye et al. 2008). Claims data were from inpatient hospitalizations, skilled nursing facility stays, outpatient hospital visits, home health care visits, and outpatient physician visits. We included preexisting chronic ACS conditions (asthma or COPD, diabetes, hypertension, congestive heart failure, and coronary artery disease) and neuropsychiatric

conditions (intellectual and/or developmental disability, dementia or Alzheimer's disease, neurologic disorders, and mental illness).

Statistical Analyses

The MCBS uses a stratified multistage probability sampling design to select from the Medicare population (Lo and Chu 2005). We used the 2006 Cost and Use cross-sectional weights to calculate the correct point estimates and to allow estimation back to the full fee-for-service Medicare population. We also accounted for the complex survey design in all analyses to estimate the variances appropriately (Centers for Medicare and Medicaid Services 2009). We used the survey procedures of *SAS[®] 9.4 software* (SAS Institute, Inc., Cary, NC, USA, 2013) for descriptive analyses to study the distribution of baseline demographic and health characteristics according to ADL stage and to determine ACS and non-ACS hospitalization rates. We used the survey procedures of *STATA 14.0* (StataCorp 2015) to perform multivariate regressions.

Overall Analytic Roadmap

We first examined important demographic and health characteristics by ADL stage. We chose characteristics known to be important predictors of ACS hospitalizations based on literature review. We then did a population-level analysis looking at rate of ACS and non-ACS hospitalization by demographic, health characteristic, and stage. Since age is such an important confounder for hospitalization rates, to facilitate comparison between groups, we age adjusted the rates. In order to adjust for important mediators and confounders of ACS hospitalizations, we performed a multivariate analysis which enabled us to adjust for important characteristics at the individual level. We performed this analysis looking at important individual predictors for ACS hospitalization in comparison with non-ACS hospitalization.

Descriptive Analyses

We first evaluated the raw numbers and weighted numbers of ACS hospitalizations over the 1 year by ADL stage. We also examined the proportion of ACS admissions that were for acute illness (dehydration, pneumonia, and urinary tract infection) by stage. We then determined rates (expressed in 1,000 person-years) by ADL stage, demographic characteristic, and health conditions. We accounted for differential lengths of time a participant was at risk for

hospitalization due to deaths during the year. (For example, a person who lived 3 months—counted for 0.25 person-years compared with 1 person-year for a person alive the entire year.) Since age is a strong confounder, to enable comparison of rates between various ADL stages and baseline demographic and health condition groups, we applied the direct standardization method (Coffey et al. 2009) and the U.S. 2000 Census population standard (Klein and Schoenborn 2001) to age-adjust ACS and non-ACS hospitalization rates using our three age groups.

Multivariate Regression

We used multivariate regression to control for other important confounders. Our outcome variable was hospitalization count and our primary predictor was ADL stage. An initial analysis using Poisson regression demonstrated overdispersion, and thus we switched to negative binomial regression to estimate adjusted rate ratios. The multivariate model was adjusted for age, sex, race, marital status, facility residence, dual eligible status, and the presence of one or more neuropsychiatric diagnoses. We used a count of chronic ACS conditions as a proxy for ACS condition severity based on the assumption that those with a higher number of ACS conditions would face increased risk of ACS hospitalization. To account for unequal “exposure time” caused by the 496 deaths in our sample, we adjusted our analyses by the number of months alive during that year. Income was not included because it was highly correlated with dual eligible status. Education was not included as it had a disproportionate amount of missing data at the higher stages and did not have a significant effect in our preliminary models. We modeled count of ACS hospitalizations and non-ACS hospitalizations separately. We did a second multivariate regression analysis using any ADL limitation as the primary predictor and the same covariates as listed above.

We tested whether the association between ADL stage and ACS hospitalization and between ADL stage and non-ACS hospitalization was different in the multivariable models by applying a bootstrap analysis. Bootstrapping was necessary because the analysis for ACS and non-ACS hospitalizations used the same patients and the regression coefficients might be correlated. Specifically, we took 1,000 bootstrap datasets from our original sample. These bootstrap datasets were of the same number of respondents as in the original sample, and the respondents were randomly chosen with replacement. Within each bootstrap dataset, we estimated the regression coefficients of ADL stage for ACS and non-ACS hospitalizations separately and calculated the

difference between regression coefficients. With the 1,000 bootstrap datasets, we were able to get the 95 percent CI for the differences in regression coefficients, which enabled us to determine whether the differences were statistically different from zero. A similar analysis tested whether the regression coefficient of any ADL limitation for ACS hospitalizations was different than the coefficient for non-ACS hospitalizations.

RESULTS

Risk Factors by ADL Stage

An estimated 34 percent of the fee-for-service Medicare population had difficulty with ADL(s). Almost 10 percent were at stage III or IV (Table 1). The prevalence of most baseline demographic and health characteristics that are associated with an increased risk for ACS hospitalization was greater at higher ADL stages. These baseline demographics and health characteristics include the following: age over 80, unmarried, low income, facility dwelling, dual Medicare/Medicaid eligibility, having a neuropsychiatric conditions (Table 2).

ACS and Non-ACS Hospitalization Rates

Of the 3,695 hospitalizations (weighted $n = 11.2$ million) within the time-frame studied, 678 (18.3 percent) were ACS, 2,831 (76.1 percent) were non-ACS, and 196 (5.6 percent) were missing primary diagnosis and could not be classified. The weighted number of ACS hospitalizations for those with no ADL difficulty was 0.8 million compared with 1.4 million in those with any ADL difficulties (stages I to IV combined). The weighted number of non-ACS hospitalizations for those with no ADL difficulty was 4.3 million compared with 4.8 million for those with any ADL difficulties. Strikingly almost 70 percent of ACS admissions for those at stage IV was for acute ACS conditions. The proportion of acute ACS hospitalizations (out of total ACS hospitalizations) was lowest at ADL stage 0 (35 percent); equivalent for stages I, II, and III (42 percent); and substantially higher for stage IV (69 percent).

Age-adjusted ACS hospitalization rates monotonically increased with stage, with those at stage IV having age-adjusted rates that were over 6 times that of those with no limitations (295.4 vs. 43.8 per 1,000 person-years). Although the rate for non-ACS hospitalizations increased in those at ADL-I,

Table 2: Baseline Demographic and Health Characteristics of Fee-for-Service Medicare Participants According to Activity of Daily Living (ADL) Stage ($n = 8,815$)*

Characteristic	Total Raw n (Weighted Column Percent)	ADL Limitation Stage					p-value
		Stage 0	Stage I	Stage II	Stage III	Stage IV	
Demographic variables							
Age group							
21–64 years	1,666 (16.2)	12.8	21.6	25.8	24.5	17.8	<.001
65–79 years	4,313 (57.7)	66.9	46.4	37.7	33.9	25.7	
≥80 years	2,836 (26.1)	20.3	32.0	36.5	41.6	56.5	
Female	4,894 (55.8)	53.1	60.5	57.5	62.6	70.1	<.001
Race or ethnic group							
Non-Hispanic	7,111 (81.2)	82.2	80.1	78	77.5	79.6	<.03
White							
Non-Hispanic	800 (8.7)	8.0	9.5	9.0	11.7	11.5	
Black							
Hispanic	498 (5.5)	5.2	5.6	6.6	6.4	6.0	
Other	406 (4.7)	4.6	4.8	6.3	4.4	2.8	
Education							
HS graduation	6,042 (71.1)	76.4	65.2	60.2	57.0	48.8	<.001
No HS graduation	2,610 (27.6)	23.2	34.0	36.5	37.9	42.3	
Missing	163 (1.3)	0.4	0.7	3.3	5.2	8.8	
Married	4,047 (50.2)	55.4	44.6	39	37.2	26.8	<.001
Facility	694 (5.1)	0.4	1.2	11.4	24.8	62.5	<.001
Income							
<\$15,000	3,370 (33.4)	27.4	38.5	46.5	50.3	60.7	<.001
\$15,000–\$29,999	2,577 (30.6)	30.6	32.8	32.2	27.7	22.5	
≥\$30,000	2,868 (36.0)	42.0	28.7	21.3	22.0	16.8	
Dual eligibility	2,301 (21.1)	14.7	24.2	34.4	39.9	63.2	<.001
Chronic ambulatory care–sensitive (ACS) condition count							
0	1,602 (17.5)	20.6	9.8	12.8	12.0	14.5	<.001
1	2,686 (30.9)	33.8	25.1	24.8	25.5	25.6	
2	2,287 (26.3)	26.1	29.5	23.9	24.3	24.6	
3	1,364 (15.5)	13.0	21.8	18.5	19.5	19.0	
4	655 (7.4)	5.1	10.6	14.3	12.5	10.0	
5	221 (2.4)	1.3	3.2	5.7	6.1	6.4	
Neuropsychiatric	4,453 (47)	37.5	53.5	68.2	77.4	93.3	<.001

Notes. Chronic ACS Condition Count includes count of the following diagnoses: diabetes, congestive heart failure, hypertension, asthma/chronic obstructive pulmonary disease, coronary heart disease. HS = high school.

*Comparisons across five ADL stages were made using Rao-Scott chi-square test on sample weighted data.

ADL-II, ADL-III, and ADL-IV compared with ADL-0, the increase was considerably less with just over a 2-fold increase in rate comparing those at ADL-I, ADL-II, ADL-III, and ADL-IV with those at ADL-0 (Figure 2).

ACS hospitalization rates were higher in those older than 80 compared with the other two younger age groups (Figure 3). Beneficiaries who were less educated, unmarried, dual eligible, and living in facilities had higher age-adjusted ACS hospitalization rates than those without those characteristics. Hispanics had a higher age-adjusted ACS hospitalization rate than other race/ethnicities. The age-adjusted rate of ACS hospitalizations increased sharply as number of chronic ACS conditions increased (Figure 3).

After adjusting for age, sex, race, marital status, dual eligibility, neuropsychiatric condition(s), living in a facility, and chronic ACS condition count, ACS hospitalization rates increased relative to stage 0 for all stages (Table 3). The adjusted rate ratios (RR) (95 percent confidence interval [CI]) increased from 1.9 (1.4–2.5; $p < .001$) for stage I to 4.1 (2.2–7.8; $p < .001$) for stage IV relative to stage 0 with the RRs of stages II and III being similar and close to 2.5. In contrast, although non-ACS hospitalization adjusted rates increased relative to stage 0 for all other stages, the adjusted RR (95 percent CI) did not increase much as stage increased and

Figure 2: Comparison of Age-Adjusted Ambulatory Care–Sensitive (ACS) Hospitalization and Non-ACS Hospitalizations Rates by Activities of Daily Living (ADL) Stage

Notes. Age-adjusted hospitalization rates per 1,000 person-years are shown according to each ADL stage. Age adjustment was performed by applying the direct standardization method, and the U.S. 2000 population standard ACS hospitalizations include those for either acute or chronic ACS conditions. Non-ACS hospitalizations encompass all other hospitalizations.

Figure 3: Age-Adjusted Ambulatory Care–Sensitive (ACS) Hospitalization Rates and Non-ACS Hospitalization Rates per 1,000 Person-Years by Demographic and Health Condition Groups

Notes. Age-adjusted hospitalization rates per 1,000 person-years are shown by demographic and health condition groups. Age adjustment was performed by applying the direct standardization method and the U.S. 2000 population standard. ACS count refers to count of underlying chronic ACS conditions (diabetes, congestive heart failure, hypertension, asthma/chronic obstructive pulmonary disease, coronary heart disease). NH = non-Hispanic; HS = high school; Dual El. = dual eligibility; Ct. = count; NP = neuropsychiatric; Dx = diagnosis.

was 1.6 (1.3–1.9; $p < .001$) for ADL stages I and II and 1.8 for stages III and IV ($p < .001$) compared with stage 0 (Table 3). The bootstrap analysis showed that the differences in the beta coefficients estimated for associa-

Table 3: Ambulatory Care–Sensitive (ACS) Hospitalization Rate Ratio (RR) Estimates and Non-ACS Hospitalization RR Estimates with 95% Confidence Intervals (CI) ($n = 8,815$)

	<i>ACS Hospitalizations</i>		<i>Non-ACS Hospitalizations</i>	
	<i>RRR (95% CI)</i>	<i>p-value</i>	<i>RRR (95% CI)</i>	<i>p-value</i>
Activities of daily living stage (reference (ref) = Stage 0)				
Stage I	1.85 (1.36, 2.51)	<.001	1.56 (1.3, 1.86)	<.001
Stage II	2.57 (1.86, 3.55)	<.001	1.55 (1.28, 1.88)	<.001
Stage III	2.34 (1.57, 3.49)	<.001	1.83 (1.47, 2.27)	<.001
Stage IV	4.1 (2.16, 7.8)	<.001	1.84 (1.36, 2.49)	<.001
Age group (ref = 21–64 years)				
65–79 years	1.27 (0.88, 1.85)	.203	1.1 (0.92, 1.31)	.297
≥80 years	1.67 (1.15, 2.43)	.008	1.78 (1.4, 2.25)	<.001
Female (ref = male)	1.17 (0.93, 1.46)	.17	0.82 (0.72, 0.93)	.003
Race (ref = Non-Hispanic White)				
Non-Hispanic Black	0.94 (0.66, 1.35)	.746	1.14 (0.93, 1.39)	.199
Hispanic	0.72 (0.46, 1.13)	.149	0.77 (0.58, 1.01)	.061
Other	0.82 (0.56, 1.19)	.288	0.87 (0.61, 1.25)	.459
Married (ref = no)	0.72 (0.57, 0.9)	.004	0.87 (0.75, 1.01)	.067
Lives in facility (ref = no)	0.67 (0.44, 1.02)	.064	0.9 (0.71, 1.14)	.4
Dual eligible (ref = no)	1.44 (1.09, 1.9)	.011	1.5 (1.25, 1.8)	<.001
Count of underlying ambulatory care–sensitive conditions* (ref = 0)				
1	2.12 (1.23, 3.66)	.007	1.5 (1.2, 1.86)	<.001
2	2.91 (1.66, 5.1)	<.001	1.97 (1.6, 2.42)	<.001
3	5.51 (3.16, 9.63)	<.001	2.45 (1.86, 3.23)	<.001
4	12.24 (7.07, 21.18)	<.001	4.3 (2.98, 6.2)	<.001
5	17.11 (10.12, 28.92)	<.001	4.73 (3.25, 6.9)	<.001
Neuropsychiatric disorder (ref = none)	1.31 (1.05, 1.65)	.019	1.4 (1.22, 1.61)	<.001

*Conditions include diabetes, congestive heart failure, hypertension, asthma/chronic obstructive pulmonary disease, and coronary heart disease.

tions between stage and ACS versus non-ACS hospitalizations were statistically significant for stage II and stage IV.

Age 80 and older (vs. age under 65), being dual eligible (vs. not), and having a neuropsychiatric condition (vs. no condition) had a higher RR of hospitalization for both ACS and non-ACS hospitalizations. Being married (vs. not married) was associated with a lower risk of ACS hospitalization, but the RR was not statistically significant for non-ACS hospitalization. Race/ethnicity was not a significant predictor of either ACS or non-ACS hospitalization. Count of chronic ACS conditions was a significant predictor of both ACS and non-ACS hospitalizations, but the increase in RR of ACS hospitalization was much greater (Table 3).

In the analyses using any ADL limitation (combining stages I, II, III, and IV) as the primary predictor, the estimated adjusted RR (95 percent CI) of hospitalization for those with any ADL limitation versus no limitation was higher for ACS hospitalizations than for non-ACS hospitalizations (2.2 [1.7–2.9] vs. 1.6 [1.4–1.9]). A bootstrap analysis confirmed that this difference was statistically significant.

DISCUSSION

Our principal finding was that ACS hospitalization rates were higher for those with ADL limitations. Although there were almost twice as many beneficiaries without an ADL limitation, persons with ADL limitations had 600,000 more ACS hospitalizations than those with no limitations. After adjusting for baseline demographic and health characteristics, the RR for those with any limitations (stages I through IV combined) was over twice that of those with no limitation, with those at stage IV having over four times the RR. While participants with ADL limitations also had increased adjusted RR of non-ACS hospitalizations, the increases were not as great as they were for ACS hospitalization. Since ACS hospitalizations are a proxy for access to primary care, this excess risk may be due to access barriers faced by people with ADL limitations, particularly those at higher stages.

People with ADL limitations are also more likely to have traits and other circumstances known to enhance vulnerability to ACS hospitalization (Larson et al. 2001; Laditka 2003; Roos et al. 2005; Laditka and Laditka 2006; Balogh et al. 2010; Phelan et al. 2012; Yoon et al. 2012). We confirmed associations between higher ADL limitation stages and low income (CDC 2011), non-high school graduate, being unmarried, having neuropsychiatric conditions, and having an ACS condition (Balogh et al. 2010; Mathew, Young, and Shrestha 2012; Davydow et al. 2014). The higher rates of ACS hospitalization associated with ADL limitation stages persisted after controlling for these factors. Notably, unlike other studies, we did not find an effect of race/ethnicity on ACS hospitalizations.

Our study has several limitations. First, stage definitions depend on the wording of ADL questions. There are subtle differences in stage-threshold definitions in MCBS and LSOA-derived stages (Stineman et al. 2014). ADL stages used here may not generalize to other populations. This, however, would not affect our finding that those with ADL limitations have much higher ACS hospitalization rates. Second, people in Medicare HMOs were

excluded for reasons stated above, limiting generalizability. Third, although there was a graded relationship between ADL stage and ACS hospitalization rates in the fully adjusted model (with the exception of stage III), our estimates lacked precision, which may be attributable in part to the relatively small sample sizes at the higher stages. However, the adjusted estimates for stage II and IV for ACS hospitalization were significantly higher than those for non-ACS hospitalization, indicating excess risk at these higher stages. Fourth, we did not have measures of ACS condition severity and thus may have incompletely controlled for its effects. We addressed this by using count of ACS conditions as a proxy for ACS severity. Finally, there may be additional unmeasured confounders which could have influenced hospitalization rates.

Factors inherent to ADL limitations could be contributing to the enhanced risk. People with disabilities are more vulnerable to the negative effects of hospitalization which can cause further functional decline (Hoogerduijn et al. 2012), potentially leading to further access difficulties and increased hospitalization risk. Greater dependence on personal care to perform ADLs may lead to increased ACS hospitalization risk if care needs are not met. For example, 11.5 percent of Medicare recipients (20.9 percent of dual eligible) needing assistance getting out of bed reported having to stay in bed in the past month because of lack of assistance and 43 percent of those requiring assistance for toileting had wet or soiled themselves (Allen, Piette, and Mor 2014). Finally, hospitalization may be necessary when an ADL limitation precludes adequate management in the home setting.

Although disease severity and disability-related factors are important, the elevated risk of ACS hospitalizations compared with non-ACS hospitalizations at higher stages indicates that people at higher stages may be particularly vulnerable to these potentially avoidable hospitalizations. Although our study cannot definitively parse out what portion of the difference in ACS hospitalization rates is due to the severity of an underlying ACS condition versus what portion is due to disparities in access to or provision of care, it provides valuable information that can be combined with cost information to help with policy and programmatic planning aimed at addressing the unmet needs of people with disabilities. Even a modest 20 percent reduction in disability-related hospital rates could have tremendous implications for quality of life and health care costs.

Adults with disabilities are more likely to report unmet medical care needs (23 percent vs. 10 percent) or delayed care (40 percent vs. 24 percent) than those without disabilities (Henning-Smith et al. 2013). Adults with physical disabilities (compared to those without) have a higher adjusted odds of

having unmet medical (1.75), dental (1.57), or prescription drug (1.85) needs (Mahmoudi and Meade 2015). Despite having insurance, older insured adults with a disability were also more likely to delay health care because of cost compared with those without one (Lee, Hasnain-Wynia, and Lau 2012). Over a third (36 percent) of uninsured adults with a disability reported being unable to get necessary medical care compared with 9.5 percent of uninsured adults without a disability (Iezzoni, Frakt, and Pizer 2011).

Medicare beneficiaries with disabilities are also more likely to perceive economic and environmental barriers to accessing ambulatory health care compared with beneficiaries without disabilities (Rosenbach 1995; CDC 2006a). Furthermore, an onsite evaluation of health care facilities in California found that only 3.6 percent had an accessible scale and only 8.4 percent had a height adjustable examination table (Mudrick et al. 2012). These findings correspond to the experience reported by wheelchair users, over 90 percent of whom encountered accessibility barriers in primary care (Stillman et al. 2014). People with disabilities have reported other barriers such as social isolation, difficulty in obtaining resource information, unmet home modification needs, poor communication (lack of interpreter, lack of materials for visually impaired, etc.), time constraints, and attitudinal barriers (fear, patronization or experience of unfair treatment from care providers) (O'Day et al. 2005; CDC 2006b; Morrison, George, and Mosqueda 2008; Yee and Breslin 2010).

People with disabilities also face nonmedical care barriers which may affect their risk of ACS condition development and hospitalization. Despite the American with Disabilities Act and Healthy People 2020 promotion of educational material on improving the accessibility of fitness facilities (North Carolina Office on Disability and Health 2008), accessibility remains inadequate, with only 20 percent of surveyed facilities having accessible locker rooms and adaptive exercise equipment (Dolbow and Figoni 2015). Studies also show that people with disabilities have greater access barriers to healthy food (Mojtahedi et al. 2008). Thus, it is important to explore how community barriers may adversely affect primary and secondary prevention efforts to reduce incidence of chronic ACS conditions or their complications, in addition to investigating how to improve access in primary care.

ADL limitations combined with comorbidities may present unique challenges that should be addressed when managing those chronic conditions. The structure of ADL stages can provide insights into these unique challenges by classifying subgroups of people likely to face similar access issues because of their disabilities. In contrast to most published population measurements of

ADL limitation which describe severity by counting the number of limited ADLs (Culler, Parchman, and Przybylski 1998; Lubitz et al. 2003; Federal Interagency Forum on Aging Related Statistics 2012), ADL stages are embedded with information about which activities are and are not limited, in addition to measuring severity. This embedded information expresses more succinctly the nature of potential accessibility challenges experienced by patients in primary care. While patients at stage I can be expected to have difficulty walking down long halls to clinics, those at higher stages will also have problems dressing and toileting, presenting incrementally greater challenges during the clinical encounter. Staging enables a more focused targeting of potentially remediable barriers to ambulatory care access relative to stage-specific subpopulations.

In seeking strategies for lowering ACS hospitalization rates, future work should delineate how specific accessibility barriers affect people by ADL stage and which ones are most instrumental in increasing the risk of ACS hospitalizations in those with disability. Similarly, a better understanding of patterns of ambulatory care service underuse (Asch et al. 2000) according to stage could guide improvements in primary care that could facilitate the greatest possible increases in access and health care value with the goal of reducing acute events in these vulnerable subgroups of beneficiaries. The relationship of ADL stage, disease severity, and accessibility barriers to other health care quality measures like 30-day-rehospitalization rates is another important research area.

While people at higher ADL stages are sicker, it is too costly to assume that increased ACS hospitalization risk merely reflects the poorer health status of people with ADL limitations without further investigation (Iezzoni 2013; Krahn, Walker, and Correa-De-Araujo 2015). An extensive disability literature on unmet needs and access barriers supports the interpretation that the elevated rates observed may be due to disparities, not just health differences. Disentangling the health, social, and medical care aspects behind the higher risk of ACS hospitalizations faced by people with disabilities is challenging. Richer data are needed, particularly on environmental and attitudinal barriers. Developing interventions to address these barriers and measuring their effect on ACS hospitalization rates is vital. Ultimately, it is precisely because people at higher stages of ADL limitation are particularly vulnerable to the adverse effects of a preventable hospitalization that we need to be aggressive about addressing existing disparities. The solutions found will ultimately benefit the health of everyone.

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SUPPORTING INFORMATION

Additional supporting information may be found in the online version of this article:

Appendix SA1: Author Matrix.