THE GERONTOLOGICAL SOCIETY OF AMERICA®

Journals of Gerontology: Medical Sciences
cite as: *J Gerontol A Biol Sci Med Sci*, 2018, Vol. 73, No. 9, 1280–1286
doi:10.1093/gerona/glw335
Advance Access publication 19 January 2017

OXFORD

Research Article

Factors Associated With Accelerated Hospitalization and Re-hospitalization Among Medicare Home Health Patients

Matthew C. Lohman,[1,2] Emily A. Scherer,[3] Karen L. Whiteman,[1,2] Rebecca L. Greenberg,[4] and Martha L. Bruce[1,2]

[1]Department of Psychiatry, Geisel School of Medicine at Dartmouth, Lebanon, New Hampshire. [2]Department of Community and Family Medicine, Dartmouth Centers for Health and Aging, Lebanon, New Hampshire. [3]Department of Biomedical Data Science, Geisel School of Medicine at Dartmouth, Lebanon, New Hampshire. [4]Institute of Geriatric Psychiatry, Weill Cornell Medical College, White Plains, New York.

Address correspondence to Matthew C. Lohman, PhD, MHS, Department of Psychiatry, Geisel School of Medicine at Dartmouth, 46 Centerra Pkwy, Rm 240, Lebanon, NH 03766. E-mail: Matthew.C.Lohman@dartmouth.edu

Received August 30, 2016; Editorial Decision Date December 11, 2016

Decision Editor: Stephen Kritchevsky, PhD

Abstract

Background: Preventing hospitalizations and re-hospitalizations of older adults receiving Medicare home health (HH) services is a key goal for patients and care providers. This study aimed to identify factors related to greater risk of and earlier hospitalizations from HH, a key step in targeting preventive efforts.

Methods: Data come from Medicare mandated start-of-care assessments from 87,780 HH patients served by 132 agencies in 32 states, collected from January 2013 to March 2015. Using parametric accelerated failure time (AFT) survival models, we evaluated the association between key patient and environmental characteristics and the hazard of and time until hospitalization and re-hospitalization.

Results: In total, 15,030 hospitalizations, including 6,539 re-hospitalizations, occurred in the sample within 60 days of start of HH. Factors most strongly associated with substantially greater risk of and earlier hospitalization included male gender, history of hospitalization, polypharmacy, elevated depressive symptoms, greater functional disability, primary diagnoses of heart disease, chronic obstructive pulmonary disease, and urinary tract infection, and government-controlled agency care. In addition to these factors, black race and primary diagnosis of skin wounds were uniquely related to risk of earlier re-hospitalization.

Conclusions: Results suggest that factors collected during routine HH patient assessments can provide important information to predict risk of earlier hospitalization and re-hospitalization among Medicare HH patients. Identified factors can help identify patients at greatest risk of early hospitalization and may be important targets for agencies and care providers to prevent avoidable hospitalizations.

Keywords: Home care—Risk factors—Hospitalization

Home health (HH) care services represent a growing segment of healthcare spending and utilization for older adults in the United States. In 2013, approximately 3.5 million Medicare beneficiaries received HH services, a 37.8% increase since 2002 (1). Prompted by growth of HH, a number of quality improvement initiatives have focused on reducing the incidence of adverse patient outcomes such as hospitalizations, which may substantially reduce patient quality of life and limit functional independence (2,3). In particular, Medicare considers acute care re-hospitalizations within 30 days of discharge from hospital to be indicators of poor quality care that may negatively affect agency quality ratings and hospital reimbursement (4). Despite subsequent reductions in rates of hospitalization, approximately 16% of HH episodes result in hospitalization, and approximately 17% of HH episodes following a hospital stay result in re-hospitalization (5,6), suggesting need for more targeted means of prevention.

Despite focus on preventing hospitalizations, few contemporary studies have evaluated risk factors for hospitalizations on a national scale. Notably, Fortinsky and colleagues investigated factors associated with 30-day hospitalization risk among a nationally-representative sample of Medicare HH patients in 2002 (7). Using Medicare claims data and patient information from the Medicare mandated Outcome and Assessment Information Set (OASIS), the authors identified skin

wounds, heart failure, dyspnea severity, presence of depressive symptoms, and black race as factors most strongly associated with greater hospitalization likelihood (7). Additional studies have identified similar risk factors, but were generally limited by small sample sizes or focus on selected risk factors (8–11). Moreover, various changes to HH practices and reporting over the past decade, including revision of the OASIS mandatory assessment and the introduction of Outcomes-Based Quality Improvement (12,13), warrant renewed interest in identifying risk factors for hospitalization among HH patients.

Another important but frequently overlooked consideration in identifying hospitalization risk factors is timing of hospitalization. Over half of hospitalizations occur within the first 14–21 days of start of HH (8), and such observations have been used to inform preventive best practices for HH agencies treating vulnerable patients (14). Furthermore, although the specific causes of hospitalizations are frequently unclear, length of HH episodes may provide insights about likely causes of hospitalization, such as inadequate post-acute transition planning, poor HH practices, or other causes unrelated to care. Thus evaluating time-to-hospitalization may provide valuable knowledge to inform targeted preventive efforts.

The purpose of this study was to identify factors related to earlier hospitalization and re-hospitalization using electronic health records for a large (n = 87,870), heterogeneous sample of Medicare patients served by 132 independent HH agencies. Using a parametric survival model approach, we evaluated factors related to hazard of hospitalization and, by extension, time-to-hospitalization during 30-day and 60-day periods during start of care (SOC) HH episodes. Consistent with prior studies of HH hospitalization risk (7), we evaluated potential patient- and environmental-level factors as guided by Andersen's Behavioral Model of Health Service Use (15).

Methods

Sample

Patient data came from the Medicare OASIS and other electronic records stored by Brightree, LLC, a software company offering web-based technology as a subscription-based service to HH agencies. Agency personnel entered clinical data collected remotely at the point-of-care (ie, patients' homes) directly into the software company's centralized database for clinical tracking, referral, care planning, reporting, and billing. Electronic health records were obtained in the context of an agency-randomized implementation trial that offered agencies access to web-based resources to support their clinicians' use of a depression care management protocol. The protocol was integrated into the standard clinical software and available to all clinicians for use with patients who screened positive for depression on the OASIS.

This sample included all Medicare HH patients (age ≥ 65) who received a SOC Medicare OASIS assessment between January 1, 2013 and December 31, 2014. Analyses used data from initial (up to) 60-day episodes of care, including follow-up data up to March 1, 2015. For the subset of patients who started HH more than once over the 2-year period (n = 13,357), only the first episode was included in analysis. Analyses were conducted using data from 87,791 unique patient SOC episodes.

Patient records came from 132 HH agencies, located across 32 states. Agencies served an average of 333 patients per year, similar to national statistics (16). Patient sociodemographic characteristics (63.3% female, 33.2% ≥ age 86, 87.5% white, 11.1% black) were likewise similar to national data (16). Data collection and analysis were approved by the Weill Cornell Medical College and Dartmouth College Institutional Review Boards.

Measures

Outcomes

We used Medicare OASIS data to determine occurrence of and days until first hospitalization during patients' SOC HH episodes. Patient home health time (HH time) was defined as the number of days from HH initiation until patients were hospitalized. Patients were censored upon discharge from HH or at the end of the 30-day analytic period, whichever came first. We excluded 11 patients from analysis because their SOC and discharge dates were the same (ie, HH time = 0 days). We defined hospitalization as any acute care hospitalizalization occurring after HH initiation and prior to or upon discharge from HH. Re-hospitalization was analyzed in the subset of patients referred to HH from an acute or long-stay hospitalization. Additional analyses considered hospitalizations among patients referred from skilled nursing or rehabilitation facilities and hospitalizations occurring up to 60 days after SOC.

Independent variables

We obtained patient-level variables from OASIS assessments, completed by trained clinical staff at start of HH. OASIS indicators of physical, mental, and functional status have demonstrated adequate reliability and validity as collected by HH clinicians (16,17). Candidate variables, according to the Anderson Model, included *predisposing* sociodemographic characteristics, *enabling* factors related to personal resources and access to care, health-related *need* variables, and *environmental* features related to agency and regional differences in care (7,9–11,15).

Predisposing characteristics

Sociodemographic characteristics included age, gender, race, and ethnicity. We operationalized age as a continuous variable scaled to 5-year increments. Race and ethnicity were operationalized using indicator variables for each race (white, black, Asian, and other race) and ethnic group (Hispanic). Data regarding marital status, education, and socioeconomic status were not available from OASIS assessments.

Enabling factors

As proximal measures of access to care, we included indicators of dual Medicare and Medicaid eligibility, whether a patient lived alone (vs living with another person or in congregate housing), and patient's referral source (ie, hospital, skilled nursing facility, community, other).

Need factors

Most variables considered in analysis were related to patients' physical, mental, and functional health statuses and thus potential need for health services. Using OASIS ICD-9 codes, we created indicator variables for primary diagnoses, defined as the principal conditions for which the patients received HH. The analysis considered all primary diagnoses reported for >1% of the sample population, including: type II diabetes, heart disease, chronic obstructive pulmonary disease (COPD), skin ulcers or wounds, stroke, osteoarthritis, neurocognitive disorders, pneumonia, and urinary tract infections. We also created indicators for the most common V-codes, defined as supplementary factors influencing health status in lieu of disease conditions. V-code indicators included rehabilitative services following bone fracture and aftercare following surgery for joint replacement, neoplasm, or circulatory conditions. ICD-9 codes used to create primary diagnoses indicators are listed in Supplementary Table 1.

A variable for medical comorbidity was created by summing the number of patients' primary and up to five secondary ICD-9 diagnoses.

Functional status was defined by level of disability in nine activities of daily living—grooming, dressing upper body, dressing lower body, bathing, toilet transferring, toilet hygiene, transferring, ambulation, and feeding—and level of disability in 3 instrumental activities of daily living—planning and preparing light meals, managing oral and injectable medications, and using the telephone. For both activities of daily living and instrumental activities of daily living separately, we summed and standardized (Mean = 0, *SD* = 1) scores (ranging from independent to totally dependent) across all items, so that higher scores represented greater dependence on others. Pain interference with patient activity ranged from 0 (no pain) to 4 (pain interferes all the time). Dyspnea severity ranged from 0 (not short of breath) to 4 (dyspneic at rest). Cognitive function ranged from 0 (alert/oriented, able to focus and shift attention) to 4 (totally dependent due to cognitive disturbances). Depressive symptoms were measured using the two-item Patient Health Questionnaire (PHQ-2) depression screen (17) with elevated depressive symptoms defined as PHQ-2 score ≥ 3.

The 2010 OASIS introduced reporting of signs and symptoms characterizing patient risk for hospitalization and adverse health outcomes (13). These signs included recent decline in mental, emotional, or behavioral status, multiple previous hospitalizations, history of falls, taking five or more medications, and frailty indicators (13). General risk factors included current smoking, obesity, alcohol dependence, and drug dependence. HH nurses code each factor as either present or absent. While reliability of nurse assessment of these signs has not been evaluated, these factors have been identified as predictive of hospitalizations in previous literature (13).

Environmental factors

Environmental variables came from Medicare's 2013 and 2014 Provider of Service files, containing aggregate patient information for all Medicare reimbursed HH providers in the United States. Agency features included service region (Northeast, South, Midwest, West), rural versus metropolitan location, auspices (private, religious, or government-controlled), and whether the agency was hospital-based or freestanding. As study data were obtained in the context of an implementation trial that randomized agencies to web-based support for depression care management, analyses also controlled for agency randomization status. Rates of hospitalization did not differ by this variable ($\chi^2 = 0.02$, $p = .88$).

Analysis

Summary descriptive statistics were generated for all potential risk factors and compared across hospitalized and non-hospitalized patients using t-tests for dichotomous variables and χ^2 tests for categorical variables.

We used parametric accelerated failure time (AFT) survival models to assess predictor influence on hazard of and time-to-hospitalization (18,19). In AFT models, the dependent outcome of interest is time-to-event (eg, hospitalization), where covariates may be associated with earlier or later hospitalization. We present two complementary measures of covariate association with hospitalization, estimated from the same AFT models: hazard ratios (HR) and time ratios (TR). HRs represent the relative hazard (ie, instantaneous probability of an event) in one level of a predictor compared to another. An HR greater than one suggests a predictor associated with greater risk of hospitalization. By reorganizing AFT model terms, we also calculated TRs, representing the relative time-to-event associated with different levels of a predictor. For instance, a TR of $\alpha = 0.90$ associated with predictor x is interpreted as a mean time-to-hospitalization of 10% fewer days when $x = 1$ compared to when $x = 0$.

Multivariable AFT models were built in a stepped process. First, we fit crude AFT models with each potential predictor as an independent variable. Predictor variables were retained for inclusion in a final adjusted AFT model if they were associated with 10% greater or lower hazard of hospitalization. We fit parametric AFT models assuming different distributions for the baseline hazard function and compared model fit using Akaike Information Criterion (results not shown). A final model assuming a Weibull distribution (best fitting distribution) and including all significant predictors was fit to estimate HRs and TRs associated with each covariate. All models were adjusted for age, race/ethnicity, and gender.

All statistical analyses were performed using Stata software, version 14.1 (StataCorp, College Station, TX), and two-tailed p values of less than .05 were considered statistically significant.

Results

In total, 87,780 patients met eligibility criteria according to SOC OASIS records. As detailed in Table 1, 15,030 (17.1%) patients were hospitalized within 60 days of starting HH, 43.5% (n = 6,539) of which were re-hospitalizations. Most hospitalizations (n = 11,457, 76.2%) occurred in the first 30 days, with an average time until hospitalization of 19.7 days. Among patients discharged to a non-hospital setting prior to 30 days, average time until discharge was 25.0 days. Compared to patients who were not hospitalized, hospitalized patients were more likely to be men (40.7% vs 35.8%), to live with anothers (76.5% vs 73.2%), and to have been referred to HH from hospital (43.5% vs 40.0%); however, there were no substantial differences between hospitalized and non-hospitalized patients in terms of age, race, or ethnicity. Hospitalized patients also had greater functional and cognitive impairment, and substantially greater prevalence of previously identified risk factors such as dyspnea, elevated depressive symptoms, and frailty.

Hospitalization

As detailed in Table 2, several factors were associated with at least 10% greater or lower hazard of hospitalization within 30 days of care in fully adjusted AFT models. Women had 16% (HR: 0.84, 95% confidence interval [CI]: 0.81–0.87) lower hazard of hospitalization compared to men, while greater age was associated with slightly (3%) lower hazard of hospitalization. Among primary diagnoses, heart disease/failure, urinary tract infections, COPD, and skin wounds were associated with greater hazard of hospitalization. As would be expected, factors associated with greater hazard of hospitalization were associated with earlier hospitalization. Table 2 presents AFT model coefficients re-expressed in terms of the percent difference in time-to-hospitalization. The primary diagnoses of heart disease, urinary tract infection, and COPD were associated with reduced times-to-hospitalization of 29.8% (CI: 25.1%–34.2%), 22.1% (CI: 9.2%–33.0%), and 19.8%, (CI: 11.7%–27.1%), respectively. Relating these values to the sample mean time-to-hospitalization (19.7 days), a 29.8% reduction in time-to-hospitalization is equivalent to average hospitalization 5.9 days earlier (19.7 × 0.298 = 5.9) for patients with a primary diagnosis of heart disease compared to other primary diagnoses.

Table 1. Characteristics of the Study Sample by Hospitalization

	Total	Not Hospitalized	Hospitalized	
	87,780 *N* (%) or Mean (*SD*)	72,750	15,030	*p* value[a]
HH duration, days	32.9 (18.5)	35.7 (17.8)	19.7 (15.8)	
Sociodemographic characteristics				
Race				<.01
White	76,847 (87.5%)	63,875 (87.8%)	12,972 (86.3%)	
Black	9,697 (11.1%)	7,868 (10.8%)	1,829 (12.2%)	
Asian	672 (0.8%)	549 (0.8%)	123 (0.8%)	
Other	563 (0.6%)	457 (0.6%)	106 (0.7%)	
Hispanic ethnicity	1,696 (1.9%)	1,396 (1.9%)	300 (2.0%)	.53
Female	55,599 (63.3%)	46,688 (64.2%)	8,911 (59.3%)	<.01
Age years, mean (*SD*)	79.9 (8.5)	79.9 (8.5)	80.0 (8.4)	.08
Enabling factors				
Live alone	22,997 (26.2%)	19,470 (26.8%)	3,527 (23.5%)	<.01
Medicare & Medicaid eligible	2,978 (3.4%)	2,356 (3.2%)	622 (4.1%)	<.01
HH referral source				<.01
Hospital	35,638 (40.6%)	29,099 (40.0%)	6,539 (43.5%)	
Community	27,619 (31.5%)	23,530 (32.3%)	4,089 (27.2%)	
SNF/Rehab/Other	24,521 (27.9%)	20,119 (27.7%)	4,402 (23.3%)	
Need factors				
Needs ADL assistance	66,699 (76.0%)	54,501 (74.9%)	12,198 (81.2%)	<.01
PHQ-2 ≥ 3	3,520 (4.1%)	2,721 (3.8%)	799 (5.5%)	<.01
Poor cognitive functioning	15,490 (17.7%)	12,408 (17.1%)	3,082 (20.5%)	<.01
Pain interferes with activities daily	51,719 (58.9%)	43,043 (59.2%)	8,676 (57.7%)	<.01
Severe dyspnea	37,048 (42.2%)	28,936 (39.8%)	8,112 (54.0%)	<.01
History of multiple hospitalizations	25,557 (29.1%)	19,131 (26.3%)	6,426 (42.8%)	<.01
Taking five or more medications	78,163 (89.0%)	64,275 (88.4%)	13,888 (92.4%)	<.01
Frailty symptoms	29,516 (33.6%)	23,110 (31.8%)	6,406 (42.6%)	<.01
Environmental factors				
Rural location	17,061 (19.5%)	13,897 (19.1%)	3,164 (21.1%)	<.01
Hospital-based agency	17,520 (20.0%)	14,394 (19.8%)	3,126 (20.8%)	.01
Agency auspices				<.01
Government	9,043 (10.3%)	7,329 (10.1%)	1,714 (11.4%)	
Religious	1,679 (1.9%)	1,385 (1.9%)	294 (2.0%)	
Private for-profit	59,946 (68.4%)	49,768 (68.5%)	10,178 (67.8%)	
Private non-profit	16,968 (19.4%)	14,151 (19.5%)	2,817 (18.8%)	

Notes: ADL = activities of daily living; HH = home health; PHQ-2 = two-item Patient Health Questionnaire; SNF = skilled nursing facility.
[a]*p* values from chi-square tests for categorical and *t* test for continuous variables.

A number of independent medical and functional need factors were associated with greater hospitalization hazard and earlier hospitalization (Table 2). Factors associated with shorter time-to-hospitalization included history of multiple hospitalizations (TR: 36.5%, CI: 33.7%–39.2%), elevated depressive symptoms (TR: 15.7%, CI: 7.8%–22.8%), taking five or more medications (TR: 15.1%, 95% CI: 8.4%–21.4%), greater activities of daily living limitation (TR: 14.5%, CI: 12.6%–16.3%), severe dyspnea (TR:11.3%, CI: 9.5%–13.0%), and frailty symptoms (TR: 10.8%, CI: 7.8%–14.5%). Compared to mean hospitalization time, these reductions represent reduced time-to-hospitalization between 7.2 days (history of multiple hospitalizations) and 2.1 days (frailty symptoms). The only environmental factor associated with greater hazard of 30-day hospitalization was government ownership. On average, patients served by government-owned agencies were hospitalized 14.0% or 2.8 days sooner than patients served by private agencies.

Re-hospitalization

Table 2 displays re-hospitalization models, restricting analysis to patients referred to HH from a hospital (*n* = 35,638, 40.1%). In general, coefficient estimates for re-hospitalizations were consistent with those for hospitalizations, with notable exceptions. First, whereas race was not significantly associated with hospitalization hazard, black patients had significantly greater hazard (HR: 1.12, CI: 1.03–1.22) of and 11% shorter time until re-hospitalizations compared to white patients. Second, while a majority (55%) of patients with COPD were referred to HH from a hospital setting, COPD was not associated with shorter time until re-hospitalization. Finally, the association between skin wound/ulcer and re-hospitalization (HR: 1.23, CI: 1.01–1.50; TR: 19.6%, CI: 0.0%–35.0%) was approximately double the association between skin wound/ulcer and hospitalization.

Results from AFT models over a 60-day HH period were similar to 30-day models (Supplementary Table 2). Notably, the greatest differences between 30-day and 60-day models were for HRs and TRs associated with elevated depressive symptoms. Compared to the 30-day HR for elevated depressive symptoms (HR: 1.17, CI: 1.08–1.27) the 60-day HR was diminished (HR: 1.11, CI: 1.04–1.20), suggesting that the hazard associated with depressive symptoms is greatest earlier in HH episodes.

Model results estimating hazard of hospitalization among patients referred from a skilled nursing or rehabilitation facility (*n* = 23,881)

Table 2. Accelerated Failure Time Models of Hospitalization (n = 15,030)

	30-day Hospitalization				30-day Re-hospitalization			
	HR	95% CI	TR	p value[a]	HR	95% CI	TR	p value[a]
Predisposing characteristics								
Race/ethnicity (ref: white/non-Hispanic)								
Asian	1.01	(0.82, 1.25)	−1.1%	.93	1.01	(0.76, 1.34)	−1.5%	.92
Black	0.99	(0.93, 1.05)	1.2%	.72	1.11	(1.02, 1.21)	−10.9%	.01
Hispanic	0.95	(0.83, 1.10)	5.4%	.50	0.92	(0.75, 1.14)	9.4%	.44
Female	0.84	(0.80, 0.87)	21.4%	<.01	0.85	(0.80, 0.90)	19.9%	<.01
Age (5 y)	0.97	(0.96, 0.98)	3.5%	<.01	0.99	(0.97, 1.00)	1.5%	.12
Need factors								
Skin wound/ulcer	1.07	(0.98, 1.18)	−7.4%	.14	1.22	(1.00, 1.49)	−19.6%	.05
Heart disease/failure	1.39	(1.31, 1.48)	−29.8%	<.01	1.28	(1.18, 1.39)	−23.6%	<.01
COPD	1.23	(1.12, 1.34)	−19.8%	<.01	1.01	(0.90, 1.15)	−1.4%	<.01
Urinary tract infection	1.26	(1.09, 1.46)	−22.1%	<.01	1.09	(0.91, 1.31)	−8.8%	.37
Dyspnea severity	1.12	(1.10, 1.14)	−11.3%	<.01	1.13	(1.10, 1.16)	−12.2%	<.01
ADL limitation	1.16	(1.13, 1.18)	−14.5%	<.01	1.16	(1.13, 1.20)	−14.9%	<.01
PHQ-2 ≥ 3	1.17	(1.08, 1.27)	−15.7%	<.01	1.20	(1.05, 1.38)	−18.3%	.01
History of multiple hospitalizations	1.52	(1.47, 1.59)	−36.5%	<.01	1.47	(1.39, 1.56)	−34.3%	<.01
Taking five or more medications	1.16	(1.08, 1.25)	−15.1%	<.01	1.13	(1.01, 1.26)	−12.3%	.03
Frailty symptoms	1.11	(1.07, 1.16)	−10.8%	<.01	1.13	(1.06, 1.20)	−12.1%	<.01
Drug dependence	1.19	(0.87, 1.63)	−17.3%	.27	1.31	(0.85, 2.02)	−25.2%	.23
Environmental factors								
Government-owned agency (ref: private non-profit)	1.15	(1.07, 1.23)	−14.0%	<.01	1.10	(1.00, 1.21)	−9.7%	.05

Notes: ADL = activities of daily living; COPD = chronic obstructive pulmonary disease; HR = hazard ratio; TR = time ratio (expressed as % change in time to hospitalization); 95% CI = 95% confidence interval.

[a]p values apply to both HR and TRs.

are shown in Supplementary Table 3. HR and TR estimates were similar to those for the overall sample and so are not discussed.

Discussion

More than one in seven HH episodes in the United States result in hospitalizations or re-hospitalizations that may substantially diminish patients' health and quality of life. This study identified several patient and environmental factors related to increased likelihood of and earlier hospitalization, including demographic factors, clinical status, and agency ownership. Furthermore, this study identified key characteristics related uniquely to re-hospitalizations from post-acute HH, such as skin wounds/ulcers and black race. Findings from this study may be important for informing more effective HH practices and interventions aimed at reducing hospitalization risk.

Despite considerable policy and practice changes aimed at reducing hospitalizations from HH, few recent studies have evaluated potential impact of these changes on hospitalization risk. In general, our results are consistent with past research identifying conditions and independent signs related to hospitalization. That is, patients with primary diagnoses of heart disease, COPD, urinary tract infection, and skin wound had significantly greater hazard of hospitalization. Indeed, targeting care and support to patients with these and other high-risk medical conditions has formed the basis of existing programs to reduce hospitalizations (20).

Consistent with previous work, we found that more severe dyspnea, greater functional limitations, and greater depressive symptoms were associated with greater hazard of hospitalization (7,10). These risk factors are particularly notable, as they may be ameliorated within the context of brief HH periods. Recent evidence suggests that interventions which address these factors also reduce hospitalization risk. For example, our group demonstrated that HH patients receiving care from nurses trained in depression care management had 35% lower risk of 30-day hospitalization compared to patients receiving usual care (21). Likewise, a coordinated care intervention focused on improving patient activities of daily living functioning was successful in reducing hospitalizations (22). The present results indicate that efforts to address polypharmacy or physical frailty symptoms, for instance, might similarly help reduce hospitalizations during HH.

This study provides further evidence that HH patients are at greatest risk of hospitalization within the first weeks of HH. Over 25% of hospitalizations occurred in the first 6 days and over 50% occurred in the first 2 weeks. Building on these observations, we identified a set of risk factors associated individually with up to 36.5% or 7.2 days earlier hospitalization. These findings underscore the importance of addressing and monitoring risk factors during high-risk periods. Factors associated with accelerated hospitalization, alone or in combination, could be used to identify patients at risk for hospitalization during the important first 2 weeks of care. Reflecting this importance, previous studies suggest that concentrating HH visits or supplementing visits with telehealth during high-risk periods may reduce hospitalizations among some patients (14,20); however, such programs may not be feasible for all or even most patients or agencies. Therefore, identifying patients with a greater number of factors associated with earlier hospitalization may help target time-sensitive interventions, improving their effectiveness and feasibility.

Re-hospitalizations of patients discharged from acute care hospitals represent especially undesirable outcomes, as reflected by Medicare's focus on reducing hospital readmissions (4). We found that, in general, factors related to hospitalizations were also associated with re-hospitalizations. Contrary to prior studies that found a greater

risk of hospitalizations among black HH patients (7), we found no racial differences in hospitalization risk; however, black patients had a significantly greater risk of re-hospitalization. The reasons for this difference are unclear. A previous study found that black and Hispanic patients were more likely to be readmitted to hospitals than white patients when discharged to skilled nursing facilities following stroke (23). The authors suggested that racial differences in mortality and end-of-life care decisions may explain these findings (23). Nevertheless, we found no racial differences in terms of mortality, discharge to hospice, or discharge to skilled nursing facilities. A potential explanation is that racial differences in care occur prior to HH, during hospital discharge and transitional periods. While we were unable to evaluate this hypothesis, a number of prior studies have demonstrated the importance of transitional care processes and discharge planning for reducing hospitalizations among high-risk patients (24–27).

In addition to identifying demographic, diagnostic, and functional risk factors, this study provides partial validation hospitalization and general risk factor questionnaires, introduced to OASIS assessments in 2010 (13). Questionnaire items, including patient history of multiple hospitalizations, taking five or more medications, frailty symptoms, and drug dependence were among the strongest predictors of hospitalization. Thus, the hospitalization risk questionnaire may be an important and expedient clinical tool for evaluating risk. Despite this potential strength, lack of evidence regarding its reliability and use as a decision-making tool precludes its use as the sole basis for identifying high-risk patients until further research determines consistency across clinicians and agencies.

Results should be interpreted in light of potential limitations. First, while geographically and demographically diverse, the study sample does not constitute a nationally-representative sample, limiting generalizability of findings. Nevertheless, the sample had considerable heterogeneity in agency location (32 states), size, and demographic makeup which were similar to national averages (16). Second, study data were derived from electronic health records, the rigor and accuracy of which may differ between clinicians and agencies completing assessments. Although models accounted for some environmental variation, unknown inter- and intra-agency differences in reporting may limit reliability of assessments. Third, we were unable to determine whether patients were hospitalized after discharge from HH thereby limiting inferences to only hospitalizations occurring during HH or upon discharge.

Strengths of this study include a large and diverse sample and investigation of alternative outcomes. By using AFT survival models, this study evaluated risk factors in terms of time-to-hospitalization, an important consideration in both HH practices and interventions aimed at reducing hospitalizations. Furthermore, this study builds on prior work by determining factors related to re-hospitalizations, a key focus of Medicare reimbursement policy. The relative consistency of results across sub-samples further strengthens confidence in our findings.

Preventing hospitalizations and re-hospitalizations has become a priority for healthcare providers, yet hospitalizations from HH settings are still common. This study suggests key markers for identifying patients at greatest risk of hospitalization and targets for mitigating risk through policy and practice change in HH agencies and hospitals. The challenge remains for future work to find practical methods for reducing hospitalizations, guided by these findings.

Supplementary Material

Supplementary data are available at *The Journals of Gerontology, Series A: Biological Sciences and Medical Sciences* online.

Funding

This work was supported by grants from the National Institute of Mental Health at the National Institutes of Health (R01 MH096441, T32 MH073553).

Conflict of Interest

The authors have no potential conflicts of interest to disclose.

References

1. Medicare Payment Advisory Commission. *Report to the Congress: Medicare Payment Policy*. Washington, DC: Medicare Payment Advisory Commission; 2015:213–236.
2. Covinsky KE, Palmer RM, Fortinsky RH, et al. Loss of independence in activities of daily living in older adults hospitalized with medical illnesses: increased vulnerability with age. *J Am Geriatr Soc*. 2003;51:451–458. doi:10.1046/j.1532-5415.2003.51152.x
3. Mudge AM, O'Rourke P, Denaro CP. Timing and risk factors for functional changes associated with medical hospitalization in older patients. *J Gerontol A Biol Sci Med Sci*. 2010;65A:866–872. doi:10.1093/gerona/glq069
4. Patient Protection and Affordable Care Act. 2010; 42 U.S.C. § 18001 et seq.
5. Centers for Medicare & Medicaid Services. Home Health Compare: Process and Outcome Quality Measures. https://www.medicare.gov/HomeHealthCompare/Data/List-Quality-Measures.html. Accessed July 2, 2016.
6. Alliance for Home Health Quality and Innovation. *Home Health Chartbook 2015*. Washington, DC: Avalere Health; 2015:60.
7. Fortinsky RH, Madigan EA, Sheehan TJ, Tullai-McGuinness S, Kleppinger A. Risk factors for hospitalization in a national sample of Medicare home health care patients. *J Appl Gerontol*. 2014;33:474–493. doi:10.1177/0733464812454007
8. Rosati RJ, Huang L. Development and testing of an analytic model to identify home healthcare patients at risk for a hospitalization within the first 60 days of care. *Home Health Care Serv Q*. 2007;26:21–36. doi:10.1300/J027v26n04_03
9. Sheeran T, Byers AL, Bruce ML. Depression and increased short-term hospitalization risk among geriatric patients receiving home health care services. *Psychiatr Serv*. 2010;61:78–80. doi:10.1176/appi.ps.61.1.78
10. Fortinsky RH, Madigan EA, Sheehan TJ, Tullai-McGuinness S, Fenster JR. Risk factors for hospitalization among Medicare home care patients. *Western J Nurs Res*. 2006;28:902–917. doi:10.1177/0193945906286810
11. O'Connor M. Hospitalization among Medicare-reimbursed skilled home health recipients. *Home Health Care Manag Pract*. 2012;24:27–37. doi:10.1177/1084822311419498
12. Centers for Medicare & Medicaid Services. *Outcome-Based Quality Improvement (OBQI) Manual*. Washington, DC: Centers for Medicare & Medicaid Services; 2010.
13. Centers for Medicare & Medicaid Services. *OASIS-C Guidance Manual. Vol Revised*. Washington, DC: Centers for Medicare & Medicaid Services; 2011.
14. Rogers J, Perlic M, Madigan EA. The effect of frontloading visits on patient outcomes. *Home Healthc Nurse*. 2007;25:103–109. doi:00004045-200702000-00011
15. Andersen RM. Revisiting the behavioral model and access to medical care: does it matter? *J Health Soc Behav*. 1995;36:1–10.
16. The National Association for Home Care and Hospice. *Basic Statistics About Home Care*. Washington, DC: The National Association for Home Care and Hospice; 2010. http://www.nahc.org/assets/1/7/10hc_stats.pdf. Accessed July 2, 2016.
17. Kroenke K, Spitzer RL, Williams JBW. The Patient Health Questionnaire-2: validity of a Two-Item Depression Screener. *Med Care*. 2003;41:1284–1292. doi:10.1097/01.MLR.0000093487.78664.3C
18. Collett D. *Modelling Survival Data in Medical Research*. Boca Raton, FL: Chapman & Hall; 1994.

19. Wei LJ. The accelerated failure time model: a useful alternative to the Cox regression model in survival analysis. *Stat Med*. 1992;11:1871–1879. doi:10.1002/sim.4780111409
20. Woods LW, Snow SW. The impact of telehealth monitoring on acute care hospitalization rates and emergency department visit rates for patients using home health skilled nursing care. *Home Healthc Nurse*. 2013;31:39–45. doi:10.1097/NHH.0b013e3182778dd3
21. Bruce M, Lohman M, Greenberg R, Bao Y, Raue P. Integrating depression care management into Medicare home health reduces risk of 30 and 60 day hospitalization: the Depression Care for Patients at Home cluster-randomized trial. *J Am Geriatr Soc*. 2016;64:2196–2203. doi:10.1111/jgs.14440
22. Tinetti ME, Charpentier P, Gottschalk M, Baker DI. Effect of a restorative model of posthospital home care on hospital readmissions. *J Am Geriatr Soc*. 2012;60:1521–1526. doi:10.1111/j.1532-5415.2012.04060.x
23. Kind AJH, Smith MA, Liou J, Pandhi N, Frytak JR, Finch MD. Discharge destination's effect on bounce-back risk in black, white, and hispanic acute ischemic stroke patients. *Arch Phys Med Rehabil*. 2010;91:189–195. doi:10.1016/j.apmr.2009.10.015
24. Naylor MD, Aiken LH, Kurtzman ET, Olds DM, Hirschman KB. The importance of transitional care in achieving health reform. *Health Aff*. 2011;30:746–754. doi:10.1377/hlthaff.2011.0041
25. Jack BW, Chetty VK, Anthony D, et al. A reengineered hospital discharge program to decrease rehospitalization: a randomized trial. *Ann Intern Med*. 2009;150:178–187. doi:10.7326/0003-4819-150-3-200902030-00007
26. Koehler BE, Richter KM, Youngblood L, et al. Reduction of 30-day post-discharge hospital readmission or emergency department (ED) visit rates in high-risk elderly medical patients through delivery of a targeted care bundle. *J Hosp Med*. 2009;4:211–218. doi:10.1002/jhm.427
27. Voss R, Gardner R, Baier R, Butterfield K, Lehrman S, Gravenstein S. The care transitions intervention: translating from efficacy to effectiveness. *Arch Intern Med*. 2011;171:1232–1237. doi:10.1001/archinternmed.2011.278