View metadata, citation and similar papers at core.ac.uk
brought to you by CORE
provided by Dartmouth Digital Commons (Dartmouth College)

Dartmouth College
Dartmouth Digital Commons

Open Dartmouth: Faculty Open Access Articles

5-20-2014

Health System Characteristics and Rates of Readmission After Acute Myocardial Infarction in the United States

Jeremiah R. Brown
Dartmouth College

Chiang-hua Chang
Dartmouth College

Weiping Zhou
Dartmouth College

Todd A. MacKenzie
Dartmouth College

David J. Malenka
Dartmouth College

See next page for additional authors

Follow this and additional works at: https://digitalcommons.dartmouth.edu/facoa

Part of the Medicine and Health Sciences Commons

Recommended Citation

Brown, Jeremiah R.; Chang, Chiang-hua; Zhou, Weiping; MacKenzie, Todd A.; Malenka, David J.; and Goodman, David C., "Health System Characteristics and Rates of Readmission After Acute Myocardial Infarction in the United States" (2014). *Open Dartmouth: Faculty Open Access Articles*. 3613.
https://digitalcommons.dartmouth.edu/facoa/3613

This Article is brought to you for free and open access by Dartmouth Digital Commons. It has been accepted for inclusion in Open Dartmouth: Faculty Open Access Articles by an authorized administrator of Dartmouth Digital Commons. For more information, please contact dartmouthdigitalcommons@groups.dartmouth.edu.

Authors
Jeremiah R. Brown, Chiang-hua Chang, Weiping Zhou, Todd A. MacKenzie, David J. Malenka, and David C. Goodman

This article is available at Dartmouth Digital Commons: https://digitalcommons.dartmouth.edu/facoa/3613

ORIGINAL RESEARCH

Health System Characteristics and Rates of Readmission After Acute Myocardial Infarction in the United States

Jeremiah R. Brown, PhD, MS; Chiang-Hua Chang, PhD; Weiping Zhou, MS; Todd A. MacKenzie, PhD; David J. Malenka, MD, MS; David C. Goodman, MD, MS

Background—Interventions to reduce early readmissions have focused on patient characteristics and the importance of early follow-up; however, less is known about the characteristics of health systems, including quality, capacity, and intensity, and their influence on readmission rates in the United States. Therefore, we examined the association of hospital patterns of medical care with rates of 30-day readmission.

Methods and Results—Medicare beneficiaries hospitalized for an AMI (n=188 611) between 2008 and 2009 in 1088 hospitals in the United States were included in our cohort. We tested the association between hospital patterns of medical care quality (discharge planning care quality), capacity (hospital size measured as the number of beds, hospital-level Medicare all medical admission rates, supply of primary care physicians and cardiologists), and intensity (measures of care during the last 6 months of life) on CMS risk-adjusted rates of 30-day readmission using Poisson multilevel mixed-effects models adjusting for patient- and hospital-level covariates. There were 38 350 readmissions at 30-days (20.3%) AMI discharges. Controlling for patient characteristics, measures of hospital care associated with higher rates of readmission included higher hospital-level rates for all medical admissions, per capita primary care physicians and cardiologists, and last 6 months of life care intensity measures including increased number of hospital days, number of ICU days, number of physician visits, and 10 or more different physicians seen during the last 6 months of life. Better discharge quality and larger hospitals were associated with lower rates of readmission.

Conclusions—In addition to quality of care, high 30-day readmission rates are associated with hospital-level measures of capacity and intensity. Efforts to reduce readmission rates may need to address these broader patterns of medical care. **(*J Am Heart Assoc*. 2014;3:e000714 doi: 10.1161/JAHA.113.000714)**

Key Words: Acute myocardial infarction • readmission • rehospitalization • Medicare • epidemiology • outcomes

One in 5 older adults in the United States are rehospitalized within 30 days of a medical or surgical hospital stay, costing Medicare over $17 billion dollars annually.[1] In an effort to engage hospitals to reduce readmissions, the Affordable Care Act directed the Centers for Medicare and Medicaid Services (CMS) to institute the hospital readmissions reduction program (HRRP) with Medicare reimbursement penalties for hospitals with higher than expected rates or readmission beginning in fiscal year 2013. Currently, 61% of US hospitals have reimbursement penalties that average 0.24% with 10% of hospitals facing the highest penalty of 1%.[2]

Clinicians and health systems have focused efforts on identifying patients at a high risk of readmission and improving the quality of inpatient clinical processes of care, care transitions, and post-discharge continuity of outpatient care.[3,4] Recent evidence suggests that non-clinical factors of regional quality and supply of health care may also influence readmission rates. Non-clinical factors include regional baseline admission rates and bed supply.[5] However, other novel measures of health care intensity and capacity have not been fully evaluated with rates of readmission. Furthermore, these measures have not been evaluated at the patient and hospital level. In addition, current investigations have not incorporated patient-level risk adjustment methods used by CMS for calculating readmission penalties.

In this paper, we test the hypothesis that hospital-specific patterns of medical care quality, capacity, and intensity of

From the Dartmouth Institute for Health Policy and Clinical Practice, Geisel School of Medicine at Dartmouth, Lebanon, NH (J.R.B., C.-H.C., W.Z., T.A.M., D.J.M., D.C.G.); Section of Cardiology, Department of Medicine, Dartmouth Hitchcock Medical Center and Geisel School of Medicine, Lebanon, NH (J.R.B., D.J.M.); Department of Pediatrics, Geisel School of Medicine, Lebanon, NH (D.C.G.).

Accompanying Tables S1 through S3 are available at http://jaha.ahajournals.org/content/3/3/e000714/suppl/DC1

Correspondence to: Jeremiah R. Brown, PhD, MS, HB 7505 DHMC One Medical Center Drive, Lebanon, NH. E-mail: jbrown@Dartmouth.edu

Received January 17, 2014; accepted April 11, 2014.

© 2014 The Authors. Published on behalf of the American Heart Association, Inc., by Wiley Blackwell. This is an open access article under the terms of the Creative Commons Attribution-NonCommercial License, which permits use, distribution and reproduction in any medium, provided the original work is properly cited and is not used for commercial purposes.

health care at the end of life, are important factors in predicting 30-day readmission rates for acute myocardial infarction (AMI).

Methods

Setting and Participants

We first identified 2008 and 2009 100% fee-for-service Medicare beneficiaries age 66 and over with Part A and Part B coverage who had an AMI hospitalization based on principal discharge diagnosis ICD-9 codes 410.00, 410.01, 410.10, 410.11, 410. 20, 410.21, 410.30, 410.31, 410. 40, 410.41, 410.50, 410.51, 410.60, 410.61, 410.70, 410.71, 410. 80, 410.81, 410.90, and 410.91, excluding 410.×2 (AMI, subsequent episode of care) using the Medicare Denominator and Medicare Provider Analysis and Review (MEDPAR) Files. AMI admissions were excluded if the patient was hospitalized for any reasons within 3 months prior to the AMI admission. For patients with more than one AMI admission during the study period, we randomly selected only one of the AMI admissions per beneficiary for inclusion in the cohort. The study cohort was further limited to hospitals with complete data on all measures of quality, capacity, and intensity and with at least 50 AMI discharges to assure statistical stability. In total, there were 188 611 index AMI admissions across 1088 hospitals. Patients were also assigned to the Hospital Service Area (HSA) of residence for hospital service area measures. HSAs are defined geographic service areas representing hospital use of care previously described by the Dartmouth Atlas of Healthcare.[6]

Design Overview

We studied the factors associated with 30-day readmissions in elderly Medicare beneficiaries with an initial admission for AMI. The unit of analysis was the patient with models incorporating system factors at the hospital or HSA level in addition to patient level covariates. We examined 3 categories of medical care: quality, capacity, and intensity. Medical care quality was assessed from the 2007 Hospital Consumer Assessment of Healthcare Providers and Systems (HCAHPS) on answering yes to both of these questions involving discharge: "During this hospital stay, did doctors, nurse or other hospital staff talk with you about whether you would have the help you needed when you left the hospital?" and "During the hospital stay, did you get information in writing about what symptoms or health problems to look out for after you left the hospital?" We also included a quality measure of hospital care transitions defined by whether or not a patient visited a primary care physician within 14 days of discharge.[7] All measures were calculated at the hospital level except for all medical admission rate, primary care provider supply and cardiologist supply, which were calculated at the HSA level to represent broader system capacity in the area.[6–9] For these 3 measures, patients were assigned to their HSA of residence. Medical care capacity was assessed using the hospital or HSA level for all medical admission rates, hospital size as a measure of the number of beds, and per capita physician workforce supply measured by the Dartmouth Atlas of Healthcare (HSA level).[7,8] Medical care intensity at the hospital level was assessed using measures of intensity of care in the last 6 months of life: total hospital days, total intensive care unit days, number of physician visits, and 10 or more different physicians seen by the Dartmouth Atlas (all measured at the hospital level).[9] This study was approved the Institutional Review Board.

Outcomes and Follow-Up

The outcome of interest was all-cause 30-day readmissions from the AMI discharge to any acute care hospital,[7] excluding readmissions for elective percutaneous coronary intervention or coronary artery bypass graft surgery.

Patient-level risk factors defined in the CMS AMI risk model were abstracted from MEDPAR (in-patient), Carrier (physicians), and Outpatient files (health centers) during the year preceding and including the index AMI.[10] All patterns of medical care quality, capacity, and intensity were calculated by the Dartmouth Atlas of Healthcare.[6–9] All measures were calculated at the hospital level except for all medical admission rates, primary care provider supply, and cardiologist supply, which were calculated at the HSA level to represent broader system capacity in the area.[6–9] For these 3 measures, patients were assigned to their HSA of residence. Discharge quality was assessed from the 2007 Hospital Consumer Assessment of Healthcare Providers and Systems (HCAHPS) as a yes answer to both of these questions involving discharge: "During this hospital stay, did doctors, nurse or other hospital staff talk with you about whether you would have the help you needed when you left the hospital?" and "During the hospital stay, did you get information in writing about what symptoms or health problems to look out for after you left the hospital?" We also determined if each patient visited a primary care physician within 14 days after discharge from the Medicare Carrier and Outpatient data files. We identified PCP vistis for each patient as follows: we selected ambulatory claims from Medicare Part B using CPT, place of service, and physician specialty codes. We abstracted Rural Health Clinic and Federally Qualifying Heath Clinic claims from the Medicare Outpatient file. Visits that occurred on the same day as the AMI index date were not counted; otherwise visits occurring up to 14 days from the discharge date were counted as a PCP visit. The all-medical admission rate was calculated at the HSA levels for 2008. Hospital size was measured as the number of hospital beds for 2008.[8] The 2006 primary care physician and cardiologist workforce supply at the HSA level were obtained from the Dartmouth Atlas project.[8] The rate of patients visiting a primary care physician within 14 days after discharge was calculated at the hospital level. As covariates in our models, we also used hospital-level covariates that the Dartmouth Atlas project identified as medical care intensity measures (2007): last 6 months of life measures of hospitals days, intensive care unit days, and seeing more than 10 different physicians.[9] We conducted sensitivity analyses removing deceased patients within the first 30 days where the date of death from the Medicare denominator file is through year 2010.

Statistical Analysis

Using univariate poisson regression we tested the association between quartiles of hospital-level measures of quality, capacity, and intensity with 30-day readmission. We then used hierarchical binary regression models, with random effect for hospital to test the association of measures of quality, capacity, and intensity of medical care on 30-day readmission adjusting for patient- and system-level covariates. Poisson regression was used in order to yield risk rates. The sandwich variance was used to determine the standard error of rates. Two modeling approaches were conducted: simple and full. *Simple models:* Using hierarchical Poisson regression, the statistical significance of each factor was evaluated comparing each quartile with the 1st quartile (lowest, referent). These simple models also included patient-level probability of 30-day readmission using patient-level risk factors of readmission derived from the CMS AMI readmission model.[10] *Full model:* We then included all variables in a Poisson multivariable model with the patient predicted probability of readmission using the CMS AMI readmission model.[10] To determine if the effects of these measures on 30-day readmission were consistent among all AMI patients alive at 30 days, we conducted a sensitivity analysis that excluded all patients deceased within 30 days of discharge.

Results

Overall there were 188 611 Medicare AMI patients across 1088 hospitals during the study period with 38 350 readmissions at 30-days (20.3%) (Table 1). There was an average of 116 AMI discharges per hospital. The mean age was 78.4 years with 51.6% male. Measures of hospital quality (discharge planning and proportion of patients visiting a primary care provider within 14 days of the AMI discharge), capacity (physician supply, hospital size, and all medical admissions), and intensity measures (last 6 months of life total hospital days, total ICU days, number of physicians seen, and ≥10 different physicians seen) are reported in Table 1.

Table 1. Hospital and Patient Characteristics and Measures of Readmission

	Frequency or Mean (SD)
Patient characteristics	
Number of AMI patients, n	188 611
Number of AMI patients per hospital	116 (125)
Mean age, y	78.4 (7.7)
Male sex, %	51.6 (50.0)
Black race, %	6.5 (24.6)
Health system characteristics	
Number of hospitals, n=1088	1088
Academic hospitals, %	8.5 (27.9)
Hospital outcomes	
30-day readmission rate, %	20.3 (6.4)
Number of readmissions, n	38 350
Case mix: predicted probability of readmission, %	21.6 (7.1)
30-day death rate, %	3.6 (18.6)
Measures of quality, capacity, and intensity	
Quality measures	
Discharge planning: HCAHPS (%, hospital level)	79.2 (4.6)
PCP visit within 14-days (%, hospital level)	60.7 (11.6)
Capacity measures	
PCPs per 100 000 population (HSA level)	72.2 (18.8)
Cardiologists per 100 000 population (HSA level)	6.6 (2.9)
Hospital size (average number of beds, hospital level)	396 (264)
All medical admission rates per 1000 beneficiaries (HSA level)	244 (41)
Intensity measures	
Last 6 months of life hospital days (hospital level)	13.4 (3.1)
Last 6 months of life ICU days (hospital level)	4.5 (2.4)
Last 6 months of life number of physician visits (hospital level)	36.8 (11.9)
Last 6 months of life 10 or more physicians seen (hospital level)	10.1 (2.0)

The value is the percentage of patients responding affirmatively to 2 questions about discharge planning on the Hospital Consumer Assessment of Healthcare Providers and Systems (HCAHPS) survey: “During this hospital stay, did doctors, nurse or other hospital staff talk with you about whether you would have the help you needed when you left the hospital?” and “During the hospital stay, did you get information in writing about what symptoms or health problems to look out for after you left the hospital?” AMI indicates acute myocardial infarction; HSA, hospital service area; ICU, intensive care unit; PCP, primary care physician.

We characterize the association of these measures of quality, capacity, and intensity by quartiles of the study population (AMI discharges) with 30-day readmission in Table 2. Better discharge planning quality and larger hospital size as measured by the number of hospital beds were significantly associated with lower 30-day readmission after AMI (Table 2). Higher area rates of Medicare all medical admissions, supply of primary care physicians and cardiologists were significantly associated with higher rates of 30-day readmission. All measures of hospital care intensity during the last 6 months of life (total hospital days, intensive care unit days, number of physician visits, and ≥10 different physicians seen) were significantly associated with higher 30-day readmission. However, the rate of patients visiting a primary care physician within 14 days of AMI discharge, a measure of hospital care transitions, was not associated with significantly lower 30-day readmission except for the highest quartile.

In multivariable hierarchical models, controlling for patient characteristics, significant associations with 30-day readmission at the patient and hospital level were observed and reported in Table 3. Table 3 stratifies these models into *simple* (evaluating each measure separately while adjusting for the CMS Readmission model factors) and *full* models (combining all measures into 1 model while adjusting for the CMS Readmission model factors). Quality measures: the third and fourth quartiles of discharge planning were significantly associated with lower 30-day readmission, however seeing a primary care physician within 14 days was not significantly protective against 30-day readmission. Capacity measures: all quartiles of hospital size (number of beds) were associated with significantly lower 30-day readmission, while all quartiles of the rates of Medicare all medical admission was associated with significantly higher 30-day readmission. In addition, only the highest quartile of per capita rates of primary care physician supply and cardiologist supper were associated with significantly higher 30-day readmission, however this effect was not preserved in both the simple and full models. Intensity measures: the last 6 months of life intensity measures significantly associated with higher 30-day readmission including total hospital days (all quartiles), total ICU days (only the highest quartile), number of physicians seen (quartiles 3 and 4), and ≥10 different physicians seen (all quartiles). All of the intensity measures were confirmed using both the simple and full model approaches with the exception of total ICU days, which lost statistical significance in the full model. In addition, the direction of the association changed for number of physician visits from a positive association with 30-day readmission in the simple model to a statistically significant negative association with 30-day readmission in the full model. We report the results for all hospitals without a denominator restriction in Table S1.

We conducted sensitivity analyses whereby we removed all discharged AMI patients who died within 30 days of discharge; all results were qualitatively similar to the hospital-level analyses of all AMI patients (Table S2). Overall, discharge planning, hospital size, all medical admission rates, and total hospital days in the last 6 months of life care intensity measures were the only factors that were associated with readmission rates after hospitalization for AMI irrespective of the analytic strategy and sensitivity analyses.

We repeated our analyses across 306 hospital referral regions (HRR, Tables S3). The HRR cohort included all 306 HRRs with complete data on all measures of quality, capacity, and intensity. Overall, the HRR level analysis confirmed our hospital level analysis with the following exceptions whereby the hospital-level analysis demonstrated significant associations in both the simple and full models for bed supply, last 6 months of life number of physician visits, and ≥10 different physicians seen and the HRR level analysis only demonstrated significance in the simple models.

Discussion

We demonstrate an association between hospital measures of quality, capacity, and intensity of medical care and 30-day readmission after AMI. These associations persisted even after including the CMS AMI risk model in our analyses to account for patient risk factors for readmission. After adjusting for patient-level factors, patient-reported quality of discharge communication was associated with lower 30-day readmission. We found a consistent effect that hospitals with greater capacity for care, as manifest by a greater tendency to admit patients, also had higher 30-day readmission. However, contrary to recent findings, we demonstrate that larger hospitals were more likely to have lower 30-day readmission. In addition, hospital measures of greater intensity of care, more hospital days in the last 6 months of life, more physicians seen, and ≥10 different physicians seen, were associated with higher 30-day readmission.

Our findings are consistent with current evidence that one effective remedy for high readmission rates is better discharge planning.[4,11] Jha and colleagues[11] originally reported no relationship between discharge planning and all-cause 30-day readmission for congestive heart failure and pneumonia using the Hospital Quality Alliance score. However, when the HCAHPS score was used in the analysis, Jha and colleagues reported a statistically significant inverse trend with the higher quartiles of HCAHPS score for discharge planning and 30-day readmission rates. These previous findings by Jha and colleagues[11] are supported in our hospital-level analysis in a new cohort of AMI discharges showing higher HCAHPS scores for discharge planning are associated with lower rates of 30-day readmission.

Table 2. Univariate Models for Quality, Capacity and Intensity Measures

	Quartile	RR	95% CI	*P* Value
Quality measures				
Discharge planning: HCAHPS (%, hospital level)	Q1	1.00		
	Q2	0.93	(0.90 to 0.96)	<0.001
	Q3	0.85	(0.82 to 0.88)	<0.001
	Q4	0.86	(0.84 to 0.89)	<0.001
PCP visit within 14-days (%, hospital level)	Q1	1.00		
	Q2	1.01	(0.97 to 1.04)	0.717
	Q3	1.01	(0.98 to 1.04)	0.471
	Q4	1.07	(1.04 to 1.11)	<0.001
Capacity measures				
PCPs per 100 000 population (HSA level)	Q1	1.00		
	Q2	1.07	(1.04 to 1.10)	<0.001
	Q3	1.06	(1.03 to 1.09)	<0.001
	Q4	1.14	(1.11 to 1.18)	<0.001
Cardiologists per 100 000 population (HSA level)	Q1	1.00		
	Q2	1.04	(1.01 to 1.07)	0.022
	Q3	1.10	(1.06 to 1.13)	<0.001
	Q4	1.21	(1.17 to 1.25)	<0.001
Average number of beds (hospital level)	Q1	1.00		
	Q2	0.86	(0.83 to 0.89)	<0.001
	Q3	0.82	(0.79 to 0.84)	<0.001
	Q4	0.80	(0.78 to 0.83)	<0.001
All medical admission rates per 1000 beneficiaries (HSA level)	Q1	1.00		
	Q2	1.13	(1.09 to 1.16)	<0.001
	Q3	1.21	(1.18 to 1.25)	<0.001
	Q4	1.30	(1.26 to 1.35)	<0.001
Intensity measures				
Last 6 months of life hospital days (hospital level)	Q1	1.00		
	Q2	1.11	(1.07 to 1.15)	<0.001
	Q3	1.19	(1.16 to 1.23)	<0.001
	Q4	1.41	(1.36 to 1.45)	<0.001
Last 6 months of life ICU days (hospital level)	Q1	1.00		
	Q2	1.02	(0.99 to 1.06)	0.141
	Q3	1.06	(1.03 to 1.09)	<0.001
	Q4	1.16	(1.13 to 1.20)	<0.001
Last 6 months of life number of physician visits (hospital level)	Q1	1.00		
	Q2	1.09	(1.06 to 1.13)	<0.001
	Q3	1.16	(1.12 to 1.20)	<0.001
	Q4	1.31	(1.27 to 1.35)	<0.001
Last 6 months of life 10 or more different physicians seen (hospital level)	Q1	1.00		
	Q2	1.08	(1.05 to 1.12)	<0.001
	Q3	1.13	(1.09 to 1.17)	<0.001
	Q4	1.28	(1.24 to 1.32)	<0.001

All estimates are calculated from univariate Poisson models comparing the highest quartile measure to the lowest. HCAHPS: The value is the percentage of patients responding affirmatively to 2 questions about discharge planning on the Hospital Consumer Assessment of Healthcare Providers and Systems (HCAHPS) survey: “During this hospital stay, did doctors, nurse or other hospital staff talk with you about whether you would have the help you needed when you left the hospital?” and “During the hospital stay, did you get information in writing about what symptoms or health problems to look out for after you left the hospital?” HSA indicates hospital service area; ICU, intensive care unit; PCP, primary care physician; RR, relative risk.

Our paper also extends the previous study by Epstein and colleagues[5] that regional hospital admission rates are associated with readmissions by incorporating measures of health care intensity at the end of life. Using multivariable models, in contrast to Epstein's univariate analyses, we did not observe an independent positive association of physician or hospital bed supply with 30-day readmissions. In contrary, our patient- and hospital-level analysis, we found larger hospitals as measured by number of beds was significantly associated with lower 30-day readmission. Our finding suggests that analyses, when done at the aggregated population level as in the case of the Epstein and colleagues[5] analysis at the HRR-level may mask underlying phenomenon of larger hospitals. Larger hospitals may have more resources and are more likely to be academic hospitals, thus have more resources to target key penalty areas such as readmissions.

Current efforts to reduce readmission rates fail to target more general health system effects. The strong association of the number of hospital days and ≥10 different physicians seen in the last 6 months of life and 30-day readmission highlights the importance of local patterns of hospital use. We demonstrate patterns of medical care and readmissions at the hospital level, which have not been shown before, and suggest rates of readmission are driven partly by the intensity of health care delivery within a hospital.

Reducing readmissions may also require health systems, hospitals, physicians, allied health professionals, as well as patients and families to work together towards reducing unnecessary end of life health care intensity. First, we recommend the use of advance care planning for patients at the end of life.[12] Patient preferences for the level of intensity of their health care and preference for location of death as much as possible should be matched with the setting and care. Larochelle and colleagues well characterize the role of the physician in end of life treatment intensity and noted variation in communication and collaboration with the care team, patient, and family members.[13] As such, we suggest targeted interventions are thus needed to reduce variation and improve the divide between physician and patient preferences. Second, high-intensity areas at the end of life could incorporate successful models such as ENABLE[14] to support patients and families at the end of life with care liasons to aid in managing pain, symptoms, and comfort while matching patient preferences for intensity of care and location of that care and death (eg, home, hospital or managed care facility).

Our finding of lower 30-day readmission with higher HCAHPS discharge quality scores is consistent with the benefits seen in intervention trials that improved patient education and information prior to discharge such as care transitions and medication reconciliation.[4,15–17] Improvements in the care patients receive after discharge including regular phone and office follow-up has also been shown to be effective and is an area of active improvement.[3,4] However, these strategies may fall short of sustained change unless they are coupled to improvements in care that generally lower the threshold of hospital admission and raise the quality of ambulatory care.

It should be noted that the patient populations used to derive the measures of hospital intensity differ from the AMI admission cohort and are from a different time period. Yet, the probability that a patient spends more time in the hospital in the last months of life strongly predicts the chances that patients will be readmitted after an AMI. These deeply embedded styles of care (specifically discharge quality, medical admission rates, and last 6 months of total hospital days) may need as much attention as improvement in care transitions.

Our results extend previous studies by evaluating system measures of capacity and health care intensity in for all AMI Medicare discharges, a relatively homogenous population compared with congestive heart failure or pneumonia.[5] We also report on effects at both the hospital and regional (HRR, see Supplemental Material) levels and demonstrate that the associations of these measures are similar at both a hospital and regional (HRR) level. We conducted patient-level risk adjustment to align with the CMS penalty calculations by using the published CMS AMI readmission model.[10] Our results are consistent with previous research by Epstein and colleagues, who demonstrated similar associations for congestive heart failure and pneumonia HRR-level discharge quality scores from HCAHPS and admission rates were associated with rates of 30-day readmission.[5] However, as discussed above, our hospital level analysis demonstrates larger hospitals are associated with lower 30-day readmission and not higher readmission as reported by Epstein and colleagues.[5]

There are several limitations of our analyses. First, while our nation-wide analysis of fee-for-service Medicare beneficiaries hospitalized for AMI captures a sizeable national sample of AMI hospitalizations across the United States, it may not be applicable to Medicare Advantage or to younger patients. Second, the HCAHPS survey used the answer to 2 questions as a metric of hospital discharge quality. These questions do not capture all of the important aspects of discharge quality. Third, while our outcome of 30-day readmissions excluded planned readmissions common after an AMI, our analysis did not focus solely on avoidable readmissions. Currently there is a lack of consensus on defining avoidable readmissions and it is not possible to review each readmission with a clinical chart review. Fourth, we employed patient-level risk adjustment using the CMS AMI readmission model, however this is limited to comorbidities and procedures that are captured in the CMS claims. Fifth, we restricted our cohort to hospitals with

Table 3. Hierarchical Models for Patient and Hospital Level Analyses

		Simple Model			Full Model		
	Quartile	RR	95% CI	*P* Value	RR	95% CI	*P* Value
Quality measures							
Discharge planning: HCAHPS (%, hospital level)	Q1	1.00			1.00		
	Q2	0.96	(0.92 to 1.00)	0.077	0.99	(0.95 to 1.03)	0.738
	Q3	0.90	(0.86 to 0.94)	<0.001	0.93	(0.89 to 0.97)	0.001
	Q4	0.92	(0.88 to 0.96)	<0.001	0.95	(0.91 to 0.99)	0.028
PCP visit within 14-days (%, hospital level)	Q1	1.00			1.00		
	Q2	1.00	(0.95 to 1.04)	0.840	0.99	(0.95 to 1.04)	0.756
	Q3	0.98	(0.93 to 1.03)	0.355	0.96	(0.92 to 1.00)	0.039
	Q4	1.01	(0.97 to 1.06)	0.664	0.98	(0.94 to 1.02)	0.358
Capacity measures							
PCPs per 100 000 population (HSA level)	Q1	1.00			1.00		
	Q2	1.03	(1.00 to 1.07)	0.043	1.03	(0.99 to 1.06)	0.105
	Q3	1.02	(0.99 to 1.06)	0.181	1.01	(0.98 to 1.05)	0.447
	Q4	1.05	(1.01 to 1.08)	0.010	1.03	(0.99 to 1.06)	0.128
Cardiologists per 100 000 population (HSA level)	Q1	1.00			1.00		
	Q2	1.00	(0.97 to 1.04)	0.845	1.00	(0.97 to 1.04)	0.870
	Q3	1.02	(0.99 to 1.05)	0.225	0.99	(0.96 to 1.03)	0.669
	Q4	1.04	(1.01 to 1.08)	0.015	0.98	(0.95 to 1.02)	0.412
Average number of beds (hospital level)	Q1	1.00			1.00		
	Q2	0.90	(0.87 to 0.94)	<0.001	0.88	(0.85 to 0.92)	<0.001
	Q3	0.87	(0.83 to 0.90)	<0.001	0.83	(0.80 to 0.86)	<0.001
	Q4	0.85	(0.81 to 0.89)	<0.001	0.79	(0.75 to 0.82)	<0.001
All medical admission rates per 1000 beneficiaries (HSA level)	Q1	1.00			1.00		
	Q2	1.06	(1.02 to 1.10)	0.003	1.04	(1.00 to 1.08)	0.032
	Q3	1.13	(1.09 to 1.18)	<0.001	1.10	(1.06 to 1.15)	<0.001
	Q4	1.16	(1.11 to 1.21)	<0.001	1.12	(1.07 to 1.16)	<0.001
Intensity measures							
Last 6 months of life hospital days (hospital level)	Q1	1.00			1.00		
	Q2	1.07	(1.03 to 1.12)	0.002	1.07	(1.01 to 1.12)	0.003
	Q3	1.11	(1.06 to 1.16)	<0.001	1.10	(1.05 to 1.16)	<0.001
	Q4	1.23	(1.18 to 1.29)	<0.001	1.23	(1.16 to 1.31)	<0.001
Last 6 months of life ICU days (hospital level)	Q1	1.00			1.00		
	Q2	1.01	(0.96 to 1.05)	0.831	0.99	(0.95 to 1.03)	0.500
	Q3	1.02	(0.98 to 1.07)	0.298	1.00	(0.96 to 1.04)	0.996
	Q4	1.09	(1.04 to 1.13)	<0.001	1.02	(0.98 to 1.07)	0.327
Last 6 months of life number of physician visits (hospital level)	Q1	1.00			1.00		
	Q2	1.04	(1.00 to 1.09)	0.065	0.96	(0.92 to 1.01)	0.087
	Q3	1.08	(1.03 to 1.13)	0.001	0.93	(0.88 to 0.98)	0.010
	Q4	1.14	(1.09 to 1.20)	<0.001	0.88	(0.82 to 0.95)	0.001

Continued

Table 3. Continued

	Quartile	Simple Model			Full Model		
		RR	95% CI	*P* Value	RR	95% CI	*P* Value
Last 6 months of life 10 or more different physicians seen (hospital level)	Q1	1.00			1.00		
	Q2	1.05	(1.01 to 1.10)	0.025	1.09	(1.05 to 1.14)	<0.001
	Q3	1.07	(1.02 to 1.12)	0.004	1.11	(1.05 to 1.16)	<0.001
	Q4	1.14	(1.09 to 1.19)	<0.001	1.15	(1.08 to 1.23)	<0.001

All estimates are calculated from Poisson models comparing the highest quartile measure to the lowest. *Simple models*: test each measure independently while adjusting for patient factors used in the CMS AMI readmission models. *Full model*: tests the independent effect of all measures combined in 1 model while adjusting for patient factors used in the CMS AMI readmission models. In the hospital analysis, PCP, cardiologist supply and all medical admissions are per-capita measures calculated at the hospital service area. HCAHPS: The value is the percentage of patients responding affirmatively to 2 questions about discharge planning on the Hospital Consumer Assessment of Healthcare Providers and Systems (HCAHPS) survey: "During this hospital stay, did doctors, nurse or other hospital staff talk with you about whether you would have the help you needed when you left the hospital?" and "During the hospital stay, did you get information in writing about what symptoms or health problems to look out for after you left the hospital?" AMI indicates acute myocardial infarction; CMS, Centers for Medicare and Medicaid Services; HSA, hospital service area; ICU, intensive care unit; PCP, primary care physician; RR, relative risk.

complete data for all of our measures. There are a total of 4315 hospitals caring for Medicare AMI patients, however only 1773 hospitals had complete data on the measures used in this study. Hospitals not included and missing this data from The Dartmouth Atlas were small hospitals that did not meet the criteria for public reporting. We further eliminated 685 hospitals and 16 902 patients to meet a minimum denominator requirement of 50 AMI discharges per hospital resulting in the final cohort of 188 611 and 1088 hospitals to have stable statistical estimates.

In conclusion, we demonstrate that patterns of hospital or regional medical care utilization, unrelated to AMI hospitalization, are associated with rates of 30-day AMI readmission. Our results suggest that efforts to reduce 30-day readmissions through better discharge planning and care coordination will help but may need to be accompanied by efforts to reduce overall hospital admission rates and end of life care intensity. Our findings point to the need for clinicians and hospital administrators to look beyond care transitions clinical workflows and also redesign the larger context of care delivery in order to reduce the overall number of hospital admissions.

Sources of Funding

We would like to acknowledge the Dartmouth Atlas of Health Care and The Dartmouth Institute of Health Policy and Clinical Practice. This study was supported, in part, by the Robert Wood Johnson Foundation and the Agency for Healthcare Research and Quality. The funders had no role in the design or conduct of the study, collection, management, analysis, or interpretation of the data, or the preparation, review, approval of the manuscript, or the decision to submit the manuscript for publication. Drs Brown and Goodman had full access to all the data in the study and take responsibility for the integrity of the data and the accuracy of the data analysis.

Disclosures

Dr. Brown received grant support from the Agency for Healthcare Research and Quality K01 HS018443. Dr. Goodman received grant support from the Robert Wood Johnson Foundation and personal fees from Intermountain Healthcare, Canadian Health Services Research Foundation, and the Massachusetts Health Data Consortium.

References

1. Jencks SF, Williams MV, Coleman EA. Rehospitalizations among patients in the Medicare fee-for-service program. *N Engl J Med*. 2009;360:1418–1428.
2. Medicare Payment Advisory Commission (U.S.). *Report to the Congress: Medicare and the Health Care Delivery System*. Washington, DC: MedPAC; 2013.
3. Hansen LO, Young RS, Hinami K, Leung A, Williams MV. Interventions to reduce 30-day rehospitalization: a systematic review. *Ann Intern Med*. 2011;155:520–528.
4. Naylor MD, Brooten D, Campbell R, Jacobsen BS, Mezey MD, Pauly MV, Schwartz JS. Comprehensive discharge planning and home follow-up of hospitalized elders: a randomized clinical trial. *JAMA*. 1999;281:613–620.
5. Epstein AM, Jha AK, Orav EJ. The relationship between hospital admission rates and rehospitalizations. *N Engl J Med*. 2011;365:2287–2295.
6. *The Dartmouth Atlas of Health Care, 1999*. Chicago IL: American Hospital Publishing; 1999.
7. After hospitalization: a Dartmouth atlas report on post-acute care for Medicare beneficiaries. The Dartmouth Atlas of Healthcare; 2011. Available at: http://www.dartmouthatlas.org/downloads/reports/Post_discharge_events_092811.pdf. Accessed September 28, 2011.
8. Hospital and physician capacity update. The Dartmouth Atlas of Healthcare; 2009. Available at: http://www.dartmouthatlas.org/downloads/reports/Capacity_Report_2009.pdf. Accessed April 16, 2013.
9. Trends and variation in end-of-life care for Medicare beneficiaries with severe chronic illness. The Dartmouth Atlas of Healthcare; 2011. Available at: http://www.dartmouthatlas.org/downloads/reports/EOL_Trend_Report_0411.pdf. Accessed December 5, 2012.
10. Krumholz HM, Lin Z, Drye EE, Desai MM, Han LF, Rapp MT, Mattera JA, Normand SL. An administrative claims measure suitable for profiling hospital performance based on 30-day all-cause readmission rates among patients with acute myocardial infarction. *Circ Cardiovasc Qual Outcomes*. 2011; 4:243–252.
11. Jha AK, Orav EJ, Epstein AM. Public reporting of discharge planning and rates of readmissions. *N Engl J Med*. 2009;361:2637–2645.
12. Curtis JR, Engelberg RA, Bensink ME, Ramsey SD. End-of-life care in the intensive care unit: can we simultaneously increase quality and reduce costs? *Am J Respir Crit Care Med*. 2012;186:587–592.

13. Larochelle MR, Rodriguez KL, Arnold RM, Barnato AE. Hospital staff attributions of the causes of physician variation in end-of-life treatment intensity. *Palliat Med*. 2009;23:460–470.

14. Bakitas M, Stevens M, Ahles T, Kirn M, Skalla K, Kane N, Greenberg ER; Project Enable C-I. Project ENABLE: a palliative care demonstration project for advanced cancer patients in three settings. *J Palliat Med*. 2004;7:363–372.

15. Brock J, Mitchell J, Irby K, Stevens B, Archibald T, Goroski A, Lynn J. Association between quality improvement for care transitions in communities and rehospitalizations among Medicare beneficiaries. *JAMA*. 2013;309:381–391.

16. Gleason KM, Brake H, Agramonte V, Perfetti C. Medications at Transitions and Clinical Handoffs (MATCH) toolkit for medication reconciliation. (Prepared by the Island Peer Review Organization, Inc, under Contract No. HHSA2902009000 13C.) AHRQ Publication No. 11(12)- 0059. Rockville, MD: Agency for Healthcare Research and Quality; 2012 Revised August 2012.

17. Gleason KM, McDaniel MR, Feinglass J, Baker DW, Lindquist L, Liss D, Noskin GA. Results of the Medications At Transitions and Clinical Handoffs (MATCH) study: an analysis of medication reconciliation errors and risk factors at hospital admission. *J Gen Intern Med*. 2010;25:441–447.