Post-Acute Service Use Following Acute Myocardial Infarction in the Elderly

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This exploratory study examined the extent to which factors beyond characteristics of the patient, such as discharging hospital attributes and State factors, contributed to variations in post-acute services use (PASU) in a cohort of elderly Medicare patients following acute myocardial infarction (AMI). Thirty-seven percent of this cohort received PAS within 30 days of discharge and home health care was the most common type of service used. Patient severity of illness at hospital discharge, for-profit ownership of the discharging hospital, and discharging hospital provision of home health services were shown to be important predictors of PASU. After adjusting for many patient and hospital characteristics, however, variation in PASU remained across States.

INTRODUCTION

AMI is a condition that affects a large volume of patients annually, involves sophisticated inpatient technology, and places a large economic burden on health systems (American Heart Association, 1996). Although patterns of care for inpatients with this condition have been studied extensively (Guadagnoli et al., 1995; Krumholz et al., 1998; Pilote et al., 1995; Tu et al., 1997), little work has been done on patterns of PASU. Information in this area is particularly important because pressures for shortened length of hospital stays result in increased need for PASU to assist patient recuperation and rehabilitation (Havranek, 1994; Naylor et al., 1999). In addition, payment mechanisms have changed considerably for post-acute care in the past 5 years (Moon, Gage, and Evans, 1997). In order to make informed decisions about allocation of resources and to understand incentives for patterns of care, factors beyond patient characteristics, such as hospital, or State must also be considered.

Among other reforms, the Balanced Budget Act (BBA) of 1997 mandated a shift from cost-based reimbursement to nationally standardized, case-mix adjusted, prospective payment systems for providers of PAS under the Medicare Program. Prior to this legislation, Medicare spending for PAS had grown dramatically (Prospective Payment Commission, 1996; 1997), and the changes required in the BBA were intended to moderate this growth in spending. A recent study (McCall et al., 2001) demonstrates a sharp decline in rates of use and payments for home health services following the BBA implementation and indicates that the legislation did alter patterns of care. Hospital transfer policies were also revised in the BBA to reduce incentives for early hospital discharge, thereby preventing a shift of costs to post-acute providers.

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The BBA requires that separate prospective payment systems be developed for each type of PAS, although the timelines for introducing these systems vary. Questions have been raised, therefore, about the extent to which these new policies may alter patterns of PASU and quality of care (Gage, 1999; McCall et al., 2001).

Depending mainly on patient need, PAS are delivered through a variety of providers including skilled nursing facilities (SNFs), rehabilitation facilities, home health agencies (HHAs), and long-term care (LTC) hospitals. Studies of variation in the use, cost, outcomes and appropriateness of PASU across a variety of patient conditions (e.g., hip fracture, stroke) have revealed that, in addition to the health and functional status of the patient, factors such as hospital and regional characteristics contribute to variations in PASU (Chen, Kane, and Finch, 2000; Cohen and Tumlinson, 1997; Hadley et al., 2000; Kane et al., 1996; Kane et al., 2000; Kane, Lin, and Blewett, 2002; Kenney and Rajan, 2000; Kenney and Dubay, 1992; Liu, Wisoker, and Rimes, 1998; Murtaugh and Litke, 2002; Welch, Weinberg, and Welch, 1996). Little research has been done in this area for patients with AMI. In this study, therefore, we explored the extent to which factors beyond the characteristics of the patient influence overall PASU in a cohort of elderly AMI patients prior to the implementation of the BBA reforms. We were interested in both hospital and State effects and, in particular, we investigated whether State-to-State variations in PASU persisted once patient and hospital variables were incorporated in an analytical model that accounted for underlying variability in the data.

METHODS

Data Sources

A subset of data from the Cooperative Cardiovascular Project (CCP) was used. The CCP is a national quality-of-care initiative sponsored by CMS and has been discussed in detail by Marciniak et al. (1998). Because the CCP includes detailed information on the severity of illness, comorbidities, and hospitalization events of elderly AMI patients, we were able to investigate many clinical variables. Detailed medical record data for patients were available in the CCP data set; information included patient demographics, symptoms on presentation, past medical history, laboratory values, test findings and hospital events. These data were supplemented with the following additional information:

Medicare Data—CMS administrative data provided information on health care services provided to Medicare beneficiaries including hospitals, HHAs, SNFs, and rehabilitation and LTC hospitals. Patient mortality was determined from the Health Insurance Master File.

Hospital Data—The CMS Provider of Services File, American Hospital Association databases, and a separate survey of hospitals for our sample (Guadagnoli et al., 1995) were linked to obtain characteristics of discharging hospitals, such as university affiliation (teaching status), number of beds, for-profit status, hospital provision of PASs, and cardiac service availability, as well as regional descriptors such as rural/urban location and State.

Definitions

Cohort

Records were selected for fee-for-service (FFS) Medicare enrollees age 65-89 who were discharged with a principal diagnosis of AMI (*International Classification of Diseases, Ninth Revision, Clinical Modification* (ICD-9-CM) (Public Health Service and the Health Care Financing Administration, 1992) 410 excluding a 5th digit of 2 [indicating AMI in the prior 8 weeks]) in all non-Federal acute care hospitals between January 1, 1994 and July 31, 1995. The analysis was restricted to patients discharged from hospitals in California, Florida, Massachusetts, New York, Ohio, Pennsylvania, and Texas because these States are known to differ in cardiac care patterns, are large, geographically diverse, and reflect common AMI practice styles across the United States (Guadagnoli et al., 1995).

This initial data set contained 66,399 patients with a confirmed AMI between the ages of 65-89. Three broad categories of exclusions were applied that were related to (1) inpatient stay, (2) eligibility for PAS, and (3) completeness of data. The primary motivation was to select a population of patients who were clinically similar. This is a standard approach for the CCP data (Guadagnoli et al., 2000; Normand et al., 2001; Petersen et al., 2000). The exclusions were as follows: patient in managed care plan (*n*=5,752), diagnosis not 410 at transfer (*n*=5,558), missing CCP record for transfer hospital (*n*=342), invalid date of death (*n*=34), non-U.S. resident (*n*=16), diagnosis not 410 at admission (*n*=6), admission prior to January 1, 1994 (*n*=4), and other missing data (*n*=193). An index admission was defined as the initial admission to an acute care hospital linked with up to one transfer to another acute care facility. Patients were associated with the discharging hospital's characteristics because this provider would have the greatest influence over patient discharge destination (and subsequent PASU). Patients with more than one transfer (*n*=237) were excluded because multiple transfers could undermine the strength of the relationships between patient characteristics at admission, processes of care in hospital, and the discharging hospital. Patients must have remained alive for the 30 days after discharge (*n*=8,956 in-hospital deaths and *n*=2,424 deaths less than 30 days after discharge) to be considered in this analysis to prevent patient attrition from biasing the investigation of PAS patterns. Patients were also excluded if they used PAS in the 60 days prior to admission (*n*=4,725). This criterion removed patients whose service use might not be due entirely to their AMI admission. After all exclusion criteria were applied, 39,837 subjects remained in our cohort.

PASU

PASU was specifically defined as a binary variable indicating the use of PASs within 30 days of discharge from the index admission to hospital. Thirty days was chosen as a sufficiently short interval to be strongly linked to the AMI discharge. Six categories of PASU were defined (no use, HHA only, SNF only, rehabilitation facilities only, LTC hospitals only, and multiple services) within the 30-day window. The first three digits of the most-responsible ICD-9-CM diagnosis on each PAS record were used to classify broadly the reason for PASU as either related to the Circulatory System (390-459) or Post-Surgical Condition/ Aftercare (V45, V53-V58, V66).

Severity of Illness

Although several studies describe strategies for risk adjustment of AMI patients at admission (Lee et al., 1995; Mark et al., 1991; Normand et al., 1996; Peterson et al., 2000), there is little published methodology on adjusting for the severity illness of AMI patients at discharge. We chose, therefore, to use a published risk-adjustment algorithm (Normand et al., 1996) to summarize patient severity at admission as a single score. This algorithm incorporated information on patient age, health history, comorbidity, and other clinical characteristics at admission. The algorithm was also extended to include additional variables related to patient demographics, hospital events, and patient status at discharge in order to develop a severity score reflecting patient condition at discharge. A standard stepwise logistic regression model, in which the response was the binary variable PASU, was developed to identify which of these variables were significant predictors (p-value $\leq$ 0.05) of PASU. (The model for the discharge severity score and its components are described in the Technical Notes at the end of this article.) The admission severity score ranged from –6.6 to 0.5 across patients and the discharge severity score ranged from –3.2 to 5.3. Higher values of the severity scores indicate greater severity of illness.

Characteristics of Patients, Hospitals, and PASU

The relationships between PASU and patient characteristics at admission and during hospitalization were investigated. Four main categories of characteristics were developed: (1) patient demographics, (2) severity of illness on admission, (3) events during hospitalization, and (4) status of patient at discharge. A further stratification compared those patients receiving only home health care in the first 30 days after discharge with those who had some contact with an inpatient post-acute facility. *T*-tests and chi-squared tests were used to evaluate significance (p-value $\leq$ 0.05) for continuous and categorical variables, respectively. Patient-level data were aggregated within discharging hospitals, and rates of PASU across hospitals and by State were investigated similarly. In addition the characteristics of hospitals, such as number of beds, type of ownership, and hospital/subsidiary provision of PASs, were compared across States using chi-squared tests. Standard stepwise logistic regression, in which the response was the binary variable PASU, was used to identify which hospital-level variables were significant predictors (p-value $\leq$ 0.05) of PASU. Due to the complex structure of the hierarchical models, this threshold was chosen in order to select a manageable number of hospital level covariates (even though some omitted variables might have improved the fit of the models).

Variation in PASU

In addition to the patient-level discharge severity score, hospital-level predictors were included in a hierarchical logistic regression model to estimate systematic and random variability in rates of PASU across hospitals (Gatsonis et al., 1995; Katon et al., 2000; Normand, Glickman, and Gatsonis, 1997) This model enabled comparisons in the rates of PASU at hospitals while controlling for hospital differences in the type and number of patients treated, and allowing for random between-hospital variation. (The model is described in the Technical Notes.)

For patients within each hospital, the discharge severity score was related to the probability of PASU using logistic regression. The effect of discharge severity on PASU was assumed to be constant across

Table 1

Post- Acute Service Use (PASU) in Elderly Medicare Patients Following Acute Myocardial Infarction, 1994-1995

	Total Cohort		Died Within 1 Year of Admission		Length of Stay in Hospital	Length of Stay in PASU[1]
Service Use	Count	Percent	Count	Percent	Mean Days	Mean Days
Any PASU[2]						
No	25,163	63.2	2,444	9.7	8.5 (4.4)	—
Yes	14,674	36.8	2,754	18.8	13.2 (9.8)	—
Type of PASU[2]						
Home Health Agency Only	10,949	74.6	1,695	15.5	11.9 (7.2)	—
Skilled Nursing Facility Only	1,704	11.6	612	35.9	16.5 (16.8)	25.8 (29.6)
Rehabilitation Facility Only	224	1.5	35	15.6	20.9 (16.2)	17.2 (10.0)
Long-Term Care Hospital Only	54	0.4	27	50.0	26.0 (19.1)	27.0 (21.2)
Multiple	1,743	11.9	385	22.1	16.5 (10.8)	—

[1] Corresponds to length of stay for first admission to specified type of post-acute service use (PASU) within 30 days of hospital discharge.

[2] All *p*-values for comparisons across categories are significant at 0.001 and correspond to *t*-tests for continuous variables and chi-square tests for categorical variables.

NOTE: Standard deviations for means are shown in parentheses.

SOURCE: Bronskilll, S.E., Institute for Clinical Evaluative Sciences, Normand, S.L.T., and McNeil, B.J., Harvard Medical School, 2002.

hospitals and the intercept term was assumed to vary across hospitals. The intercept term, representing the log-odds of PASU for a patient of average severity, was related to hospital characteristics (rural/urban, hospitals with a separate, long-term nursing home unit, government ownership, teaching, provision of home health services, for-profit ownership) and State of the discharging hospital via linear regression. Odds ratios (ORs), predicted probabilities and corresponding 95-percent intervals were used to describe the strength of the association of patient, hospital, and State factors with PASU.

RESULTS

Characteristics of Patients, Hospitals, and PASU

Patterns of PASU are displayed in Table 1. More than 63 percent of the patients returned to their homes and received no PASs in the 30 days after discharge. Of the remaining 37 percent, 75 percent received only home health services. Patients with PASU had longer lengths of in-hospital stay (13.2 versus 8.5 days) and were more likely to die within 1 year of their admission for AMI (19 versus 10 percent). For patients who had contact with an inpatient post-acute care provider, the mean length of stay for the initial admission was shorter for rehabilitation facilities (17.2 days) compared with SNFs (25.8 days) and LTC hospitals (27.0 days). HHA, SNF, and LTC patients were more likely to have an admitting diagnosis related to the circulatory system (84, 66, and 45 percent of cases respectively) whereas rehabilitation facility patients were more likely to have an admitting diagnosis indicating post-surgical condition/aftercare (56 percent).

Detailed features of the patients in the cohort are listed in Table 2. Post-acute care recipients were generally older (77.2 versus 73.9 mean age). In particular, the proportion of individuals age 80 or over was greater in those with PASU than those without (40 versus 21 percent). Post-acute care recipients were more severely ill at admission (–3.5 versus –4.0 severity score), experienced more health-related events in hospital, and were less mobile at discharge (61 percent could walk independently versus

Table 2

Characteristics of Elderly Medicare Patients Using Post-Acute Services Following Acute Myocardial Infarction, 1994-1995

	Post Acute Service Use[1]				Type of Service[2]			
Characteristic	No (*n*=25,163)	Percent	Yes (*n*=14,674)	Percent	Home Health Agency Only (*n*=10,949)	Percent	Some Inpatient Contact (*n*=3,725)	Percent
Demographics								
Age								
Mean[3]	73.9 (6.2)	—	77.2 (6.4)	—	76.8 (6.4)	—	78.4 (6.4)	—
65-69 Years	7,263	28.9	2,124	14.5	1,714	15.7	410	11.0
70-74 Years	7,420	29.5	3,162	21.6	2,502	22.9	660	17.7
75-79 Years	5,229	20.8	3,543	24.1	2,671	24.4	872	23.4
80-84 Years	3,619	14.4	3,568	24.3	2,529	23.1	1,039	27.9
85-89 Years	1,632	6.5	2,277	15.5	1,533	14.0	744	20.0
Female	9,704	38.6	8,159	55.6	5,959	54.4	2,200	59.1
Race								
White	22,860	90.9	13,340	90.9	9,925	90.7	3,415	91.7
Black	1,070	4.6	666	4.5	508	4.6	158	4.2
Hispanic	962	3.8	515	3.5	419	3.8	96	2.6
Other	271	1.1	153	1.0	97	0.9	56	1.5
Dually Eligible	2,277	9.1	1,981	13.5	1,275	11.6	706	19.0
Severity on Admission								
Admission Severity Score[4]	-4.0 (0.8)	—	-3.5 (0.8)	—	-3.6 (0.8)	—	-3.2 (0.9)	—
Events in Hospital								
Cardiac Catheterization	13,287	52.8	6,674	45.5	5,200	47.5	1,474	39.6
CABG	1,955	7.7	3,207	21.9	2,279	20.8	928	24.9
PTCA	6,154	24.5	2,113	14.4	1,712	15.6	401	10.8
Pneumonia	1,285	5.1	1,771	12.1	1,066	9.7	705	18.9
Deep Vein Thrombosis	87	0.4	124	0.9	78	0.7	46	1.2
Cerebrovascular Accident/Stroke	226	0.9	696	4.7	253	2.3	443	11.9
Anoxic Brain Damage	63	0.3	145	1.0	55	0.5	90	2.4
Do Not Resuscitate Order	992	3.9	1,538	10.5	803	7.3	735	19.7
Blood Transfusion	2,703	10.7	4,085	27.8	2,777	25.4	1,308	35.1
Status at Discharge								
Urinary Continence								
Missing	88	0.4	70	0.5	40	0.4	30	0.8
Continent	24,306	96.6	13,012	88.7	10,349	94.5	2,663	71.5
Totally/Occasionally Incontinent	694	2.8	1,544	10.5	533	4.9	1,011	27.1
No Urine Output	75	0.3	48	0.3	27	0.3	21	0.6
Mobility								
Missing	147	0.6	107	0.7	58	0.5	49	1.3
Walks Independently	21,768	86.5	9,009	61.4	7,886	72.0	1,123	30.1
Walks with Assistance	2,897	11.5	4,938	33.7	2,853	26.1	2,085	56.0
Unable to Walk	351	1.4	620	4.2	152	152.1	468	12.6

[1] All *p*-values are significant at 0.001 except race (*p*-value = 0.23) and correspond to *t*-tests for continuous variables and chi-square tests for categorical variables.

[2] All *p*-values are significant at 0.001 and correspond to *t*-tests for continuous variables and chi-square tests for categorical variables.

[3] Mean age in years.

[4] Higher values of score represent increased severity of illness.

NOTES: Values are mean for continuous variables and count for categorical variables. Standard deviations are shown in parentheses. CABG is coronary artery bypass graft surgery. PTCA is percutaneous transluminal coronary angioplasty.

SOURCES: Bronskill, S.E., Institute for Clinical Evaluative Sciences, Normand, S.L.T., and McNeil, B.J., Harvard Medical School, 2002.

87 percent). Race was not associated with PASU, and patients who had both Medicare and Medicaid coverage used more PAS than those who did not.

These features were stratified further to compare characteristics of patients who received HHA only with those who had some contact with an inpatient post-acute facility. Older adults with inpatient post-acute contact were generally older (78.4 versus 76.8 mean age), more likely to be a dually eligible enrollee (19 versus 12 percent) and more severely ill at admission (–3.2 versus –3.6 severity score) than those who received home health care only. In addition, patients with inpatient post-acute contact were more likely to have experienced events in hospital including pneumonia (19 versus 10 percent), cerebrovascular accident (12 versus 2 percent) and blood transfusion (35 versus 25 percent). These individuals were less likely to be continent at discharge (72 versus 95 percent) and much less likely to be walking independently (30 versus 72 percent).

Hospital characteristics are examined in Table 3. AMI patients were discharged from 1,500 hospitals in the seven States. The overall rate of PASU across States varied from 31 percent in Ohio to 44 percent in Massachusetts. Comparable rates for HHA use ranged from 21 percent in Texas to 35 percent in New York and for some inpatient contact from 6 percent in New York to 14 percent in Massachusetts. Table 3 also indicates that significant differences in hospital characteristics are present across States, particularly the percentage of rural hospitals (5-39 percent), the percentage of teaching hospitals (10-39 percent), for-profit ownership (0-39 percent), hospital or subsidiary provision of home health services (33-68 percent), and the existence of a separate, long-term nursing home unit (14-32 percent).

Variation in PASU

The ORs and corresponding 95 percent intervals for the variables included in the hierarchical logistic regression model are shown in Table 4. The patient discharge severity score had a large, significant association with PASU (OR=2.85 [2.78, 2.93]). Patients discharged from for-profit hospitals (OR=1.23 [1.08, 1.39]) or from institutions where home health services were provided by the hospital or subsidiary (OR=1.15 [1.05, 1.25]) were more likely to receive PASU. The predicted probability of PASU for each of the seven States is also shown in Table 4. Even after controlling for patient and hospital characteristics, State remained an important predictor of PASU. Patients from Ohio and Texas were less likely to receive PAS than patients from Pennsylvania, Florida, New York, and Massachusetts.

DISCUSSION

This exploratory study is one of the first to characterize and compare the distribution of PASU in AMI patients immediately following discharge. Using clinically rich data sets to control for patient and hospital characteristics, we found that for-profit ownership of the hospital and the provision of home health services through the hospital or a subsidiary were significant predictors of PASU. The differences in PASU between States persisted, however, after many patient and hospital characteristics were accounted for in the model.

For-profit ownership has previously been identified as a factor related to expenditures on home health care. Silverman et al. (1999) reported that per capita Medicare spending on home health care was higher in areas served by for-profit hospitals than

Table 3
Characteristics of Hospitals Discharging Elderly Medicare Beneficiaries After Acute Myocardial Infarction, by State: 1994-1995

Characteristic	7 States *n*=1,500	California *n*=352	Florida *n*=187	Massachusetts *n*=80	New York *n*=209	Ohio *n*=169	Pennsylvania *n*=196	Texas *n*=307
Hospitals	100	23.5	12.5	5.3	13.9	11.3	13.1	20.5
					Percent[1]			
Post-Acute Service Use								
Overall	36.8	35.3	40.2	44.4	40.7	30.6	37.8	29.9
Home Health Agency Only	27.5	22.4	32.4	30.2	34.8	21.3	28.5	20.7
Some Inpatient Contact	9.3	12.9	7.8	14.3	5.9	9.3	9.3	9.2
Hospital Characteristics								
Less than 100 Beds	24.4	22.7	15.5	18.8	20.6	20.7	19.4	41.0
100-500 Beds	64.5	69.9	69.5	76.2	61.2	65.7	70.4	50.2
500 or More Beds	11.1	7.4	15.0	5.0	18.2	13.6	10.2	8.8
Rural	22.1	9.9	15.5	5.0	20.6	33.7	21.9	39.1
Teaching	23.3	19.6	18.7	31.3	39.2	21.9	36.7	9.5
Ownership								
Government	17.4	20.7	13.9	7.5	11.0	14.8	0.5	34.9
Not-For-Profit	64.9	56.0	46.5	92.5	83.7	84.6	96.9	34.9
For-Profit	17.7	23.3	39.6	0.0	5.3	0.6	2.6	30.3
Cardiac Services								
None	54.9	51.7	39.6	53.8	72.7	56.2	53.1	56.7
Catheterization Only	18.1	12.8	28.3	30.0	12.4	21.9	25.0	12.4
CABG/PTCA	26.9	35.5	32.1	16.2	14.8	21.9	21.9	30.9
Other Services								
Inpatient Beds for Rehabilitation Care [2]	18.3	14.2	10.7	8.8	19.6	21.3	25.5	23.1
Inpatient Beds for Skilled Nursing Care [2]	30.7	33.2	18.2	15.0	26.3	32.5	28.1	43.0
Hospital/Subsidiary Provider of Rehabilitation Care	27.9	23.3	25.1	26.3	30.1	29.6	33.7	29.3
Hospital/Subsidiary Provider of Skilled Nursing Care	32.3	34.7	18.7	17.5	27.8	34.3	28.1	46.3
Hospital/Subsidiary Provider of Home Health Services	50.0	41.2	47.1	43.8	33.0	57.4	55.1	67.8
Separate Long-Term Nursing Home Unit [3]	25.5	26.4	15.0	13.8	25.8	25.4	28.6	31.9

[1] Percentages correspond to the number of hospitals with a particular characteristic. All hospital characteristics significantly differ across States (p=0.001 using chi-squared test statistic).

[2] At least one inpatient bed set up and staffed for rehabilitation (skilled nursing) care at the hospital.

[3] Beds set up and staffed for a separate long-term nursing home unit at the hospital.

NOTES: CABG is coronary artery bypass graft surgery. PTCA is percutaneous transluminal coronary angioplasty.

SOURCES: Bronskill, S.E., Institute for Clinical Evaluative Sciences, Normand, S.L.T., and McNeil, B.J., Harvard Medical School, 2002

Table 4

Predictors of Post-Acute Service Use (PASU) in Elderly Medicare Beneficiaries After Acute Myocardial Infarction from Hierarchiacal Logistic Regression, 1994-1995

Characteristic	Adjusted Odds Ratio
Patient	
(Discharge Severity Score–Mean Severity)	2.85 (2.78, 2.93)[1]
Discharging Hospital	
Rural	0.92 (0.82, 1.05)
Separate Long-Term Nursing Home Unit in Hospital	0.93 (0.84, 1.02)
Government Ownership[2]	1.05 (0.92, 1.20)
Teaching Hospital	1.06 (0.96, 1.17)
Home Health Services Offered by Hospital/Subsidiary	1.15 (1.05, 1.25)[1]
For-Profit Ownership[2]	1.23 (1.08, 1.39)[1]
	Predicted Probability of PASU[3]
State	
Ohio	23.7 (21.2, 26.2)
Texas	25.2 (22.7, 27.8)
California	29.2 (27.0, 31.6)
Pennsylvania	32.8 (30.1, 35.6)
Florida	34.3 (31.4, 37.3)
New York	35.9 (33.1, 38.7)
Massachusetts	40.7 (36.8, 44.6)

[1] 95 percent interval does not overlap 1.0.

[2] Compared with not-for-profit hospital.

[3] Probability of PASU for a patient of average discharge severity discharged from an urban, not-for-profit hospital, with no separate long-term nursing-home unit, and no provision of home health services by the hospital or a subsidiary.

NOTE: 95 percent intervals are shown in parentheses.

SOURCES: Bronskill, S.E., Institute of Evaluative Sciences, Normand, S.L.T., and McNeil, B.J., Harvard Medical School, 2002.

in areas served by not-for-profit hospitals and offered the following three explanations for this finding: (1) specific characteristics of Medicare populations served by for-profit hospitals, including the possibility that patients remaining in traditional FFS Medicare in these areas have a greater severity of illness due to increased health maintenance organization penetration; (2) other unmeasured attributes of the for-profit hospitals; and (3) differing organizational behavior of for-profit hospitals. Patients in our post-acute cohort were FFS Medicare patients who were clinically homogeneous (due to their AMI and adjustment for admission and discharge severity). Thus, the first explanation is unlikely to apply to our results. In addition, our analyses took into account many characteristics of the discharging hospital. Our results, therefore, are most likely explained by the third proposed explanation. We cannot exclude, however, the possibility that the data examined did not capture all relevant characteristics of hospitals, such as a hospital's proportion of Medicare patients. It is also possible that the effect of financial incentives across both for-profit and not-for-profit hospitals is not fully captured in our analyses.

This study does not clarify the association between for-profit ownership of the discharging hospital and increased PASU. Several explanations are possible. For example, for-profit hospitals could be more effective at discharge planning and implementing appropriate rehabilitative strategies. Alternatively, for-profit hospitals could be more likely to respond to financial pressures to reduce hospital stays than not-for-profit hospitals, resulting in premature discharges that necessitate more PASU. These issues warrant further study.

The finding of a significant, positive association between the provision of home health services by the discharging hospital and PASU also suggests the importance of the organizational structure of hospitals in influencing patterns of service use. This result is consistent with the finding of a previous study (Blewett, Kane, and Finch, 1995) that examined the relationship of hospital characteristics to PASU for patients with stroke, chronic obstructive pulmonary disease, congestive heart failure, and hip procedures in three cities in the United States. These authors suggested that Medicare's prospective payment system for hospital inpatient services increased the incentive for hospitals to buy, build, or affiliate PAS in order to maximize profit and/or quality of care. The authors proposed that such a relationship would: (1) shorten the length of inpatient stays; (2) increase access to needed PAS, (3) shift the cost of care from a prospective payment to a cost-based reimbursement; and (4) diversify hospital business during a time when hospital admissions were falling. Disentangling these explanations further is an area for future research because it is possible that, in a period of contraction such as that reported by McCall et al. (2001) for home health services, reverse findings could be possible. Such activities will require detailed information on discharge planning and an objective measurement of patient need for PAS.

Hospital characteristics that predicted inpatient cardiac service use and outcomes, such as teaching status, did not predict PASU. Teaching hospitals are often perceived as providing improved access to and a higher quality of care; yet, in this study they were not significantly related to PASU. In general, patient characteristics were more important predictors of PASU than hospital factors. Blewett, Kane, and Finch (1995) have found similar results.

Geographical variation in PASU was quite broad, on both an individual hospital and regional basis. This appears to reflect known statewide patterns regarding the availability of services (Picone and Wilson, 1999). Several authors have identified the importance of State factors, particularly those related to supply of services, in explaining regional variations in PASU (Cohen and Tumlinson, 1997; Kenney and Dubay, 1992). To investigate the State variations further, we constructed additional models of PASU (results not shown) which incorporated the State factors listed in Table 5. Surprisingly, these models revealed no significant relationships and the associations between the patient and hospital characteristics and PASU did not change. These results suggest that we were unable to identify the important State-level variables or perhaps that regional variations in PASU are driven by factors associated with units larger than hospitals, but smaller than States.

Given the variations in PASU across States for elderly AMI patients, the potential for differential impacts of the post-acute payment policies mandated by the BBA warrants discussion. The possibility that differing payment policies across PASs will induce assignment of clinically similar patients to the setting with the largest remuneration is an ongoing concern for policymakers (Gage, 1999). Because there was little variation in the type of PAS used by the AMI cohort (75 percent of PASU in this study was in the form of HHA), we were unable to address the question of whether patients using different PASU options were clinically different from each other and, therefore, unlikely to have one type of PAS substituted for another. The identification of factors beyond the patient, in particular for-profit hospitals and hospitals that offer HHA, as

Table 5
Summary of Post-Acute Care Systems Across States, 1994-1995

Characteristic	California	Florida	Massachusetts	New York	Ohio	Pennsylvania	Texas
Licensed Home Health Agencies, 1994	1,169	1,450	NL	822	NL	403	1,836
Medicare Home Health Beneficiaries Per 1,000 Beneficiaries, 1994	100.1	118.0	127.9	75.8	79.5	104.3	106.9
Average Medicare Reimbursement for Home Health Per Visit, 1994	$88	$61	$50	$75	$59	$67	$61
Average Medicare Reimbursement for Home Health Per Enrollee, 1994	$408	$542	$553	$252	$239	$301	$637
Certified Nursing Facilities, 1995	1,382	627	550	624	943	726	1,266
Number of Beds in Certified Nursing Facilities, 1995	140,203	72,656	54,532	107,750	106,884	92,625	123,056
Nursing Home Beds Per 1,000 Age 65 or Over Population, 1994	41	30	65	47	61	60	69
Medicare SNF Admissions Per 1,000 Beneficiaries, 1994	63	42	52	24	45	41	43
Average Medicare Program Payments for SNF (Per Day), 1994	$270	$193	$145	$97	$161	$151	$213

NOTES: NL is not licensed. SNF is skilled nursing facility.

SOURCES: Graves, N., and Bectel, R. Across the States 1996: Profiles of Long-Term Care Systems; AARP Policy Institute. Washington, DC. 1996; and *Health Care Financing Review, Statistical Supplement*, October 1996.

predictors of PASU suggests that discretionary placement of clinically similar patients might be occurring.

In general, rates of PASU for AMI patients were similar to those reported for all Medicare beneficiaries, but lower than those according several major disease categories. In 1995, Gage (1999) reported that 62 percent of Medicare hospital discharges did not use PAS and that use of home health care was 20 percent, SNFs 9 percent, rehabilitation facilities 0.9 percent and multiple services 8.3 percent. Compared with a recent study (Kane, Lin, and Blewett, 2002) of 1997 Medicare beneficiaries across a variety of disease groups, the AMI cohort had a higher rate of patients using no PASU within 30 days of hospital discharge (63 versus 30 percent stroke, 10 percent hip fracture, 58 percent chronic obstructive pulmonary disease [COPD], and 50 percent congestive heart failure). In general, the disease-specific cohorts used more inpatient PAS with rates of skilled nursing ranging from 9 percent for COPD to 49 percent for hip fracture.

Even though AMI patients are not among the top 10 types of patients likely to use PAS (Gage, 1999), examining patterns of service use in this area is important. The clinical feasibility (Every et al., 1996; Moss, 1996) and cost-effectiveness of shortened hospital stays for AMI patients have recently received considerable attention. It has been suggested that hospitalization beyond 3 days after thrombolysis for patients with uncomplicated AMI is not cost effective (Newby et al., 2000). As these issues evolve into practice guidelines, it is likely that similar recommendations will be necessary for PASU. In this study, only 37 percent of our cohort actually received PASU and we could not assess the appropriateness of this care.

Two important limitations to this study should be addressed in future research. First, PAS use is not dichotomous as analyzed in this article. In the time following a hospital discharge, the mix and volume of PASU can vary dramatically across patients and we did not capture this heterogeneity in our analyses. While the presentation of our analyses is consistent with other work in this area (Kane et al., 2002), an enhanced understanding of the interactions between types of PAS and measurement of the intensity of service use is needed. Second, the parameters we investigated did not account for all of the variation observed in PASU. The availability of support at home for patients from family members, such as a spouse or children, has been shown to predict PASU (Kane et al., 1996) In addition, our summary score for patient severity at discharge was based on factors known to predict both in-hospital and 30-day mortality from admission. Even though we supplemented the admission information with hospitalization and discharge data, risk adjustment of AMI patients at discharge requires more rigorous investigation and the inclusion of other measures of function such as activities of daily living. It would also be interesting to collect information on outpatient services used by the AMI cohort and to include the quantity and duration of PASU. These factors are likely to strongly influence patterns of PASU.

These analyses have succeeded in documenting and disentangling some of the effects of patient, hospital, and State factors on PASU for elderly AMI patients. In particular, they highlight how variations in patterns of service use across States are mitigated, but not eliminated, by controlling for patient and hospital characteristics.

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TECHNICAL NOTES

Components of Score Measuring Severity of Patient Illness at Discharge

A model predicting PASU based on characteristics of patient admission severity, demographic information, events in hospital and patient status at discharge was fitted to construct the severity score measuring severity of patient illness at discharge. A standard stepwise logistic regression model, in which the response was the binary variable PASU, was developed to identify which of these variables were significant predictors (p-value$\leq$0.05) of PASU. Because the model was being used for estimation not prediction, the full cohort of 39,837 elderly, AMI patients was used in development. We constructed partial residual plots to identify potential problematic areas of model fit but found no striking departures from our assumptions (Landwehr, Pregibon, and Shoemaker, 1984). We tested model discrimination by means of the *c statistic.*(Hanley and McNeil, 1982). The *c statistic* for the model was 0.78, which fell above generally accepted value for good accuracy of 0.75.

Table A lists the individual severity variables, mean values, and estimated regression coefficients. Discharge severity for the j^{th} patient at the i^{th} hospital was defined as:

$$\text{severity}_{ij} = \sum_{p=1}^{p} \hat{\delta}_p X_{ijp}$$

where p indexes the number of covariates, $\hat{\delta}_p$ is the regression coefficient specified in the table, and X_{ijp} is the value of the p^{th} covariate for the j^{th} patient at the i^{th} hospital.

Structure of Hierarchical Logistic Regression Model

A hierarchical logistic regression model was used to model both systematic and random variability in PASU by patients within hospitals. Assume that PASU data are collected on the j^{th} patient (j=1, …, n_i) for each hospital i (i=1, …, 1,500). Let Y_{ij}=1 if the j^{th} patient of the i^{th} hospital used PAS within 30 days of hospital discharge and Y_{ij}=0 otherwise. Therefore, the probability of PASU (p_{ij}) for the j^{th} patient discharged from the i^{th} hospital follows the logistic model:

Stage 1: Within-Hospital Variability

$$\text{logit}(p_{ij} \mid \alpha_i,\beta) = \text{logit})\Pr(Y_{ij}=1) \mid \alpha_i,\beta) \\ = \alpha_i + \beta(SS_{ij} - \overline{SS})$$

where SS_{ij} is the discharge severity score for the j^{th} patient of the i^{th} hospital and $\overline{SS}$ is the average discharge severity score across all patients. The intercept term, α_i , represents the log-odds of PASU for a patient of average discharge severity treated at the i^{th} hospital, and is assumed to vary across hospitals. β represents the change in the log-odds of PASU per unit change in patient severity and is assumed not to vary across hospitals.

Hospital covariates are incorporated using a regression model on α_i:

Stage 2: Between-Hospital Variability

$$\alpha_i \mid \gamma \sim N(\gamma_0 rural_i + \gamma_1 nunit_i + \gamma_2 gov_i \\ + \gamma_3 teach_i + \gamma_4 hha_i + \gamma_5 fp_i \\ + \gamma_6 OH_i + \gamma_7 TX_i + \gamma_8 CA_i \\ + \gamma_9 PA_i + \gamma_{10} FL_i + \gamma_{11} NY_i \\ + \gamma_{12} MA_i, \sigma^2)$$

Table A

Model Predicting Post-Acute Service Use Following Acute Myocardial Infarction in Elderly Medicare Beneficiaries: 1994-1995

Characteristic	Regression Coefficient[1]	Adjusted Odds Ratio	*p*-value	Mean Value[2]	Percent
Admission Severity					
Adjusted Age (75)	0.07	1.08	0.0001	0.14 (6.5)	—
Adjusted Age^2 (75)^2	-0.001	1.00	0.001	41.8 (43.6)	—
History of Cancer	0.05	1.05	0.5	897	2.3
History of Congestive Heart Failure	0.01	1.01	0.83	6,619	16.6
Ventricular Rate Greater Than 100	0.18	1.20	0.0001	10,516	26.4
Stress-Induced Cardiac Ischemia	0.19	1.21	0.003	2,332	5.9
Ischemia Not Measured/Missing	0.28	1.33	0.0001	33,709	84.6
Mobility (Reference: Independent)					
With Assistance	-0.10	0.91	0.02	4,633	11.6
Unable to Walk	-0.03	0.97	0.78	632	1.6
Missing	-0.01	0.99	0.92	513	1.3
Body Mass Index (kg/m^2)	0.002	1.00	0.55	23.4 (9.6)	—
BMI Missing/Not Measured	0.10	1.11	0.19	4,538	11.4
Log Mean Arterial Pressure	-0.92	0.40	0.0001	2.0 (0.25)	—
Missing Mean Arterial Pressure	-1.64	0.19	0.0001	552	1.4
Respiration Rate	0.009	1.01	0.0001	21.4 (6.5)	—
Respiration Rate Missing/Not Measured	0.47	1.60	0.0001	491	1.2
Albumin (g/L)	-0.12	0.89	0.0001	2.8 (1.7)	—
Albumin Missing/Not Measured	-0.47	0.63	0.0001	10,746	27.0
Log Blood Urea Nitrogen	0.49	1.63	0.0001	1.26 (0.3)	—
Missing BUN	0.49	1.64	0.002	918	2.3
Creatinine 1.5mg/dl – 7.0mg/dl	0.04	1.04	0.27	7,909	19.9
Creatinine Missing/Not Measured	-0.09	0.91	0.34	1,209	3.0
Conduction Disturbance on ECG+	0.08	1.09	0.006	7,950	20.0
Shock on Arrival	0.3	1.36	0.002	633	1.6
S3 Gallop Rhythm	0.13	1.13	0.05	1,359	3.4
Congestive Heart Failure on Admission	0.24	1.27	0.0001	15,239	38.3
Cardiomegaly on Admission	0.08	1.08	0.003	12,924	32.4
Cardiac Arrest 6 Hours Prior or at Admission	0.10	1.11	0.27	784	2.00
Demographic					
Female	0.62	1.85	0.0001	17,863	44.8
Dually Eligible	0.20	1.22	0.0001	4,258	10.7
Events in Hospital					
Cardiac Catheterization	-0.09	0.91	0.005	19,961	50.1
CABG	1.49	4.46	0.0001	5,162	13.0
PTCA	-0.08	0.92	0.03	8,267	20.8
Pneumonia	0.47	1.61	0.0001	3,056	7.7
Deep Vein Thrombosis	0.53	1.69	0.001	211	0.5
Cerebrovascular Accident/Stroke	1.26	3.52	0.0001	922	2.3
Anoxic Brain Damage	0.94	2.57	0.0001	208	0.5
Do Not Resuscitate Order	0.24	1.27	0.0001	2,530	6.4
Blood Transfusion	0.52	1.68	0.0001	6,788	17.0
Status at Discharge					
Urinary Incontinence	0.51	1.66	0.0001	2,238	5.6
Mobility (Reference: Independent)					
With Assistance	0.93	2.54	0.0001	7,835	19.7
Unable to Walk	0.72	2.07	0.0001	971	2.4
Missing	0.26	1.29	0.08	254	0.6
Intercept	-0.48	—	0.13	—	—

[1] Coefficients are from logistic regression model where post-acute service use within 30 days of hospital discharge is the outcome of interest (*c-statistic*=0.75).

[2] Mean value reflects mean (standard deviation) for continuous variables and count for categorical variables.

NOTES: The sample consisted of 39,837 acute myocardial infarction patients and 14,674 (36.8 percent) used post-acute services within 30 days of hospital discharge.CABG is coronary artery bypass graft surgery. PTCA is percutaneous transluminal coronary angioplasty.

SOURCE: Bronskill, S.E., Institute for Clinical Evaluative Sciences, Normand, S.L.T., and McNeil, B.J., Harvard Medical School, 2002.

where α_i is assumed to be a function of individual hospital characteristics (γ's) and random error (σ^2). Hospital characteristics indicated whether or not a hospital: was rural (*rural*), had a separate long-term nursing home unit (*nunit*), was government owned (*gov*), was a teaching hospital (*teach*), provided home health services (*hha*), was for-profit (*fp*) or was located in a specific State (*OH=Ohio, TX=Texas, CA=California, PA=Pennsylvania, FL=Florida, NY=New York, MA=Massachusetts*). ($\gamma_6, \ldots, \gamma_{12}$) represent the log-odds of PASU for a patient of average discharge severity treated at an urban, not-for-profit hospital that provides no home health services and has no separate long-term nursing home unit in a particular State. The remaining γ's represent the change in the log-odds of PASU for a change in the respective hospital indicator variable. σ^2 represents between hospital random variation after adjusting for patient severity and systematic hospital characteristics. In order to complete the specification of the model, non-informative proper prior distributions were assumed for remaining Stage 2 parameters (γ, σ^2). Gibbs sampling was implemented in the BUGS software program (Gilks, Thomas, and Spiegelhalter, 1994) to fit the models.