Title

Looking Forward, Looking Back

Journal

Circulation Cardiovascular Quality and Outcomes, 2(6)

ISSN

1941-7713

Authors

Ong, Michael K
Mangione, Carol M
Romano, Patrick S
et al.

Publication Date

2009-11-01

DOI

10.1161/circoutcomes.108.825612

Peer reviewed

Looking Forward, Looking Back

Assessing Variations in Hospital Resource Use and Outcomes for Elderly Patients With Heart Failure

Michael K. Ong, MD, PhD; Carol M. Mangione, MD, MSPH; Patrick S. Romano, MD, MPH; Qiong Zhou, MA; Andrew D. Auerbach, MD, MPH; Alein Chun, PhD, MSPH; Bruce Davidson, PhD, MPH; Theodore G. Ganiats, MD; Sheldon Greenfield, MD; Michael A. Gropper, MD, PhD; Shaista Malik, MD, PhD; J. Thomas Rosenthal, MD; José J. Escarce, MD, PhD

Background—Recent studies have found substantial variation in hospital resource use by expired Medicare beneficiaries with chronic illnesses. By analyzing only expired patients, these studies cannot identify differences across hospitals in health outcomes like mortality. This study examines the association between mortality and resource use at the hospital level, when all Medicare beneficiaries hospitalized for heart failure are examined.

Methods and Results—A total of 3999 individuals hospitalized with a principal diagnosis of heart failure at 6 California teaching hospitals between January 1, 2001, and June 30, 2005, were analyzed with multivariate risk-adjustment models for total hospital days, total hospital direct costs, and mortality within 180-days after initial admission ("Looking Forward"). A subset of 1639 individuals who died during the study period were analyzed with multivariate risk-adjustment models for total hospital days and total hospital direct costs within 180-days before death ("Looking Back"). "Looking Forward" risk-adjusted hospital means ranged from 17.0% to 26.0% for mortality, 7.8 to 14.9 days for total hospital days, and 0.66 to 1.30 times the mean value for indexed total direct costs. Spearman rank correlation coefficients were −0.68 between mortality and hospital days, and −0.93 between mortality and indexed total direct costs. "Looking Back" risk-adjusted hospital means ranged from 9.1 to 21.7 days for total hospital days and 0.91 to 1.79 times the mean value for indexed total direct costs. Variation in resource use site ranks between expired and all individuals were attributable to insignificant differences.

Conclusions—California teaching hospitals that used more resources caring for patients hospitalized for heart failure had lower mortality rates. Focusing only on expired individuals may overlook mortality variation as well as associations between greater resource use and lower mortality. Reporting values without identifying significant differences may result in incorrect assumption of true differences. **(*Circ Cardiovasc Qual Outcomes*. 2009;2:548-557.)**

Key Words: heart failure ■ delivery of health care ■ outcome assessment ■ healthcare costs ■ healthcare economics ■ organizations

Recent national[1,2] and California[3] studies have documented substantial variation across hospitals in the resources used to care for expired elderly Medicare beneficiaries with chronic illnesses, including heart failure (HF), during the 6-month period immediately preceding death. The premise of these studies is that examining hospital resource use among expired elderly Medicare beneficiaries during a fixed time interval before death, which we term as the "Looking Back" method, minimizes the likelihood that variations in resource use are attribut-

Received October 3, 2008; accepted September 1, 2009.

From the Departments of Medicine (M.K.O., C.M.M., Q.Z., J.T.R., J.J.E.) and Health Services (C.M.M.), University of California, Los Angeles; Department of Medicine (P.S.R.), University of California, Davis; Department of Medicine (A.D.A., M.A.G.), University of California, San Francisco; Department of Resource and Outcomes Management (A.C., B.D.), Cedars-Sinai Medical Center, Los Angeles; Department of Family and Preventive Medicine (T.G.G.), University of California, San Diego; Department of Medicine (S.G., S.M.), University of California, Irvine; and RAND Health (J.J.E.), Santa Monica, Calif.

The online-only Data Supplement is available at http://circoutcomes.ahajournals.org/cgi/content/full/CIRCOUTCOMES.108.825612/DC1.

Correspondence to Michael K. Ong, MD, PhD, David Geffen School of Medicine at the University of California, Los Angeles, Department of Medicine, Division of General Internal Medicine & Health Services Research, 911 Broxton Ave, 1st Floor, Los Angeles, CA 90024. E-mail michael.ong@ucla.edu

Circ Cardiovasc Qual Outcomes **is available at http://circoutcomes.ahajournals.org** **DOI: 10.1161/CIRCOUTCOMES.108.825612**

able to differences in severity of illness, because all patients have the same outcome: death. Therefore, the argument goes, hospitals with the lowest resource use can be used to establish performance benchmarks, whereas hospitals with the highest resource use can be identified as inefficient. Public discussions of these studies suggest that reducing hospital resource use to these performance benchmarks would result in substantial savings from current health care spending without adversely affecting health outcomes.[4–6]

However, the "Looking Back" method suffers from 2 potentially serious shortcomings. First, by design, the method used in these studies cannot identify differences across hospitals in health outcomes. By analyzing only expired patients, this method forces health outcomes to be identical across hospitals: 100% mortality. The "Looking Back" method ignores the possibility that resource-intensive care may improve survival, and therefore identifies resource-intensive care as inherently inefficient. Second, the "Looking Back" method implicitly assumes that patterns of resource use observed among expired patients accurately reflect patterns of resource use among all patients, including patients who survived. Thus, the "Looking Back" method ignores the possibility that some hospitals may direct resources to patients in a selective manner, based in part on the likelihood that the patient will benefit from receiving those resources.

This study examines these 2 concerns regarding the "Looking Back" method by comparing it with a "Looking Forward" methodology which allows conclusions to be drawn about survival in addition to resource use. For physicians, patients, and patients' families, survival is a critical concern in patient care.[7] Specifically, our goals were (1) to determine whether health outcomes for chronically ill patients vary across hospitals, as measured by mortality rates over fixed time intervals after hospitalization, and (2) to determine whether the patterns of hospital resource use observed among expired patients accurately reflect the patterns among all patients hospitalized during the same time period, including patients who survived. To achieve these goals, we examined 2 cohorts of elderly Medicare beneficiaries hospitalized for HF at 6 nonprofit academic hospitals in California between 2001 and 2005: a "Looking Forward" cohort, which included all patients hospitalized during the study period, whether they expired or survived, and a "Looking Back" cohort of patients who expired during the study period, drawn from the "Looking Forward" cohort. The 6 study hospitals include the 5 University of California Medical Centers (UC Davis, UC Irvine, UC Los Angeles, UC San Diego, and UC San Francisco) and Cedars-Sinai Medical Center in Los Angeles. Cedars-Sinai is the largest teaching hospital in California and is academically affiliated with UC Los Angeles. These hospitals varied widely on hospital resource use in the prior studies,[1–3] and they include both hospitals identified as examples of performance benchmarks (UC Davis and UC San Francisco) as well as hospitals identified as examples of high resource use (Cedars-Sinai and UC Los Angeles).

WHAT IS KNOWN

- Substantial variation has been documented among hospitals in the resources used to care for elderly Medicare beneficiaries with chronic illnesses during the last 6 months of life.
- By only including individuals who have died in the analyses, researchers cannot identify differences on health outcomes such as survival.

WHAT THE STUDY ADDS

- This study found variation among California teaching hospitals in survival for patients hospitalized with heart failure. This variation would have been overlooked by a study that only examined heart failure patients who died.
- When analyzing all patients hospitalized for heart failure, California teaching hospitals that used more resources had lower mortality rates.
- When analyzing all patients hospitalized for heart failure, the variation in resource use among California teaching hospitals was 27% to 44% less than the variation observed when analyzing only heart failure patients who died.

Methods

"Looking Forward" Cohort

We used administrative data from the 6 study hospitals to identify hospitalizations for 4990 elderly (age 65 or over at admission) Medicare beneficiaries that occurred between January 1, 2001 and June 30, 2005 with a principal diagnosis of HF as defined by ICD-9-CM codes used by the Dartmouth Atlas of Health Care (398.9, 398.90, 398.91, 398.99, 402.0, 402.01, 402.1, 402.11, 402.9, 402.91, 404.0, 404.01, 404.03, 404.11, 404.13, 404.91, 404.93, 428.0, 428.1, 428.9, but not 428.2, 428.3, or 428.4)[1,8] or with a principal ICD-9-CM code of acute respiratory failure and a secondary diagnosis of HF.[9] We defined initial hospitalizations as HF hospitalizations that occurred within the specified time period at the 6 sites and were not preceded by any other HF hospitalization within the previous 6 months. To enhance clinical homogeneity, we excluded initial hospitalizations for 107 patients assigned to a surgical Diagnostic Related Group (DRG) classification[10] (except for valve replacement and pacemaker/defibrillator placement, which we included); for 120 patients who were transferred from another acute care hospital (because of unknown severity of illness and resource use at the preceding facility)[11–14]; and for 53 patients who had received a cardiac, renal, or hepatic transplant or were admitted for transplant evaluation based on ICD-9-CM codes (996.8, 996.80, 996.81, 996.82, 996.83, 996.89, E878.0, v42.0 v42.1, v42.7, v42.9, v49.83). We also excluded 711 individuals hospitalized at site F during 2001 and the first half of 2002 who had missing cost data. For the 445 patients who had multiple initial hospitalizations during the period, we randomly selected 1 of the initial hospitalizations to minimize bias in the assessment of hospital differences in mortality rates. The final "Looking Forward" cohort consisted of 3999 patients.

"Looking Back" Cohort

The "Looking Back" cohort were drawn from the 1650 patients in the "Looking Forward" cohort who expired between July 1, 2001, and December 31, 2005. Dates of death were identified using the hospital administrative data and the National Death Index (http://www.cdc.gov/nchs/ndi.htm). We excluded an additional 11 individ-

uals hospitalized at site F who had missing cost data for hospitalizations before the initial hospitalization used in the "Looking Forward" cohort. The final "Looking Back" cohort consisted of 1639 patients.

Outcomes

We generated 2 resource use outcomes, total hospital days and indexed total direct costs, from each hospital's administrative data, and we obtained mortality outcomes from the administrative data and the National Death Index. For the "Looking Forward" cohort, we determined total hospital days during the 180-day period after each initial HF hospitalization by summing the lengths of stay for the initial hospitalization and any subsequent hospitalization, regardless of principal diagnosis, for which the admission date occurred within 180 days of the initial hospitalization admission date. We determined total direct costs using internal cost accounting system data for each hospitalization included in the calculation of total hospital days. We also assessed total hospital days and total direct costs for the initial hospitalization (not shown in tables). We did not use total (direct plus indirect) costs because of concerns regarding a lack of comparability of indirect cost accounting across sites. Total direct costs were indexed to 2005 using the medical care component of the Consumer Price Index (www.bls.gov/CPI). To avoid revealing proprietary information about hospital-specific costs, we then divided each site's predicted total direct cost estimate by the mean predicted estimate for the entire study cohort (all 6 hospitals). We assessed mortality during the initial hospitalization and at 30 and 180 days after the initial hospitalization admission date. We chose to limit mortality assessment to 180 days after the initial hospitalization as one of our outcomes to be consistent with the 180-day resource use outcomes, and because previous studies have found that death up to 180 days after an initial hospitalization is associated with processes of care during the initial hospitalization.[15]

For the "Looking Back" cohort, we followed the same procedures except that we determined total hospital days and total hospital direct costs during the 180-day period immediately preceding death by summing the lengths of stay and costs from all hospitalizations that overlapped the beginning of a 180-day period counted backwards from the date of death.[1–3]

Statistical Analysis

We used multivariate regression analysis to assess differences across the study hospitals in the study outcomes, adjusted for differences in patient characteristics that can influence use and mortality. The key independent variables in the models were indicator variables for the 6 study hospitals, and the covariates included indicator variables for patient age on admission, gender, race/ethnicity (Hispanic, black, other, white), admission year, Medicaid as an additional payor, DRG for valve replacement or pacemaker/defibrillator placement, and each of 21 comorbidities derived from the Agency for Healthcare Research and Quality's Healthcare Cost & Utilization Project, after taking out HF, comorbidities subject to misclassification (coagulopathies, electrolytes and fluid disorders), and comorbidities too rare to include in the analysis (chronic peptic ulcer disease, drug abuse, HIV and AIDS, pulmonary circulation disorders, and valvular disease).[16,17] Covariates for the "Looking Forward" cohort were derived from the initial hospitalization, whereas covariates for the "Looking Back" cohort were derived from the earliest hospitalization within 180 days of death.

For the "Looking Forward" cohort, we used zero-truncated Poisson regression models for total hospital days, zero-truncated negative binomial regression models for total hospital direct costs, and logistic regression models for mortality. We chose zero-truncated models for days and direct costs because these outcomes assume only nonzero positive values.[18,19] We further confirmed the choice of models by assessing goodness of fit for alternative models (negative binomial versus overdispersed Poisson models, and models without zero truncation). For the "Looking Back" cohort, we used overdispersed Poisson regression models for total hospital days and ordinary least square regression models for total hospital direct costs, which were the methods used by prior studies.[1–3] Cost analyses with negative binomial models found similar results. In all models, we used the Huber-White sandwich estimator to obtain robust standard errors for the regression coefficients that accounted for the nonindependence (ie, clustering) of observations within hospitals. All analyses were performed using Stata 10 (College Station, Tex).

We report results as unadjusted and risk-adjusted means and proportions, where the latter are estimated using the method of recycled predictions.[20–25] This method is the most appropriate method for estimating the risk-adjusted mean value of an outcome variable from nonlinear regression models, because it enables us to estimate what each study outcome would have been at each study hospital in 2005 if the hospital's patients had the same distribution of characteristics as the entire study population. We used the delta method to obtain standard errors for each hospital's risk-adjusted means and proportions and to conduct statistical tests of pair-wise differences between hospitals in these outcomes.[19,26,27] To ensure that these standard errors and tests also accounted for clustering, we applied the delta method to the robust variance-covariance matrix estimates obtained using the Huber-White estimator. A probability value of 0.05 or less was used as the criterion for statistical significance in all analyses, without adjustment for multiple comparisons due to differing views about the appropriate null hypothesis.[28] The institutional review boards at all 6 study hospitals approved this study. The authors had full access to the data and take responsibility for its integrity. All authors have read and agree to the manuscript as written.

Table 1. Patient Characteristics

Characteristics	"Looking Forward" Cohort	"Looking Back" Cohort
Total, n	3999	1639
Mean age	80.3 (SD=8.2; 77.4–81.8)	82.0 (SD=8.2; 78.3–83.9)
Male gender, %	48.1 (43.7–50.8)	50.8 (36.3–55.6)
White ethnicity, %	71.9 (38.7–86.3)	74.6 (40.3–89.0)
Hispanic ethnicity, %	4.8 (0.0–10.6)	3.7 (0.0–6.1)
Black ethnicity, %	11.4 (3.3–15.8)	10.4 (4.4–15.8)
Other ethnicity, %	11.9 (2.1–37.6)	11.3 (2.1–37.8)
Medicaid coinsurance, %	33.9 (7.4–55.8)	31.3 (7.3–53.6)
Surgical DRG, %	3.5 (1.1–4.9)	9.3 (6.1–11.5)
Site A, %	11.4	12.0
Site B, %	4.6	5.6
Site C, %	19.1	19.6
Site D, %	13.2	13.1
Site E, %	13.4	14.3
Site F, %	38.3	35.6

Ranges are provided in parentheses across the 6 medical centers.

Results

Table 1 describes the demographic characteristics of the "Looking Back" and "Looking Forward" cohorts. The "Looking Back" cohort was older (82.0 years versus 80.3 years), had a slightly lower proportion with Medicaid coinsurance (31.3% versus 33.9%), and a higher proportion of whites (74.6% versus 71.9%) than the "Looking Forward" cohort. The demographic characteristics of the "Looking Back" cohort were derived from each patient's first hospitalization, which may or may not have been for HF. As a result, the "Looking Back" cohort had a higher prevalence of surgical DRGs than the "Looking Forward" cohort (9.3% to 3.5%).

Table 2. 180-Day Mortality: "Looking Forward" Cohorts

Site	"Looking Forward" Mortality, %		
	180-d Mortality (Unadjusted)	180-d Mortality (Adjusted)	
		Estimate	95% CI
A	21.7	26.0*,**	(21.7–30.4)
B	21.9	22.7	(16.5–28.9)
C	18.4	19.1	(16.2–22.0)
D	21.6	22.9†	(19.3–26.5)
E	20.5	21.6‡	(17.9–25.3)
F	19.1	17.0	(15.1–18.8)

*Significantly different from site F at $P<0.001$.
†Significantly different from site F at $P<0.01$.
‡Significantly different from site F at $P<0.05$.
§Significantly different from site E at $P<0.01$.
‖Significantly different from site E at $P<0.05$.
¶Significantly different from site C at $P<0.001$.
**Significantly different from site C at $P<0.05$.

We report the risk-adjusted mean values by site for mortality rates, total hospital days, and indexed total direct hospital costs at 180-days (Table 2). We only analyzed adjusted mortality for the "Looking Forward" cohort (Figure 1). Across sites, the difference between the highest and lowest adjusted mortality increased with longer follow-up periods. The adjusted mortality estimates ranged from 2.2% to 4.7% for inpatient mortality, from 5.1% to 8.8% for 30-day mortality, and from 17.0% to 26.0% for 180-day mortality. There were no significant differences between sites for inpatient or 30-day mortality. However, the site with the lowest 180-day mortality (site F) was significantly lower than sites A, D, and E; site C also was significantly lower than site A.

Across sites, the adjusted mean number of hospital days at 180-days ranged from 9.1 days to 21.7 days for the "Looking Back" cohort, and from 7.8 days to 14.9 days for the "Looking Forward" cohort (Table 3 and Figure 2). This difference in ranges was 44% less in the "Looking Forward" cohort than in the "Looking Back" cohort (7.0 days versus 12.6 days, respectively). The rank order for total hospital days between the "Looking Back" and "Looking Forward" cohorts differed for 4 of the 6 sites; only the sites with the highest and lowest ranks stayed the same across cohorts (Table 4). The 4 sites that changed ranks did not significantly differ from each other on mean total hospital days in either cohort. Site F was significantly higher than all other sites in both cohorts, whereas site D also was significantly lower than sites C and E in the "Looking Back" cohort.

Across sites, the adjusted mean indexed value of total direct hospital costs at 180-days ranged from 0.91 to 1.79 for the "Looking Back" cohort, and from 0.66 to 1.30 for the "Looking Forward" cohort (Table 3 and Figure 3). This difference in ranges for nonindexed values was 27% less in

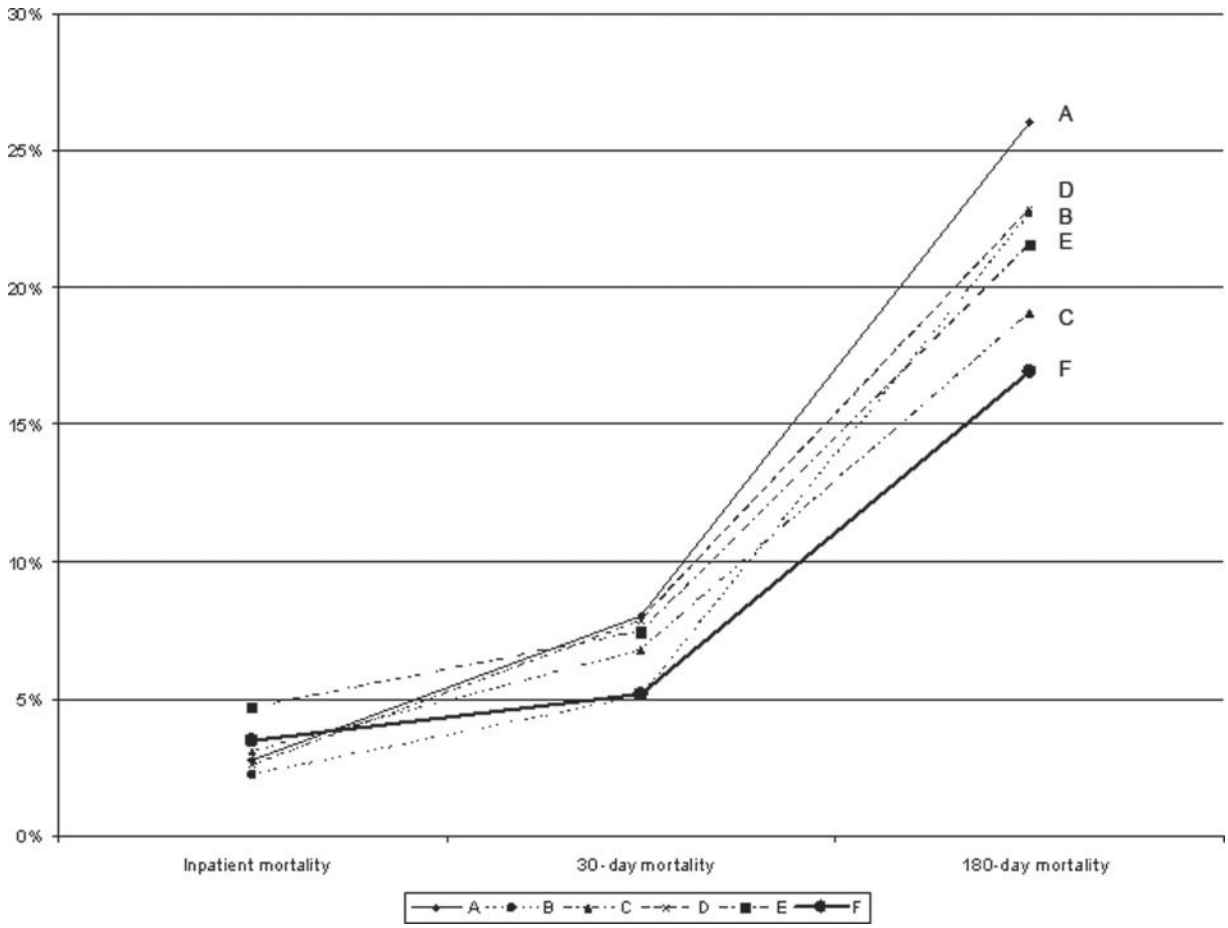

Figure 1. "Looking Forward" cohort inpatient, 30-day, and 180-day mortality rates.

Table 3. 180-Day Total Hospital Days and Indexed Total Direct Costs: "Looking Forward" and "Looking Back" Cohorts

	"Looking Forward" Use			"Looking Back" Use		
		180-d Total Hospital Days (Adjusted)			180-d Total Hospital Days (Adjusted)	
Site	180-d Total Hospital Days (Unadjusted)	Estimate	95% CI	180-d Total Hospital Days (Unadjusted)	Estimate	95% CI
A	8.25	8.24*	(7.25–9.23)	11.18	11.08*	(8.93–13.23)
B	8.53	9.54*	(7.22–11.85)	9.96	10.27*	(6.36–14.19)
C	8.98	8.79*	(7.96–9.62)	11.71	12.58*	(10.38–14.78)
D	7.55	7.84*	(6.92–8.76)	8.62	9.14*§**	(7.23–11.06)
E	8.34	8.82*	(7.92–9.71)	12.27	13.39*	(11.16–15.63)
F	15.38	14.86	(13.96–15.77)	23.78	21.73	(19.66–23.79)
		180-d Indexed Total Direct Costs (Adjusted)			180-d Indexed Total Direct Costs (Adjusted)	
Site	180-d Indexed Total Direct Costs (unadjusted)	Estimate	95% CI	180-d Indexed Total Direct Costs (unadjusted)	Estimate	95% CI
A	0.77	0.75*,**	(0.64–0.85)	1.07	0.97*‖	(0.72–1.23)
B	0.85	0.83*	(0.63–1.04)	0.99	0.95†	(0.42–1.48)
C	0.92	0.90*	(0.81–0.99)	1.15	1.26†	(0.96–1.55)
D	0.65	0.66*§¶	(0.57–0.76)	0.83	0.91*§	(0.69–1.14)
E	0.85	0.87*	(0.77–0.97)	1.31	1.39‡	(1.13–1.65)
F	1.30	1.30	(1.21–1.39)	1.89	1.79	(1.61–1.97)

*Significantly different from site F at $P<0.001$.
†Significantly different from site F at $P<0.01$.
‡Significantly different from site F at $P<0.05$.
§Significantly different from site E at $P<0.01$.
‖Significantly different from site E at $P<0.05$.
¶Significantly different from site C at $P<0.001$.
**Significantly different from site C at $P<0.05$.

the "Looking Forward" cohort than in the "Looking Back" cohort. The rank order for total direct costs between the "Looking Back" and "Looking Forward" cohorts differed for 4 of the 6 sites; only the sites with the highest and lowest ranks stayed the same across cohorts (Table 4). Of the 4 sites that changed ranks, 2 pairs switched rank orders. These pairs did not significantly differ from each other on mean total direct costs in either cohort. Site F was significantly higher than all sites, and site D was significantly lower from site E, in both cohorts. In addition, site E was significantly higher than site A in the "Looking Back" cohort, and site C was significantly higher from sites A and D in the "Looking Forward" cohort.

For the "Looking Forward" cohort, the Spearman rank correlation coefficient between adjusted mortality and adjusted total hospital days at 180-days was −0.68 ($P=0.12$), and between adjusted mortality and adjusted indexed total direct costs at 180-days was −0.93 ($P<0.01$). Site F had the highest hospital use by both measures, but it also had the lowest mortality. Dropping site F from the analysis changed the correlation estimates for the 180-day outcomes to −0.45 ($P=0.43$) and −0.88 ($P=0.04$), respectively. Similarly, the Spearman rank correlation coefficient between adjusted 180-day mortality and adjusted initial hospitalization total hospital days was −0.45 ($P=0.36$), and between adjusted 180-day mortality and adjusted initial hospitalization indexed total direct costs was −0.87 ($P=0.02$). The Spearman rank correlation coefficients between the "Looking Forward" and "Looking Back" cohorts were 0.62 ($P=0.17$) for adjusted total hospital days (Figure 4) and 0.87 ($P=0.02$) for adjusted indexed total direct costs at 180-days (Figure 5).

Sensitivity Analyses

We conducted the following sensitivity analyses to assess the robustness of our findings: (1) analyses of the "Looking Forward" and "Looking Back" cohorts that included individuals with missing cost data (Appendix 2), (2) analyses that used total costs instead of direct costs (Appendix 3), (3) analyses that included initial hospitalizations for patients transferred from other hospitals, transplant patients, and patients in surgical DRGs besides valve replacement or pacemaker placement (Appendix 4), (4) analyses of the "Looking Forward" cohort using all initial HF hospitalizations, including multiple initial hospitalizations for the same patient (Appendix 5), and (5) analyses of subsamples from the "Looking Forward" and "Looking Back" cohorts that included clinical laboratory values at admission (blood urea nitrogen, serum creatinine) as covariates in the multivariate regression models (Appendix 6). We did not use laboratory values in the main analyses as they were available only for an unevenly distributed subset of patients. We found that the results of the sensitivity analyses exhibited the same patterns as the findings of the main analyses (data not shown). In addition, associations between adjusted outcome variables at the hospital level were very similar, in both magnitude and statistical significance, when we estimated weighted Pearson

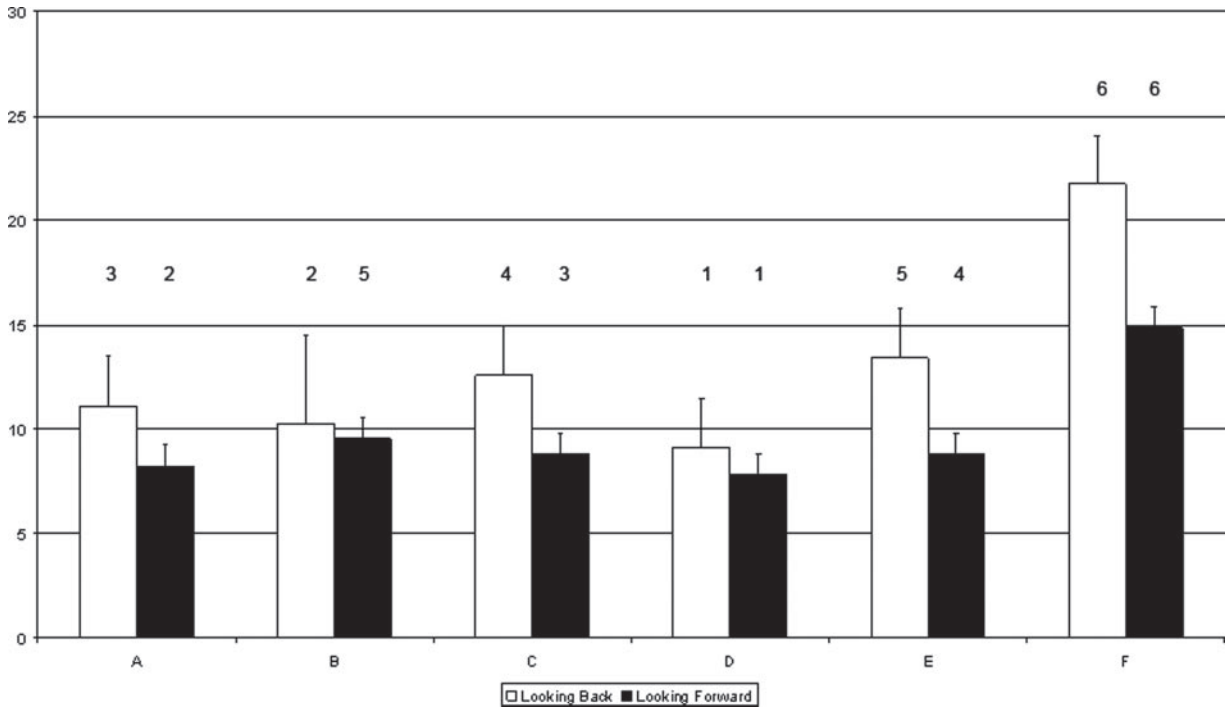

Figure 2. 180-day total hospital days for the "Looking Back" and "Looking Forward" cohorts.

correlations instead of Spearman rank correlations (eg, $r=-0.79$ [$P=0.046$] between adjusted mortality and adjusted total hospital days; $r=-0.86$ [$P=0.017$] between adjusted mortality and adjusted indexed total direct costs at 180-days).

Discussion

Prior studies of variation in hospital resource use that focus only on expired patients have been interpreted to mean that hospitals with low resource use should be regarded as performance benchmarks. Our findings agree with previous investigators that such benchmarking based only on expired individuals should be viewed with caution,[29] particularly when benchmarking is extrapolated beyond expired individuals.[4–6] First, and most importantly, this study identified substantial variation among the 6 study hospitals on adjusted mortality rates in the "Looking Forward" cohort, particularly when observed for 180 days after the initial admission. This health outcome variation also was inversely correlated with resource use variation, meaning that hospitals with higher adjusted resource use within 180 days after an initial hospitalization also had lower adjusted mortality.

Table 4. Ranks for 180-Day Mortality, Total Hospital Days, and Indexed Total Direct Costs: "Looking Forward" and "Looking Back" Cohorts

Cohort	Outcome	Rank Measure	Site A	Site B	Site C	Site D	Site E	Site F
"Looking Forward"	180-d total hospital days	Point estimate of rank	2	5	3	1	4	6
		Mean rank	2.25	4.15	3.47	1.53	3.60	6.00
		Standard deviation	1.05	1.28	0.98	0.82	1.00	0.00
	180-d indexed total direct costs	Point estimate of rank	2	3	5	1	4	6
		Mean rank	2.20	3.27	4.33	1.19	4.02	6.00
		Standard deviation	0.67	1.19	0.74	0.43	0.77	0.03
	180-d mortality	Point estimate of rank	6	4	2	5	3	1
		Mean rank	5.58	4.10	2.27	4.25	3.63	1.17
		Standard deviation	0.71	1.41	0.78	0.97	1.03	0.41
"Looking Back"	180-d total hospital days	Point estimate of rank	3	2	4	1	5	6
		Mean rank	2.77	2.39	3.92	1.38	4.54	6.00
		Standard deviation	0.87	1.23	0.84	0.58	0.67	0.00
	180-d indexed total direct costs	Point estimate of rank	3	2	4	1	5	6
		Mean rank	2.29	2.33	3.92	1.80	4.69	5.98
		Standard deviation	0.88	1.34	0.78	0.75	0.58	0.16

Mean rank and standard deviations are calculated over 1000 iterations.

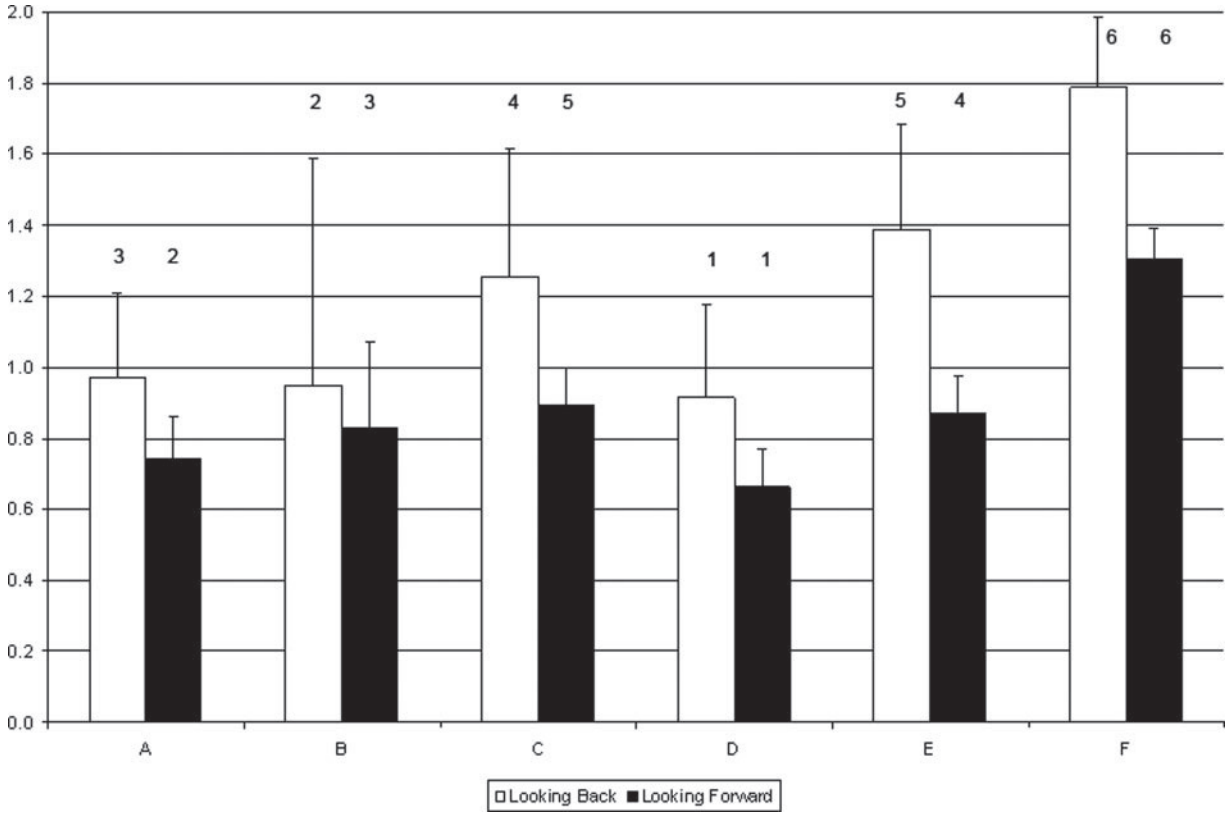

Figure 3. 180-day indexed total direct costs for the "Looking Back" and "Looking Forward" cohorts.

Second, the patterns of resource use across hospitals were not the same between the "Looking Forward" and "Looking Back" cohorts; the only consistent pattern was that site 6 had the highest level and site 4 had the lowest level of resource use in both cohorts, when measured by either use measure. However, changes in rank order occurred among sites that did not significantly differ from each other; simple reporting of means without accounting for significant differences, although simpler for general audiences, may result in incorrect assumptions that sites truly differ from each other on use measures. Further, the study hospitals varied considerably in the size of the difference between risk-adjusted use measures derived from all patients and measures derived only from expired patients.

The 1.5-fold difference across the 6 study hospitals in risk-adjusted 180-day mortality among elderly Medicare patients hospitalized for HF challenges the notion that studies of expired patients provide valid and useful information on hospital efficiency, which should be measured by both resource use and health outcomes. Although prior studies have demonstrated mortality variation across hospitals for HF patients,[7] we also found negative correlations between measures of resource use and 180-day mortality across the study hospitals. Although we do not intend to suggest that this correlation implies a causal relationship between more resources and better outcomes, it does suggest a need for further work to explore how care processes and resource use during an initial hospitalization and subsequent visits influence health outcomes. Although hospitals with excellent adherence to evidence-based process measures[30] have slightly lower risk-adjusted mortality than hospitals with poorer adherence,[7,31] these widely accepted process measures are unlikely to drive the substantial differences in resource use that we observed across teaching hospitals in a single state.

The authors of prior studies of variations in hospital resource use have acknowledged that use must be weighed with outcomes to assess efficiency. However, the common practice of restricting analyses to expired individuals (which is represented with our "Looking Back" approach) ignores outcome differences and overlooks the real possibility that resource use influences outcomes. The relationship between hospital efficiency and quality of care is complex,[32–36] and focusing on expired individuals is likely to be overly simplistic. Appropriate estimation of the value of health care spending requires assessment of potential outcome differences and cannot be done with a "Looking Back" approach. We believe that future studies should use the "Looking Forward" approach to ensure that important outcomes are not missed. Furthermore, clinicians have very limited ability to identify patients who are destined to die within 6 months and selectively withhold health care resources from those patients.[37–39] Although studying only expired patients is expedient because of human subject protection issues that apply only to living individuals,[40] a better solution is to study databases that include all individuals and to not ignore health outcomes.

The methods we used differed in several ways from the methods used in prior studies of variations in hospital resource use, but in most cases the changes in methods strengthened the study. Notably, we examined patients with a

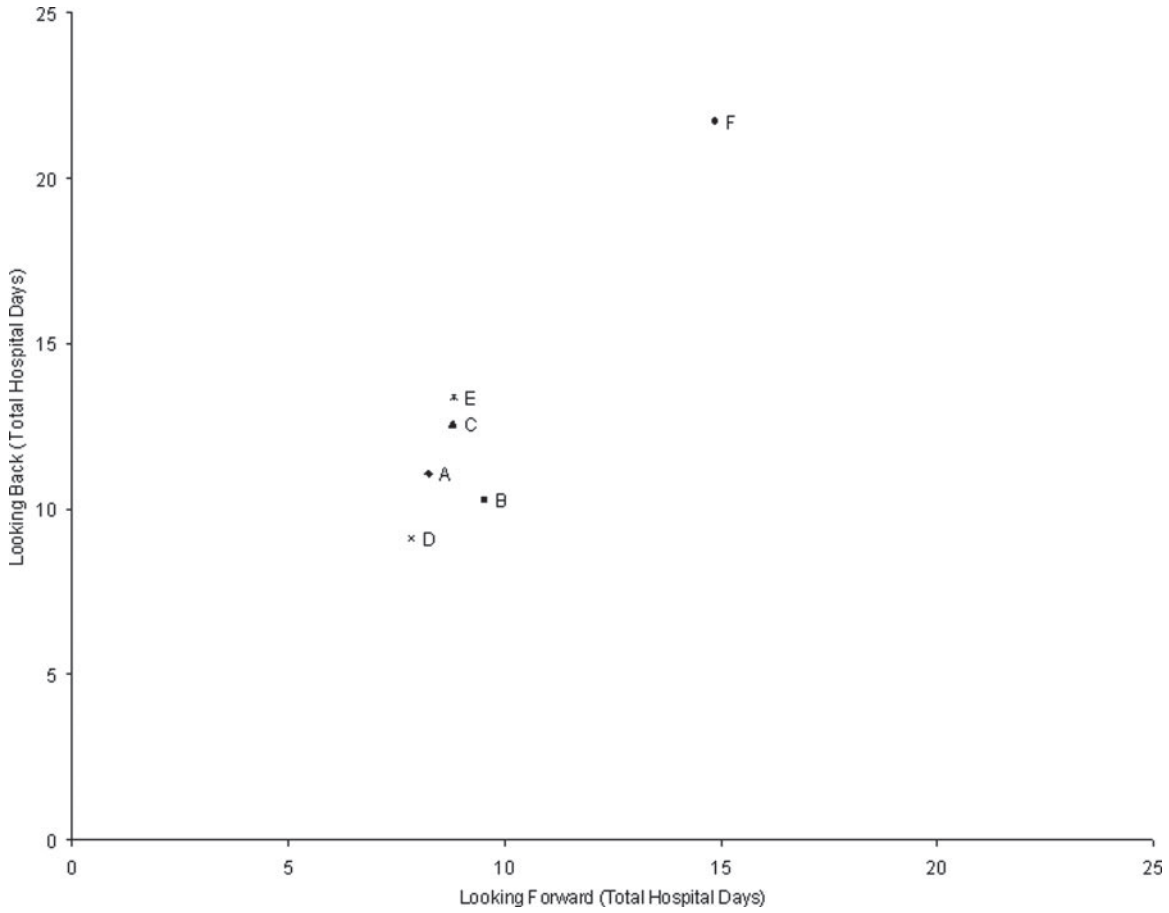

Figure 4. 180-day total hospital days for the "Looking Back" and "Looking Forward" cohorts.

principal diagnosis of HF, whereas prior studies included patients with a principal or secondary diagnosis of HF. We chose to be more restrictive to enhance the clinical homogeneity of the study cohort, because resource use patterns are likely to be driven by the principal diagnosis. For instance, use of resources to care for a patient who is hospitalized for hip fracture will differ from the use of resources to care for a patient who is hospitalized for HF, even if the hip fracture patient receives some treatment for HF. Similarly, we excluded patients whose clinical characteristics were likely to skew use patterns. Transfer[11–14] and transplant patients[41–43] often have unmeasured severity of illness beyond what can be captured by diagnosis codes or comorbid conditions.[44] Hospitalizations associated with surgery incur additional resource use and convalescence that occurs with surgical procedures. Future studies should exclude these types of patients, because these types of patients can vary substantially across hospitals. Of note, although the proportion of patients in the excluded categories varied substantially across hospitals, sensitivity analyses that included these patients also found substantial health outcome variation between sites that were inversely correlated with resource use variation.

We also expanded on the risk-adjustment methodology used by prior studies of variations in hospital resource use,[1–3] which only adjusted for age, gender, ethnicity, and the presence of 12 chronic conditions. Our regression models adjusted for age, gender, ethnicity, 21 comorbid conditions, dual Medicaid eligibility (to partially account for socioeconomic status), and admission year (to account for secular trends in clinical practice). In addition, we performed sensitivity analyses that adjusted for selected clinical laboratory values as well. Risk-adjustment methods using administrative data are subject to potential biases from unmeasured risk factors and other differences in care.[45] Although the risk-adjustment methods we used cannot capture all differences across HF patients at different hospitals, we use a comprehensive list of covariates that are similar to other validated risk adjustment models for HF,[45] and we also find similar results with our sensitivity analyses using clinical laboratory values that may capture some of these unmeasured risk factors.

Our study has additional limitations. First, excluding individuals with missing cost data could affect internal validity of this study if there was a systematic pattern of missingness, such as related to severity of illness. However, the underlying cause of missing cost data were attributable to a known variable (in this case, time), and inclusion of these individuals actually strengthens our findings of mortality differences between sites (Appendix 2).

Second, because we used administrative data from the 6 study hospitals, we were unable to identify hospitalizations at other hospitals or include them in our calculations of resource use. However, prior studies suggest very high "hospital loyalty" among patients hospitalized for chronic illnesses[46];

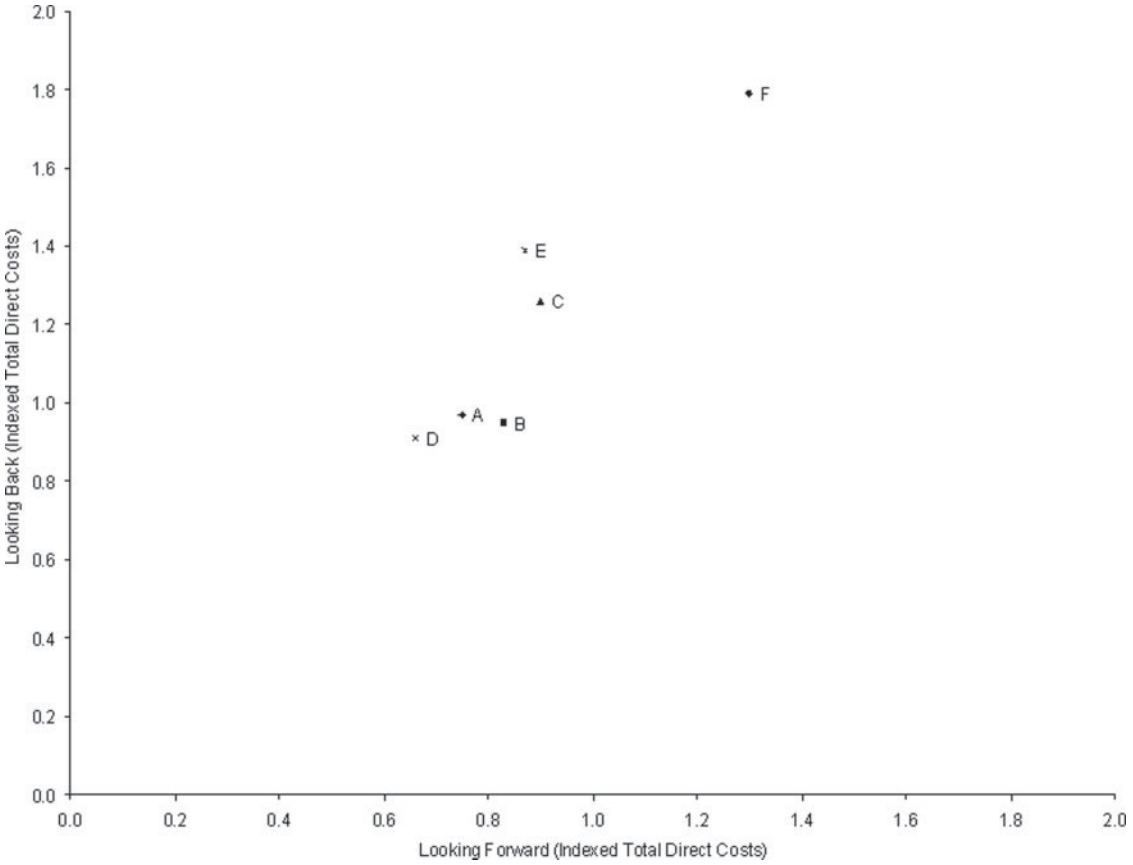

Figure 5. 180-day indexed total direct costs for the "Looking Back" and "Looking Forward" cohorts.

specifically, these studies found that chronically ill patients who were hospitalized in any of our 6 study hospitals had 80% to 90% of their total hospital days in the same hospital.[47]

Third, because of lack of data, our study could not account for outpatient use. It is possible that the rank ordering of hospitals on resource use and the relationship between resource use and mortality would have changed if we had been able to include outpatient care.

Fourth, by counting hospital days and costs for all hospitalizations during the 180-day period of analysis for each patient, we included resource use that may not be directly attributable to the study condition, HF. However, we adopted this approach for comparability with prior studies, and analyses of days and costs for initial hospitalizations alone found similar variation across hospitals as our main analyses.

Fifth, even the direct cost values from one site may incorporate other costs (eg, teaching costs) that would have been attributed differently at another site. However, the similar associations observed between 180-day mortality and both resource use measures, total direct costs and total hospital days, suggest that total direct costs are a reasonable representation of resource use.

Finally, our results may not generalize to smaller hospitals and nonteaching hospitals, which did not participate in our study. Nonetheless, our findings suggest that focusing only on expired patients may lead to different ranking of hospitals with regard to resource use. More importantly, these studies ignore potentially large differences in health outcomes among chronically ill patients. Further studies should be conducted that include these and other hospitals to determine whether similar findings occur.

Assessing hospital efficiency requires that we consider outputs as well as inputs, that is, health outcomes as well as resource use. Contrary to public discussion of variation,[4–6] it is likely that not all variation is inefficient or wasteful. However, much more work is needed to truly distinguish inefficient from beneficial resource use. The 6 hospitals involved in our study are currently investigating the underlying processes and practices that contribute to the variation in resource use and outcomes for HF that we identified. Their goal is to improve the outcomes of patients with HF and to provide care to those patients as efficiently as possible.

Acknowledgments

We gratefully acknowledge the analysis assistance by Alfonso Ang, PhD; Honghu Liu, PhD; Connie Wu, PhD; Wenyi Xiong, MS; and Haiyong Xu, PhD; and the assistance of the Chief Medical Officers at the 6 medical centers with data collection: Allan Siefkin, MD; Eugene Spiritus, MD; Angela Scioscia, MD; Ernest Ring, MD; and Michael Langberg, MD.

Sources of Funding

We gratefully acknowledge our funding from the California Health Care Foundation (06-1311), and the in-kind support from the 6 medical centers included in the study. Dr Mangione received support from the Resource Centers for Minority Aging Research/Center for Health Improvement of Minority Elderly (RCMAR/CHIME) funded by National Institutes of Health/National Institute on Aging (P30

AG021684) and from the UCLA Older Americans Independence Center funded by the National Institutes of Health/National Institute on Aging (5 P30 AG028748).

Disclosures

None.

References

1. *Dartmouth Atlas of Health Care. The Care of Patients With Severe Chronic Illness*. Hanover, NH: Center for the Evaluative Clinical Sciences, Dartmouth Medical School; 2006.
2. *Dartmouth Atlas of Health Care. Tracking the Care of Patients with Severe Chronic Illness*. Lebanon, NH: The Dartmouth Institute for Health Policy and Clinical Practice; 2008.
3. Wennberg JE, Fisher ES, Baker L, Sharp SM, Bronner KK. Evaluating the efficiency of California providers in caring for patients with chronic illnesses. *Health Affairs (Millwood)*. 2005; Supplemental Web Exclusives:526–43.
4. Brownlee S. *Overtreated*. New York: Bloomsbury USA; 2007.
5. New York Times Editorial. Quality care at bargain prices. *New York Times*. 2008.
6. Pear R. Researchers find huge variations in end-of-life treatment. *New York Times*. 2008.
7. Krumholz HM, Normand S-LT, Spertus JA, Shahian DM, Bradley EH. Measuring performance for treating heart attacks and heart failure: the case for outcomes measurement. *Health Affairs (Millwood)*. 2007;26:75–85.
8. Iezzoni LI, Heeren T, Foley SM, Daley J, Hughes J, Coffman GA. Chronic conditions and risk of in-hospital death. *Health Serv Res*. 1994;29:435–460.
9. Goff DC Jr, Pandey DK, Chan FA, Ortiz C, Nichaman MZ. Congestive heart failure in the United States: is there more than meets the I(CD code)? The Corpus Christi Heart Project. *Arch Intern Med*. 2000;160:197–202.
10. Manitoba Centre for Health Policy. Surgical/medical/obstetrical inpatient identification. http://www.umanitoba.ca/centres/mchp/concept/dict/surgmed_inpt.html.
11. Bernard AM, Hayward RA, Rosevear J, Chun H, McMahon LF. Comparing the hospitalizations of transfer and non-transfer patients in an academic medical center. *Acad Med.* 1996;71:262–266.
12. Escarce JJ, Kelley MA. Admission source to the medical intensive care unit predicts hospital death independent of APACHE II score. *JAMA*. 1990;264:2389–2394.
13. Gordon HS, Rosenthal GE. Impact of interhospital transfers on outcomes in an academic medical center. Implications for profiling hospital quality. *Med Care*. 1996;34:295–309.
14. Rosenberg AL, Hofer TP, Strachan C, Watts CM, Hayward RA. Accepting critically ill transfer patients: adverse effect on a referral center's outcome and benchmark measures. *Ann Intern Med*. 2003;138:882–890.
15. Kahn KL, Keeler EB, Sherwood MJ, Rogers WH, Draper D, Bentow SS, Reinisch EJ, Rubenstein LV, Kosecoff J, Brook RH. Comparing outcomes of care before and after implementation of the DRG-based prospective payment system. *JAMA*. 1990;264:1984–1988.
16. Agency for Healthcare Research and Quality. HCUP Comorbidity Software, Version 3.2. http://www.hcup-us.ahrq.gov/toolssoftware/comorbidity/comorbidity.jsp.
17. Baldwin LM, Klabunde CN, Green P, Barlow W, Wright G. In search of the perfect comorbidity measure for use with administrative claims data: does it exist? *Med Care*. 2006;44:745–753.
18. Grogger JT, Carson RT. Models for truncated counts. *J Appl Economet*. 1991;6:225–238.
19. StataCorp. Stata Statistical Software: Release 10. College Station, TX: StataCorp LP; 2007.
20. Graubard BI, Korn EL. Predictive margins with survey data. *Biometrics*. 1999;55:652–659.
21. Basu A, Meltzer D. Implications of spillover effects within the family for medical cost-effectiveness analysis. *J Health Econ*. 2005;24:751–773.
22. Davern M, Rodin H, Blewett LA, Call KT. Are the Current Population Survey uninsurance estimates too high? An examination of the imputation process. *Health Serv Res*. 2007;42:2038–2055.
23. Heslin KC, Andersen RM, Ettner SL, Cunningham WE. Racial and ethnic disparities in access to physicians with HIV-related expertise. *J Gen Intern Med*. 2005;20:283–289.
24. Liao TF. *Interpreting Probability Models: Logit, Probit, and Other Generalized Linear Models*. Newbury Park, Calif: Sage Publications; 1994.
25. Manning WG, Newhouse JP, Duan N, Keeler EB, Leibowitz A. Health insurance and the demand for medical care: evidence from a randomized experiment. *The Am Econ Rev*. 1987;77:251–277.
26. Greene WH. *Econometric Analysis*. 6th Edition ed. Upper Saddle River, NJ: Pearson Prentice Hall; 2008.
27. Bishop YMM, Fienberg SE, Holland PW, (with the collaboration of Light RJ & Mosteller F). *Discrete Multivariate Analysis: Theory and Practice*. Cambridge, Mass: MIT Press; 1975.
28. Rothman KJ. No adjustments are needed for multiple comparisons. *Epidemiology*. 1990;1:43–46.
29. Bach PB, Schrag D, Begg CB. Resurrecting treatment histories of dead patients: a study design that should be laid to rest. *JAMA*. 2004;292:2765–2770.
30. Centers for Medicare and Medicaid Services. Hospital Compare. http://www.hospitalcompare.hhs.gov. Accessed July 4, 2008.
31. Werner RM, Bradlow ET. Relationship between medicare's hospital compare performance measures and mortality rates. *JAMA*. 2006;296:2694–2702.
32. Ayanian JZ, Weissman JS. Teaching hospitals and quality of care: a review of the literature. *Milbank Quarterly*. 2002;80:569–593.
33. Fleming ST. The relationship between the cost and quality of hospital care: a review of the literature. *Med Care Rev*. 1990;47:487–502.
34. Morey RC, Fine DJ, Loree SW, Retzlaff-Roberts DL, Tsubakitani S. The trade-off between hospital cost and quality of care. An exploratory empirical analysis. *Med Care*. 1992;30:677–698.
35. Siegrist RB Jr, Kane NM. Exploring the relationship between inpatient hospital costs and quality of care. *Am J Manag Care*. 2003;9:SP43–SP49.
36. Thomas JW, Guire KE, Horvat GG. Is patient length of stay related to quality of care? *Hospit Health Serv Admin*. 1997;42:489–507.
37. Poses RM, Smith WR, McClish DK, Huber EC, Clemo FL, Schmitt BP, Alexander-Forti D, Racht EM, Colenda CC III, Centor RM. Physicians' survival predictions for patients with acute congestive heart failure. *Arch Intern Med*. 1997;157:1001–1007.
38. Sinuff T, Adhikari NK, Cook DJ, Schünemann HJ, Griffith LE, Rocker G, Walter SD. Mortality predictions in the intensive care unit: comparing physicians with scoring systems. *Crit Care Med*. 2006;34:878–885.
39. Detsky AS, Stricker SC, Mulley AG, Thibault GE. Prognosis, survival, and the expenditure of hospital resources for patients in an intensive-care unit. *N Engl J Med*. 1981;305:667–672.
40. Protection of Human Subjects. In: Department of Health and Human Services, ed. Code of Federal Regulations. 2005;45.
41. Angus DC, Clermont G, Kramer DJ, Linde-Zwirble WT, Pinsky MR. Short-term and long-term outcome prediction with the Acute Physiology and Chronic Health Evaluation II system after orthotopic liver transplantation. *Crit Care Med*. 2000;28:150–156.
42. Sadaghdar H, Chelluri L, Bowles SA, Shapiro R. Outcome of renal transplant recipients in the ICU. *Chest*. 1995;107:1402–1405.
43. Sawyer RG, Durbin CG, Rosenlof LK, Pruett TL. Comparison of APACHE II scoring in liver and kidney transplant recipients versus trauma and general surgical patients in a single intensive-care unit. *Clin Transplant*. 1995;9:401–405.
44. Iezzoni LI. The risks of risk adjustment. *JAMA*. 1997;278:1600–1607.
45. Krumholz HM, Wang Y, Mattera JA, Wang Y, Han LF, Ingber MJ, Roman S, Normand SL. An administrative claims model suitable for profiling hospital performance based on 30-day mortality rates among patients with heart failure. *Circulation*. 2006;113:1693–1701.
46. Wennberg JE, Fisher ES, Stukel TA, Skinner JS, Sharp SM, Bronner KK. Use of hospitals, physician visits, and hospice care during last six months of life among cohorts loyal to highly respected hospitals in the United States. *BMJ*. 2004;328:607–611.
47. Hospital performance reports by state: California. 2006. http://www.dartmouthatlas.org/data/download/perf_reports/CA_HOSP_perfrpt.pdf. Accessed March 11, 2008.

Circulation
Cardiovascular Quality and Outcomes

Looking Forward, Looking Back: Assessing Variations in Hospital Resource Use and Outcomes for Elderly Patients With Heart Failure

Michael K. Ong, Carol M. Mangione, Patrick S. Romano, Qiong Zhou, Andrew D. Auerbach, Alein Chun, Bruce Davidson, Theodore G. Ganiats, Sheldon Greenfield, Michael A. Gropper, Shaista Malik, J. Thomas Rosenthal and José J. Escarce

Circ Cardiovasc Qual Outcomes. 2009;2:548-557; originally published online October 13, 2009;
doi: 10.1161/CIRCOUTCOMES.108.825612
Circulation: Cardiovascular Quality and Outcomes is published by the American Heart Association, 7272 Greenville Avenue, Dallas, TX 75231

Print ISSN: 1941-7705. Online ISSN: 1941-7713

SUPPLEMENTAL MATERIAL

Appendix 1: Detailed Main Analyses

Appendix 1: "Looking Back": Utilization (n = 1,639)

Site	180-Day Total Hospital Days (unadjusted)	180-Day Total Hospital Days (adjusted)	95% CI
A	11.18	11.08 [a]	(8.93 - 13.23)
B	9.96	10.27 [a]	(6.36 - 14.19)
C	11.71	12.58 [a]	(10.38 - 14.78)
D	8.62	9.14 [a,d,g]	(7.23 - 11.06)
E	12.27	13.39 [a]	(11.16 - 15.63)
F	23.78	21.73	(19.66 - 23.79)

Site	180-Day Indexed Total Direct Costs (unadjusted)	180-Day Indexed Total Direct Costs (adjusted)	95% CI
A	1.07	0.97 [a,e]	(0.72 - 1.23)
B	0.99	0.95 [b]	(0.42 - 1.48)
C	1.15	1.26 [b]	(0.96 - 1.55)
D	0.83	0.91 [a,d]	(0.69 - 1.14)
E	1.31	1.39 [c]	(1.13 - 1.65)
F	1.89	1.79	(1.61 - 1.97)

Appendix 1: Looking Forward: Utilization (n = 3,999)

Site	Initial Hospitalization Length of Stay (unadjusted)	Initial Hospitalization Length of Stay (adjusted)	95% CI	180-Day Total Hospital Days (unadjusted)	180-Day Total Hospital Days (adjusted)	95% CI
A	4.51	4.62 [a]	(4.07 - 5.16)	8.25	8.24 [a]	(7.25 - 9.23)
B	4.55	5.23 [c]	(3.55 - 6.91)	8.53	9.54 [a]	(7.22 - 11.85)
C	5.13	4.96 [a,e]	(4.58 - 5.35)	8.98	8.79 [a]	(7.96 - 9.62)
D	4.42	4.53 [a]	– (4.15 - 4.91)	7.55	7.84 [a]	(6.92 - 8.76)
E	4.19	4.33 [a]	(3.91 - 4.75)	8.34	8.82 [a]	(7.92 - 9.71)
F	7.81	7.44	– (7.08 - 7.79)	15.38	14.86	(13.96 - 15.77)

Site	Initial Hospitalization Indexed Total Direct Costs (unadjusted)	Initial Hospitalization Indexed Total Direct Costs (adjusted)	95% CI	180-Day Indexed Total Direct Costs (unadjusted)	180-Day Indexed Total Direct Costs (adjusted)	95% CI
A	0.39	0.41 [a,h]	(0.36 - 0.45)	0.77	0.75 [a,g]	(0.64 - 0.85)
B	0.48	0.47 [b]	(0.34 - 0.60)	0.85	0.83 [a]	(0.63 - 1.04)
C	0.52	0.51 [a,e]	(0.47 - 0.56)	0.92	0.90 [a]	(0.81 - 0.99)
D	0.34	0.36 [a,e,f]	(0.32 - 0.39)	0.65	0.66 [a,d,f]	(0.57 - 0.76)
E	0.42	0.44 [a]	(0.38 - 0.49)	0.85	0.87 [a]	(0.77 - 0.97)
F	0.66	0.65	(0.61 - 0.69)	1.30	1.30	(1.21 - 1.39)

Appendix 1: Looking Forward: Mortality (n = 3,999)

Site	Initial Hospitalization Mortality (unadjusted)	Initial Hospitalization Mortality (adjusted)	95% CI	One Month Mortality (unadjusted)	One Month Mortality (adjusted)	95% CI	180-Day Mortality (unadjusted)	180-Day Mortality (adjusted)	95% CI
A	2.0%	2.8%	(0.9% - 4.6%)	5.9%	8.0%	(5.0% - 11.1%)	21.7%	26.0% [a,g]	(21.7% - 30.4%)
B	2.7%	2.2%	(0.3% - 4.1%)	5.5%	5.1%	(2.1% - 8.1%)	21.9%	22.7%	(16.5% - 28.9%)
C	3.0%	3.1%	(1.8% - 4.3%)	6.6%	6.8%	(4.9% - 8.6%)	18.4%	19.1%	(16.2% - 22.0%)
D	2.7%	2.6%	(1.2% - 4.0%)	7.8%	7.8%	(5.5% - 10.2%)	21.6%	22.9% [b]	(19.3% - 26.5%)
E	4.3%	4.7%	(2.7% - 6.7%)	7.5%	7.4%	(5.2% - 9.7%)	20.5%	21.6% [c]	(17.9% - 25.3%)
F	3.8%	3.5%	(2.5% - 4.5%)	5.7%	5.2%	(4.1% - 6.3%)	19.1%	17.0%	(15.1% - 18.8%)

[a] significantly different from site F at p<0.001

[b] significantly different from site F at p<0.01

[c] significantly different from site F at p<0.05

[d] significantly different from site E at p<0.01

[e] significantly different from site E at p<0.05

[f] significantly different from site C at p<0.001

[g] significantly different from site C at p<0.05

[h] significantly different from site C at p<0.01

Statistical testing reported for 180-day adjusted results only. Adjusted results for Looking Forward Inpatient Death and 30-Day Mortality did not have statistically significant findings.

Appendix 1: Pairwise Comparison p-Values for Outcomes

Looking Forward: Total Hospital Days

Site	A	B	C	D	E
A					
B	0.3160				
C	0.4156	0.5559			
D	0.5736	0.1783	0.1353		
E	0.3824	0.5681	0.9707	0.1478	
F	0.0000‡	0.0000‡	0.0000‡	0.0000‡	0.0000‡

Looking Forward: Indexed Total Direct Costs

Site	A	B	C	D	E
A					
B	0.4709				
C	0.0326*	0.5625			
D	0.2365	0.1403	0.0004‡		
E	0.0724	0.7257	0.6888	0.0028†	
F	0.0000‡	0.0000‡	0.0000‡	0.0000‡	0.0000‡

Looking Forward: 180-Day Mortality

Site	A	B	C	D	E
A					
B	0.3901				
C	0.0101*	0.3069			
D	0.2822	0.9585	0.1013		
E	0.1160	0.7622	0.2927	0.6159	
F	0.0003‡	0.0809	0.2271	0.0052†	0.0372*

Looking Back: Total Hospital Days

Site	A	B	C	D	E
A					
B	0.7302				
C	0.3325	0.3274			
D	0.1884	0.6079	0.0223*		
E	0.1313	0.1779	0.5916	0.0056†	
F	0.0000‡	0.0000‡	0.0000‡	0.0000‡	0.0000‡

Looking Back: Indexed Total Direct Costs

Site	A	B	C	D	E
A					
B	0.9472				
C	0.1533	0.3619			
D	0.7378	0.8994	0.0774		
E	0.0243*	0.1560	0.4643	0.0081†	
F	0.0000‡	0.0036†	0.0050†	0.0000‡	0.0172*

*p<0.05, †p<0.01, ‡p<0.001.

Appendix 2: Analyses Including 711 Individuals Excluded Due to Missing Cost Data

Appendix 2: "Looking Back": Utilization (n = 1,848)

Site	180-Day Total Hospital Days (unadjusted)	180-Day Total Hospital Days (adjusted)	95% CI
A	11.18	11.34 [a]	(9.40 - 14.03)
B	9.96	10.94 [a]	(7.33 - 15.71)
C	11.71	13.11 [a]	(11.07 - 15.72)
D	8.62	9.47 [a,d,g]	(7.61 - 11.53)
E	12.27	14.14 [b]	(11.82 - 16.53)
F	21.32	19.03	(17.42 - 20.81)

Site	180-Day Indexed Total Direct Costs (unadjusted)	180-Day Indexed Total Direct Costs (adjusted)	95% CI
A	1.07	1.00 [a,e]	(0.77 - 1.26)
B	0.98	1.05	(0.61 - 1.64)
C	1.14	1.29	(1.06 - 1.65)
D	0.82	0.95 [a,d]	(0.76 - 1.22)
E	1.30	1.44	(1.19 - 1.70)
F	1.74	1.58	(1.43 - 1.74)

Appendix 2: Looking Forward: Utilization (n = 4,710)

Site	Initial Hospitalization Length of Stay (unadjusted)	Initial Hospitalization Length of Stay (adjusted)	95% CI	180-Day Total Hospital Days (unadjusted)	180-Day Total Hospital Days (adjusted)	95% CI
A	4.47	4.59	(4.11 - 5.19)	8.26	8.47 [a]	(7.58 - 9.57)
B	4.51	5.29	(4.06 - 7.39)	8.50	9.58 [a]	(7.54 - 12.11)
C	5.06	5.03	(4.68 - 5.47)	8.87	8.92 [a]	(8.12 - 9.91)
D	4.38	4.61	(4.24 - 5.02)	7.62	8.08 [a]	(7.20 - 9.03)
E	4.10	4.36	(3.94 - 4.86)	8.26	9.02 [a]	(8.11 - 9.93)
F	7.82	7.39	(7.11 - 7.69)	15.22	14.48	(13.80 - 15.24)

Site	Initial Hospitalization Indexed Total Direct Costs (unadjusted)	Initial Hospitalization Indexed Total Direct Costs (adjusted)	95% CI	180-Day Indexed Total Direct Costs (unadjusted)	180-Day Indexed Total Direct Costs (adjusted)	95% CI
A	0.75	0.77	(0.69 - 0.86)	0.77	0.75 [a,g]	(0.65 - 0.86)
B	0.92	0.89	(0.67 - 1.19)	0.85	0.83 [a]	(0.65 - 1.07)
C	1.00	0.98	(0.89 - 1.06)	0.92	0.90 [a]	(0.81 - 1.00)
D	0.65	0.69	(0.62 - 0.76)	0.65	0.66 [a,d,f]	(0.58 - 0.77)
E	0.81	0.83	(0.74 - 0.94)	0.85	0.87 [a]	(0.77 - 0.98)
F	1.27	1.24	(1.15 - 1.30)	1.30	1.30	(1.21 - 1.39)

Appendix 2: Looking Forward: Mortality (n = 4,710)

Site	Initial Hospitalization Mortality (unadjusted)	Initial Hospitalization Mortality (adjusted)	95% CI	One Month Mortality (unadjusted)	One Month Mortality (adjusted)	95% CI	180-Day Mortality (unadjusted)	180-Day Mortality (adjusted)	95% CI
A	2.0%	2.7%	(1.1% - 4.7%)	5.7%	7.8%	(5.0% - 11.0%)	21.4%	25.4% [a,g]	(21.3% - 30.0%)
B	2.7%	2.7%	(0.7% - 5.7%)	6.6%	6.7%	(3.6% - 11.1%)	23.0%	24.9% [c]	(18.6% - 30.8%)
C	3.2%	3.2%	(2.0% - 4.6%)	7.1%	7.2%	(5.3% - 9.1%)	19.0%	19.7%	(17.0% - 22.9%)
D	2.7%	2.7%	(1.5% - 4.2%)	7.4%	7.7%	(5.4% - 10.0%)	21.6%	23.2% [a]	(19.8% - 26.8%)
E	4.3%	4.9%	(3.0% - 7.1%)	7.3%	7.5%	(5.2% - 9.9%)	20.1%	20.6% [c]	(16.9% - 24.0%)
F	3.6%	3.3%	(2.5% - 4.0%)	5.5%	5.1%	(4.2% - 6.1%)	17.9%	16.5%	(15.0% - 18.1%)

[a] significantly different from site F at p<0.001

[b] significantly different from site F at p<0.01

[c] significantly different from site F at p<0.05

[d] significantly different from site E at p<0.01

[e] significantly different from site E at p<0.05

[f] significantly different from site C at p<0.001

[g] significantly different from site C at p<0.05

Statistical testing reported for 180-day adjusted results only.

Appendix 2: Pairwise Comparison p-Values for Outcomes

Looking Forward: Total Hospital Days

Site	A	B	C	D	E
A					
B	0.3766				
C	0.5074	0.5938			
D	0.5774	0.2180	0.1952		
E	0.4103	0.6493	0.8872	0.1548	
F	0.0000‡	0.0001‡	0.0000‡	0.0000‡	0.0000‡

Looking Forward: Indexed Total Direct Costs

Site	A	B	C	D	E
A					
B	0.4872				
C	0.0328*	0.5716			
D	0.2520	0.1466	0.0003‡		
E	0.0812	0.7358	0.6911	0.0037†	
F	0.0000‡	0.0001‡	0.0000‡	0.0000‡	0.0000‡

Looking Forward: 180-Day Mortality

Site	A	B	C	D	E
A					
B	0.8905				
C	0.0353*	0.1391			
D	0.4470	0.6543	0.1223		
E	0.0725	0.2520	0.7027	0.3133	
F	0.0002‡	0.0126*	0.0549	0.0007‡	0.0477*

Looking Back: Total Hospital Days

Site	A	B	C	D	E
A					
B	0.8710				
C	0.2880	0.3745			
D	0.2340	0.5369	0.0222*		
E	0.0875	0.1861	0.5152	0.0036†	
F	0.0000‡	0.0005‡	0.0000‡	0.0000‡	0.0014†

Looking Back: Indexed Total Direct Costs

Site	A	B	C	D	E
A					
B	0.8567				
C	0.1428	0.4633			
D	0.7873	0.7172	0.0918		
E	0.0155*	0.2037	0.3888	0.0067†	
F	0.0002‡	0.0544	0.0788	0.0000‡	0.3446

*p<0.05, †p<0.01, ‡p<0.001.

Appendix 3: Analyses Using Indexed Total Costs Instead of Indexed Total Direct Costs

Appendix 3: "Looking Back": Utilization (n = 1,639)

Site	180-Day Total Hospital Days (unadjusted)	180-Day Total Hospital Days (adjusted)	95% CI
A	11.18	11.08 [a]	(9.04 – 13.47)
B	9.96	10.27 [a]	(6.73 – 14.51)
C	11.71	12.58 [a]	(10.60 - 14.97)
D	8.62	9.14 [a,d,g]	(7.49 – 11.45)
E	12.27	13.39 [a]	(11.30 - 15.82)
F	23.78	21.73	(19.81 - 24.06)

Site	180-Day Indexed Total Costs (unadjusted)	180-Day Indexed Total Costs (adjusted)	95% CI
A	1.17	1.09 [a]	(0.84 - 1.34)
B	0.80	0.78 [a,e]	(0.39 - 1.31)
C	1.14	1.27 [b]	(1.02 - 1.63)
D	0.77	0.87 [a,d,g]	(0.69 - 1.12)
E	1.33	1.43 [b]	(1.20 - 1.72)
F	1.99	1.88	(1.69 - 2.08)

Appendix 3: Looking Forward: Utilization (n = 3,999)

Site	Initial Hospitalization Length of Stay (unadjusted)	Initial Hospitalization Length of Stay (adjusted)	95% CI	180-Day Total Hospital Days (unadjusted)	180-Day Total Hospital Days (adjusted)	95% CI
A	4.51	4.62	(4.14 - 5.26)	8.25	8.24 [a]	(7.28 - 9.32)
B	4.55	5.23	(3.87 - 7.10)	8.53	9.54 [a]	(7.51 - 12.24)
C	5.13	4.96	(4.57 - 5.33)	8.98	8.79 [a]	(8.02 - 9.67)
D	4.42	4.53	(4.18 - 4.94)	7.55	7.84 [a]	(7.00 - 8.83)
E	4.19	4.33	(3.92 - 4.74)	8.34	8.82 [a]	(7.95 - 9.75)
F	7.81	7.44	(7.09 - 7.80)	15.38	14.86	(13.89 - 15.77)

Site	Initial Hospitalization Indexed Total Costs (unadjusted)	Initial Hospitalization Indexed Total Costs (adjusted)	95% CI	180-Day Indexed Total Costs (unadjusted)	180-Day Indexed Total Costs (adjusted)	95% CI
A	0.83	0.86	(0.76 - 0.96)	0.85	0.82 [a,i]	(0.72 - 0.95)
B	0.75	0.74	(0.57 - 0.98)	0.70	0.69 [a,e,g]	(0.54 - 0.89)
C	0.99	0.98	(0.90 - 1.06)	0.90	0.89 [a]	(0.81 - 0.98)
D	0.64	0.68	(0.62 - 0.76)	0.62	0.64 [a,f,j]	(0.57 - 0.74)
E	0.82	0.85	(0.75 - 0.96)	0.86	0.89 [a]	(0.79 - 1.00)
F	1.27	1.23	(1.16 - 1.30)	1.31	1.31	(1.22 - 1.40)

Appendix 3: Looking Forward: Mortality (n = 3,999)

Site	Initial Hospitalization Mortality (unadjusted)	Initial Hospitalization Mortality (adjusted)	95% CI	One Month Mortality (unadjusted)	One Month Mortality (adjusted)	95% CI	180-Day Mortality (unadjusted)	180-Day Mortality (adjusted)	95% CI
A	2.0%	2.8%	(1.1% - 4.7%)	5.9%	8.0%	(5.3% - 11.6%)	21.7%	26.0% [a,g]	(22.0% - 30.9%)
B	2.7%	2.2%	(0.5% - 4.4%)	5.5%	5.1%	(2.5% - 8.5%)	21.9%	22.7%	(16.4% - 29.3%)
C	3.0%	3.1%	(1.9% - 4.3%)	6.6%	6.8%	(4.9% - 8.6%)	18.4%	19.1%	(16.3% - 22.1%)
D	2.7%	2.6%	(1.4% - 4.3%)	7.8%	7.8%	(5.7% - 10.5%)	21.6%	22.9% [b]	(19.7% - 26.8%)
E	4.3%	4.7%	(2.8% - 6.8%)	7.5%	7.4%	(5.2% - 9.7%)	20.5%	21.6% [c]	(18.3% - 25.3%)
F	3.8%	3.5%	(2.6% - 4.5%)	5.7%	5.2%	(4.0% - 6.2%)	19.1%	17.0%	(15.3% - 18.8%)

[a] significantly different from site F at p<0.001

[b] significantly different from site F at p<0.01

[c] significantly different from site F at p<0.05

[d] significantly different from site E at p<0.01

[e] significantly different from site E at p<0.05

[f] significantly different from site C at p<0.001

[g] significantly different from site C at p<0.05

[h] significantly different from site C at p<0.01

[i] significantly different from site D at p<0.05

[j] significantly different from site E at p<0.001

Statistical testing reported for 180-day adjusted results only.

Appendix 3: Pairwise Comparison p-Values for Outcomes

Looking Forward: Total Hospital Days

Site	A	B	C	D	E
A					
B	0.3287				
C	0.4127	0.5660			
D	0.5842	0.1828	0.1310		
E	0.3989	0.5766	0.9712	0.1515	
F	0.0000‡	0.0001‡	0.0000‡	0.0000‡	0.0000‡

Looking Forward: Indexed Total Costs

Site	A	B	C	D	E
A					
B	0.2039				
C	0.3664	0.0409*			
D	0.0144*	0.6174	0.0001‡		
E	0.3789	0.0466*	0.9864	0.0004‡	
F	0.0000‡	0.0000‡	0.0000‡	0.0000‡	0.0000‡

Looking Forward: 180-Day Mortality

Site	A	B	C	D	E
A					
B	0.3995				
C	0.0117*	0.3125			
D	0.2892	0.9590	0.0993		
E	0.1163	0.7656	0.2969	0.6464	
F	0.0003‡	0.0867	0.2279	0.0045†	0.0343*

Looking Back: Total Hospital Days

Site	A	B	C	D	E
A					
B	0.7336				
C	0.3422	0.3329			
D	0.1977	0.6122	0.0203*		
E	0.1250	0.1839	0.5842	0.0046†	
F	0.0000‡	0.0000‡	0.0000‡	0.0000‡	0.0000‡

Looking Back: Indexed Total Costs

Site	A	B	C	D	E
A					
B	0.2655				
C	0.3594	0.1125			
D	0.2080	0.7209	0.0339*		
E	0.0643	0.0193*	0.3627	0.0011†	
F	0.0000‡	0.0000‡	0.0012†	0.0000‡	0.0082†

*p<0.05, †p<0.01, ‡p<0.001.

Appendix 4: Analyses Including Transfer Patients, Transplant Patients, and Patients With Surgical DRGs

Appendix 4: "Looking Back": Utilization (n = 1,756)

Site	180-Day Total Hospital Days (unadjusted)	180-Day Total Hospital Days (adjusted)	95% CI
A	11.29	11.38 [a]	(9.47 – 13.57)
B	9.77	9.85 [a]	(6.79 – 14.25)
C	12.89	13.39 [a]	(11.48 - 15.72)
D	9.56	10.10 [a,e,g]	(8.11 – 12.27)
E	12.37	13.36 [a]	(11.40 - 15.96)
F	24.35	22.63	(20.59 - 25.13)

Site	180-Day Indexed Total Direct Costs (unadjusted)	180-Day Indexed Total Direct Costs (adjusted)	95% CI
A	0.97	0.93 [a,e]	(0.71 - 1.18)
B	0.85	0.75 [a]	(0.38 - 1.37)
C	1.22	1.26 [c]	(1.01 - 1.55)
D	0.86	0.92 [a,e]	(0.73 - 1.17)
E	1.18	1.25 [b]	(1.03 - 1.50)
F	1.75	1.70	(1.55 - 1.89)

Appendix 4: Looking Forward: Utilization (n = 4,249)

Site	Initial Hospitalization Length of Stay (unadjusted)	Initial Hospitalization Length of Stay (adjusted)	95% CI	180-Day Total Hospital Days (unadjusted)	180-Day Total Hospital Days (adjusted)	95% CI
A	4.61	4.96	(4.51 - 5.67)	8.33	8.69 [a,h]	(7.70 - 9.81)
B	4.56	5.01	(3.89 - 7.11)	8.44	9.18 [a]	(7.35 - 11.80)
C	7.07	6.68	(6.07 - 7.47)	11.14	10.73 [a,d]	(9.81 - 11.80)
D	4.84	5.11	(4.65 - 5.77)	8.10	8.51 [a,h]	(7.64 - 9.71)
E	4.51	4.70	(4.31 - 5.17)	8.55	9.00 [a]	(8.18 - 9.94)
F	8.33	7.89	(7.51 - 8.35)	16.00	15.42	(14.57 - 16.39)

Site	Initial Hospitalization Indexed Total Direct Costs (unadjusted)	Initial Hospitalization Indexed Total Direct Costs (adjusted)	95% CI	180-Day Indexed Total Direct Costs (unadjusted)	180-Day Indexed Total Direct Costs (adjusted)	95% CI
A	0.65	0.77	(0.69 - 0.88)	0.69	0.73 [a,f]	(0.64 - 0.84)
B	0.75	0.80	(0.62 - 1.09)	0.72	0.75 [a,g]	(0.59 - 0.98)
C	1.37	1.06	(0.97 - 1.17)	1.15	0.97 [a]	(0.88 - 1.08)
D	0.64	0.67	(0.60 - 0.75)	0.66	0.67 [a,d,f]	(0.58 - 0.77)
E	0.75	0.81	(0.72 - 0.93)	0.79	0.86 [a]	(0.77 - 0.96)
F	1.13	1.20	(1.12 - 1.29)	1.22	1.27	(1.19 - 1.37)

Appendix 4: Looking Forward: Mortality (n = 4,249)

Site	Initial Hospitalization Mortality (unadjusted)	Initial Hospitalization Mortality (adjusted)	95% CI	One Month Mortality (unadjusted)	One Month Mortality (adjusted)	95% CI	180-Day Mortality (unadjusted)	180-Day Mortality (adjusted)	95% CI
A	2.7%	3.8%	(2.1% - 6.3%)	6.8%	9.4%	(6.5% - 12.9%)	22.4%	27.6% [a,e,h]	(23.3% - 31.8%)
B	2.6%	2.5%	(0.6% - 5.1%)	6.3%	5.7%	(2.7% - 9.1%)	22.1%	22.4%	(16.8% - 28.9%)
C	3.9%	3.7%	(2.5% - 5.1%)	6.2%	6.3%	(4.6% - 8.0%)	19.2%	20.0%	(17.4% - 22.7%)
D	3.2%	3.2%	(1.9% - 4.9%)	8.1%	7.9%	(5.5% - 10.3%)	22.9%	23.9% [b]	(20.2% - 27.5%)
E	4.7%	5.3%	(3.4% - 7.4%)	7.6%	7.8%	(5.5% - 10.2%)	20.1%	21.4% [c]	(18.0% - 25.4%)
F	4.3%	3.9%	(3.0% - 4.9%)	5.5%	5.1%	(4.1% - 6.3%)	19.3%	17.0%	(15.1% - 18.9%)

[a] significantly different from site F at p<0.001

[b] significantly different from site F at p<0.01

[c] significantly different from site F at p<0.05

[d] significantly different from site E at p<0.01

[e] significantly different from site E at p<0.05

[f] significantly different from site C at p<0.001

[g] significantly different from site C at p<0.05

[h] significantly different from site C at p<0.01

Statistical testing reported for 180-day adjusted results only.

Appendix 4: Pairwise Comparison p-Values for Outcomes

Looking Forward: Total Hospital Days

Site	A	B	C	D	E
A					
B	0.7025				
C	0.0050†	0.2226			
D	0.7993	0.5935	0.0015†		
E	0.6484	0.8860	0.0091†	0.4851	
F	0.0000‡	0.0000‡	0.0000‡	0.0000‡	0.0000‡

Looking Forward: Indexed Total Direct Costs

Site	A	B	C	D	E
A					
B	0.8944				
C	0.0007‡	0.0440*			
D	0.3400	0.4536	0.0000‡		
E	0.0758	0.3040	0.0744	0.0057†	
F	0.0000‡	0.0000‡	0.0000‡	0.0000‡	0.0000‡

Looking Forward: 180-Day Mortality

Site	A	B	C	D	E
A					
B	0.1800				
C	0.0043†	0.4902			
D	0.1985	0.6832	0.0752		
E	0.0272*	0.7927	0.5186	0.3306	
F	0.0000‡	0.0934	0.0846	0.0011†	0.0397*

Looking Back: Total Hospital Days

Site	A	B	C	D	E
A					
B	0.4791				
C	0.1693	0.1240			
D	0.3904	0.9069	0.0328*		
E	0.1883	0.1151	0.9817	0.0348*	
F	0.0000‡	0.0000‡	0.0000‡	0.0000‡	0.0000‡

Looking Back: Indexed Total Direct Costs

Site	A	B	C	D	E
A					
B	0.5224				
C	0.0650	0.0991			
D	0.9365	0.5107	0.0631		
E	0.0492*	0.0656	0.9422	0.0342*	
F	0.0000‡	0.0003‡	0.0115*	0.0000‡	0.0030†

*p<0.05, †p<0.01, ‡p<0.001

Appendix 5: Analyses Allowing for Individuals to Have Multiple Episodes.

Appendix 5: "Looking Back": Utilization (n = 1,639)

Site	180-Day Total Hospital Days (unadjusted)	180-Day Total Hospital Days (adjusted)	95% CI
A	11.18	11.08 [a]	(9.04 – 13.47)
B	9.96	10.27 [a]	(6.73 – 14.51)
C	11.71	12.58 [a]	(10.60 - 14.97)
D	8.62	9.14 [a,d,g]	(7.49 – 11.45)
E	12.27	13.39 [a]	(11.30 - 15.82)
F	23.78	21.73	(19.81 - 24.06)

Site	180-Day Indexed Total Direct Costs (unadjusted)	180-Day Indexed Total Direct Costs (adjusted)	95% CI
A	1.07	0.97 [a,e]	(0.74 - 1.21)
B	0.99	0.95 [b]	(0.50 - 1.59)
C	1.15	1.26 [b]	(1.01 - 1.62)
D	0.83	0.91 [a,d]	(0.72 - 1.18)
E	1.31	1.39 [c]	(1.16 - 1.69)
F	1.89	1.79	(1.61 - 1.98)

Appendix 5: Looking Forward: Utilization (n = 4,508)

Site	Initial Hospitalization Length of Stay (unadjusted)	Initial Hospitalization Length of Stay (adjusted)	95% CI	180-Day Total Hospital Days (unadjusted)	180-Day Total Hospital Days (adjusted)	95% CI
A	4.34	4.36	(3.91 - 4.95)	8.14	8.12 [a]	(7.21 - 9.12)
B	4.52	5.21	(4.01 - 7.12)	8.56	9.49 [a]	(7.61 - 11.75)
C	5.03	4.89	(4.53 - 5.26)	8.91	8.81 [a]	(8.01 - 9.60)
D	4.35	4.43	(4.06 - 4.79)	7.73	7.99 [a]	(7.13 - 8.91)
E	4.12	4.24	(3.89 - 4.71)	8.31	8.88 [a]	(8.09 - 9.79)
F	7.73	7.39	(7.04 - 7.70)	15.49	14.89	(14.12 - 15.78)

Site	Initial Hospitalization Indexed Total Direct Costs (unadjusted)	Initial Hospitalization Indexed Total Direct Costs (adjusted)	95% CI	180-Day Indexed Total Direct Costs (unadjusted)	180-Day Indexed Total Direct Costs (adjusted)	95% CI
A	0.73	0.75	(0.67 - 0.83)	0.75	0.73 [a,e,g]	(0.63 - 0.82)
B	0.91	0.89	(0.69 - 1.19)	0.84	0.82 [a]	(0.65 - 1.04)
C	0.98	0.97	(0.89 - 1.05)	0.90	0.89 [a]	(0.82 - 0.98)
D	0.65	0.68	(0.62 - 0.74)	0.66	0.67 [a,d,f]	(0.59 - 0.78)
E	0.78	0.82	(0.73 - 0.93)	0.83	0.88 [a]	(0.79 - 0.97)
F	1.28	1.25	(1.19 - 1.34)	1.30	1.29	(1.21 - 1.38)

Appendix 5: Looking Forward: Mortality (n = 4,508)

Site	Initial Hospitalization Mortality (unadjusted)	Initial Hospitalization Mortality (adjusted)	95% CI	One Month Mortality (unadjusted)	One Month Mortality (adjusted)	95% CI	180-Day Mortality (unadjusted)	180-Day Mortality (adjusted)	95% CI
A	1.7%	2.5%	(1.1% - 4.5%)	5.4%	7.7%	(5.1% - 10.7%)	20.4%	25.2% [a,e,h]	(21.0% - 29.4%)
B	3.0%	2.4%	(0.8% - 4.9%)	6.5%	6.1%	(3.2% - 10.0%)	21.4%	22.5% [c]	(17.1% - 29.4%)
C	2.9%	3.0%	(1.9% - 4.3%)	6.4%	6.6%	(4.9% - 8.4%)	17.6%	18.3%	(15.4% - 20.8%)
D	2.4%	2.3%	(1.2% - 3.7%)	7.0%	7.1%	(5.1% - 9.5%)	20.9%	22.0% [b]	(18.5% - 25.6%)
E	3.7%	4.0%	(2.6% - 5.9%)	6.7%	6.7%	(5.0% - 8.8%)	19.0%	20.0% [c]	(17.0% - 23.5%)
F	3.5%	3.2%	(2.3% - 4.1%)	5.2%	4.7%	(3.7% - 5.7%)	17.6%	15.5%	(13.9% - 17.2%)

[a] significantly different from site F at p<0.001

[b] significantly different from site F at p<0.01

[c] significantly different from site F at p<0.05

[d] significantly different from site E at p<0.01

[e] significantly different from site E at p<0.05

[f] significantly different from site C at p<0.001

[g] significantly different from site C at p<0.05

[h] significantly different from site C at p<0.01

Statistical testing reported for 180-day adjusted results only.

Appendix 5: Pairwise Comparison p-Values for Outcomes

Looking Forward: Total Hospital Days

Site	A	B	C	D	E
A					
B	0.2434				
C	0.2759	0.5557			
D	0.8476	0.2010	0.1823		
E	0.2335	0.5945	0.9162	0.1765	
F	0.0000‡	0.0000‡	0.0000‡	0.0000‡	0.0000‡

Looking Forward: Indexed Total Direct Costs

Site	A	B	C	D	E
A					
B	0.4169				
C	0.0127*	0.4794			
D	0.4026	0.1883	0.0004‡		
E	0.0276*	0.5910	0.7864	0.0031†	
F	0.0000‡	0.0000‡	0.0000‡	0.0000‡	0.0000‡

Looking Forward: 180-Day Mortality

Site	A	B	C	D	E
A					
B	0.4775				
C	0.0074†	0.2215			
D	0.2571	0.8894	0.0939		
E	0.0440*	0.4873	0.4359	0.4023	
F	0.0000‡	0.0260*	0.0808	0.0013†	0.0281*

Looking Back: Total Hospital Days

Site	A	B	C	D	E
A					
B	0.7336				
C	0.3422	0.3329			
D	0.1977	0.6122	0.0203*		
E	0.1250	0.1839	0.5842	0.0046†	
F	0.0000‡	0.0000‡	0.0000‡	0.0000‡	0.0000‡

Looking Back: Indexed Total Direct Costs

Site	A	B	C	D	E
A					
B	0.9461				
C	0.1406	0.3674			
D	0.7349	0.8999	0.0736		
E	0.0197*	0.1592	0.4541	0.0064†	
F	0.0000‡	0.0035†	0.0047†	0.0000‡	0.0172*

*p<0.05, †p<0.01, ‡p<0.001.

Appendix 6: Analyses Including Lab Variables as Covariates

Appendix 6: "Looking Back": Utilization (n = 1,097)

Site	180-Day Total Hospital Days (unadjusted)	180-Day Total Hospital Days (adjusted)	95% CI
A	12.86	12.01 [a]	(9.20 - 15.64)
C	11.90	12.87 [a,g]	(10.53 - 15.62)
D	7.83	8.55 [a]	(6.59 - 10.81)
E	13.21	15.17	(9.31 - 23.76)
F	23.55	22.44	(20.45 - 24.72)

Site	180-Day Indexed Total Direct Costs (unadjusted)	180-Day Indexed Total Direct Costs (adjusted)	95% CI
A	1.27	0.97 [b]	(0.61 - 1.41)
C	1.12	1.27 [c,g]	(0.99 - 1.65)
D	0.66	0.78 [a]	(0.55 - 1.00)
E	1.30	1.35	(0.65 - 2.14)
F	1.75	1.71	(1.55 - 1.90)

Appendix 6: Looking Forward: Utilization (n = 2,706)

Site	Initial Hospitalization Length of Stay (unadjusted)	Initial Hospitalization Length of Stay (adjusted)	95% CI	180-Day Total Hospital Days (unadjusted)	180-Day Total Hospital Days (adjusted)	95% CI
A	4.47	4.69	(3.97 - 5.73)	8.49	8.95 [a]	(7.58 - 10.50)
C	5.15	5.16	(4.69 - 5.62)	8.68	8.76 [a]	(7.90 - 9.64)
D	4.39	4.79	(4.27 - 5.33)	7.15	7.84 [a]	(6.92 - 8.98)
E	4.56	4.55	(3.54 - 5.95)	8.46	9.44 [b]	(6.47 - 12.87)
F	7.85	7.55	(7.20 - 7.88)	15.32	14.81	(13.94 - 15.61)

Site	Initial Hospitalization Indexed Total Direct Costs (unadjusted)	Initial Hospitalization Indexed Total Direct Costs (adjusted)	95% CI	180-Day Indexed Total Direct Costs (unadjusted)	180-Day Indexed Total Direct Costs (adjusted)	95% CI
A	0.73	0.66	(0.55 - 0.71)	0.77	0.66 [a,g]	(0.56 - 0.79)
C	0.96	0.97	(0.87 - 1.07)	0.88	0.87 [a]	(0.77 - 0.97)
D	0.65	0.73	(0.64 - 0.83)	0.58	0.60 [a,f]	(0.51 - 0.70)
E	0.77	0.55	(0.43 - 0.72)	0.74	0.68 [a]	(0.44 - 0.98)
F	1.14	1.16	(1.09 - 1.24)	1.19	1.23	(1.14 - 1.31)

Appendix 6: Looking Forward: Mortality (n = 2,706)

Site	Initial Hospitalization Mortality (unadjusted)	Initial Hospitalization Mortality (adjusted)	95% CI	One Month Mortality (unadjusted)	One Month Mortality (adjusted)	95% CI	180-Day Mortality (unadjusted)	180-Day Mortality (adjusted)	95% CI
A	2.4%	3.0%	(0.7% - 6.1%)	6.1%	7.1%	(3.4% - 11.0%)	20.7%	22.8%	(17.7% - 29.0%)
C	2.5%	2.8%	(1.4% - 4.4%)	5.3%	5.8%	(3.9% - 7.9%)	17.9%	19.5%	(16.6% - 23.0%)
D	2.1%	4.1%	(1.4% - 7.3%)	8.2%	13.3%	(8.7% - 18.5%)	22.3%	29.2% [a,h]	(24.0% - 34.8%)
E	14.8%	12.6%	(3.9% - 24.8%)	18.5%	11.3%	(5.4% - 19.9%)	25.9%	23.5%	(14.2% - 35.5%)
F	3.8%	3.3%	(2.3% - 4.0%)	5.8%	5.1%	(4.0% - 6.2%)	19.5%	17.6%	(15.7% - 19.6%)

[a] significantly different from site F at p<0.001

[b] significantly different from site F at p<0.01

[c] significantly different from site F at p<0.05

[d] significantly different from site E at p<0.01

[e] significantly different from site E at p<0.05

[f] significantly different from site C at p<0.001

[g] significantly different from site C at p<0.05

[h] significantly different from site C at p<0.01

Statistical testing reported for 180-day adjusted results only.

Appendix 6: Pairwise Comparison p-Values for Outcomes

Looking Forward: Total Hospital Days

Site	A	C	D	E
A				
C	0.8336			
D	0.2327	0.1741		
E	0.7706	0.6862	0.3447	
F	0.0000‡	0.0000‡	0.0000‡	0.0014†

Looking Forward: Indexed Total Direct Costs

Site	A	C	D	E
A				
C	0.0109*			
D	0.3931	0.0001‡		
E	0.9173	0.1908	0.5850	
F	0.0000‡	0.0000‡	0.0000‡	0.0001‡

Looking Forward: 180-Day Mortality

Site	A	C	D	E
A				
C	0.3367			
D	0.1113	0.0013†		
E	0.9064	0.4889	0.3627	
F	0.0943	0.3217	0.0001‡	0.2931

Looking Back: Total Hospital Days

Site	A	C	D	E
A				
C	0.6806			
D	0.0657	0.0111*		
E	0.4138	0.5467	0.0823	
F	0.0000‡	0.0000‡	0.0000‡	0.0557

Looking Back: Indexed Total Direct Costs

Site	A	C	D	E
A				
C	0.2894			
D	0.3960	0.0270*		
E	0.3807	0.8441	0.1666	
F	0.0012†	0.0283*	0.0000‡	0.3618

*p<0.05, †p<0.01, ‡p<0.001