

Variations in and Correlates of Length of Stay in Academic Hospitals Among Patients with Heart Failure Resulting from Systolic Dysfunction

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Abstract

Objective: Given the high cost of caring for patients with congestive heart failure, there are strong incentives to decrease hospital costs by shortening length of hospital stay. We sought to identify factors associated with length of stay among patients admitted for the treatment of heart failure resulting from systolic dysfunction.

Study Design: Retrospective cohort study.

Methods: We examined data from patients with a principal discharge diagnosis of congestive heart failure who had been admitted to 1 of the 49 academic hospitals across the United States that participated in the CHF Benchmark Project, a large collaborative quality improvement project coordinated by the University HealthSystem Consortium. Patients were discharged between January 1 and June 30, 1996. We obtained patient characteristics and hospitalization data by retrospectively reviewing medical records. We used linear regression models to identify major determinants of length of stay.

Results: Among the 1046 patients eligible for the study, 59% were women, 55% were white, and 58% were aged 65 years or older. Adjusting for patient demographic and admission clinical characteristics, the mean length of stay was 4.9 ± 0.9 days. Length of stay varied significantly among hospitals, even after adjusting for differences in patient characteristics. In multivariate regression models, factors that were independently associated with a significantly longer length of stay were prior renal failure, peripheral edema, atrial fibrillation, hyponatremia, urinary catheter on admission, initiation of an antiarrhythmic or warfarin, and major complications. Patient characteristics and hospital events combined explained 16% of the variation in the length of stay. Adjusting for the individual hospitals explained an additional 10% of the variation in the length of stay.

Conclusions: Although a number of patient and hospitalization factors were associated with length of stay in patients with congestive heart failure resulting from systolic dysfunction, much unexplained variation remained. Clinical factors alone explained about 50% more variation than did factors specific to the individual hospitals.

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Treatment of heart failure, the most common reason for hospital admission among persons aged 65 years or older,¹⁻³ costs more than \$10 billion annually.⁴ Hospital care accounts for most of the costs of care for patients with heart failure, with

\$7.5 billion spent for almost 6 million hospital days.⁵ Thus there are strong incentives for focusing on hospital care in an effort to decrease the cost of caring for patients with heart failure.

Clinicians across the United States are evaluating strategies to decrease hospital admissions and improve the quality of care. Hospitals are using care pathways, care management, and discharge planning to improve efficiency. However, one attempt to reduce length of stay for heart failure patients by using guidelines to identify low-risk patients actually increased the number of hospital days.⁶ A better understanding of the principal factors associated with length of stay may contribute to the development of more effective interventions. Also, as hospitals use length of stay to benchmark performance in the care of patients with heart failure, identifying the patient-specific factors to be included in the risk-adjustment model becomes increasingly important. To address these issues, we sought to identify clinical and nonclinical factors that influence hospital length of stay among patients admitted for treatment of heart failure resulting from systolic dysfunction. We hypothesized that patient characteristics would explain only a small amount of the variation in length of stay and that initiation of new therapies would be associated with longer length of stay because physicians might require additional time to observe patients' response to new treatments.

... METHODS ...

Patients with congestive heart failure (CHF) admitted between January 1 and June 30, 1996, to 1 of the 49 hospitals participating in the CHF Benchmark Project were eligible for this retrospective study. The CHF Benchmark Project was designed to identify risk, process, and outcome measures for patients with CHF. The participating hospitals were associated with medical schools and were members of the University HealthSystem Consortium, a member-driven alliance of academic health centers. By generating ideas and disseminating information, the consortium helps strengthen the competitive position of its members in their respective healthcare markets.

We collected data from each hospital from approximately 30 consecutive medical records of patients who were at least 18 years old and had a principal discharge diagnosis of CHF/right heart failure (DRG 428), left heart failure (DRG 428.1), or

heart failure unspecified (DRG 428.9). Patients were excluded if they were younger than age 18 years, had no significant left ventricular systolic dysfunction (left ventricular ejection fraction > 40%) or left ventricular ejection fraction measure not documented, or had a heart transplant, chronic renal failure or dialysis, postheart transplant, or moderate or severe aortic or mitral stenosis. We also excluded patients admitted from or discharged to another hospital, those enrolled in a research protocol, and those who died in the hospital. To avoid the influence of outliers, we also excluded patients whose length of hospital stay exceeded 15 days.

We designed standardized data abstraction forms for data collection. Trained abstractors from each hospital received instruction for standardization of abstraction. Information on patient characteristics at admission (demographics, medical history, comorbidity, preadmission medications, precipitating factors, clinical presentation, clinical findings, and laboratory tests) and hospitalization factors (initiation of medications, complications, and procedures during hospital stay) was collected.

Demographic variables included age, sex, race (coded as white or nonwhite), lifestyle (coded as living at skilled nursing facility or long-term rehabilitation facility, or living at home), attending physician specialty (cardiologist or other), and insurance status (none, or Medicare, Medicaid, managed care, or private/indemnity). Historical and comorbidity variables included current smoker, diabetes mellitus, chronic obstructive pulmonary disease, stroke, peripheral vascular disease, cancer, renal function, myocardial infarction, angina, coronary artery disease, low left ventricular ejection fraction (< 20%) before hospitalization, and prior admission for CHF within 1 year. Precipitating factors included worsening chronic heart failure, ischemic heart disease, respiratory infection, uncontrolled hypertension, and tachyarrhythmia. Clinical presentation at admission included admission through emergency department, dyspnea at rest, dyspnea on exertion, pulmonary congestion/rales, peripheral edema, chest pain, atrial fibrillation, and vital signs (systolic/diastolic blood pressure, pulse, and respiratory rate). Laboratory data were the values recorded during the first 24 hours of admission, including blood urea nitrogen, creatinine, sodium, and potassium.

Data on hospitalization included intubation on admission, admission to an intensive care unit, placement of a urinary catheter on admission, and

Table 1. Median and Mean Length of Stay by Patient Factors at Admission

Variable	n (%)	Length of Stay		P Value*
		With Variable Mean (Median)	Without Variable Mean (Median)	
Total sample	1046 (100)	4.89 (4.0)		
Demographics				
Sex, female	612 (59)	4.83 (4.0)	4.98 (4.0)	0.39
Age ≥ 65 years	609 (58)	4.88 (4.0)	4.92 (4.0)	0.68
Race, white	580 (55)	4.98 (4.0)	4.78 (4.0)	0.32
Admitted from SNF	36 (3)	6.22 (6.0)	4.84 (4.0)	0.009
Attending physician cardiologist	619 (59)	5.02 (4.0)	4.71 (4.0)	0.02
Medical history/comorbidity				
Current smoker	159 (15)	4.57 (4.0)	4.95 (4.0)	0.18
Diabetes	417 (40)	4.02 (4.0)	4.81 (4.0)	0.58
COPD	212 (20)	5.08 (4.0)	4.84 (4.0)	0.46
Prior stroke	140 (13)	4.94 (4.0)	4.88 (4.0)	0.49
Prior MI	379 (36)	4.97 (4.0)	4.85 (4.0)	0.98
Prior angina	160 (15)	4.78 (4.0)	4.91 (4.0)	0.32
Prior CAD	541 (52)	4.95 (4.0)	4.83 (4.0)	0.94
Prior PVD	118 (11)	5.36 (4.0)	4.83 (4.0)	0.11
Prior cancer	88 (8)	5.27 (4.0)	4.86 (4.0)	0.21
Prior renal failure	213 (20)	5.66 (4.0)	4.70 (4.0)	0.0001
Prior CHF admission within 1 year	365 (35)	4.84 (4.0)	4.92 (4.0)	0.59
Severe LVEF (< 20%)	301 (29)	5.08 (4.0)	4.81 (4.0)	0.08
Medication before admission				
Aspirin	354 (34)	4.65 (4.0)	5.02 (4.0)	0.06
Antiarrhythmic	117 (11)	4.84 (4.0)	4.90 (4.0)	0.77
β-blocker	115 (11)	4.50 (4.0)	4.94 (4.0)	0.37
Calcium channel blocker	170 (16)	4.79 (4.0)	4.91 (4.0)	0.47
Digoxin	511 (49)	4.93 (4.0)	4.85 (4.0)	0.49
ACE inhibitor	543 (52)	4.73 (4.0)	5.06 (4.0)	0.08
Warfarin	247 (24)	4.86 (4.0)	4.90 (4.0)	0.83
Precipitating factors				
Worsening CHF	690 (66)	5.06 (4.0)	4.56 (4.0)	0.002
Ischemic heart disease	129 (12)	4.71 (4.0)	4.92 (4.0)	0.26
Respiratory infection	77 (7)	5.48 (5.0)	4.85 (4.0)	0.06
Uncontrolled hypertension	44 (4)	4.61 (4.0)	4.90 (4.0)	0.68
Tachyarrhythmia	79 (8)	5.05 (4.0)	4.88 (4.0)	0.79
Clinical presentation				
Admitted through ED	709 (68)	4.76 (4.0)	5.18 (4.0)	0.002
Peripheral edema	548 (52)	5.40 (5.0)	4.33 (3.0)	0.0001
Atrial fibrillation	207 (20)	5.66 (5.0)	4.70 (4.0)	0.0001
Vital signs/laboratory tests				
SBP < 100 mm Hg	72 (7)	5.11 (4.0)	4.88 (4.0)	0.77
Pulse > 100 beats/min	354 (34)	4.97 (4.0)	4.85 (4.0)	0.33
Respiratory rate > 24 breaths/min	301 (29)	4.72 (4.0)	4.97 (4.0)	0.41
Creatinine > 2.0 mg/dL	163 (16)	5.33 (4.0)	4.81 (4.0)	0.10
Sodium < 135 mmol/L	171 (16)	5.78 (5.0)	4.72 (4.0)	0.0001
Potassium > 5.0 mmol/L	121 (12)	5.20 (4.0)	4.85 (4.0)	0.54
BUN:creatinine > 20	361 (35)	5.24 (4.0)	4.71 (4.0)	0.02

ACE = angiotensin converting enzyme; BUN = blood urea nitrogen; CAD = coronary artery disease; CHF = congestive heart failure; COPD = chronic obstructive pulmonary disease; ED = emergency department; LVEF = left ventricular ejection fraction; MI = myocardial infarction; PVD = peripheral vascular disease; SBP = systolic blood pressure; SNF = skilled nursing facility.

*P value based on nonparametric Wilcoxon signed-rank test.

new use of aspirin, anti-arrhythmic medications, β -blockers, digoxin, calcium channel blockers, angiotensin converting enzyme inhibitors, or warfarin. Hospital complications were coded as present if any of the following conditions occurred during the hospitalization: stroke, myocardial infarction, pulmonary edema, arrhythmia, pneumonia, renal failure requiring dialysis, and cardiac/respiratory arrest.

Statistical Analysis

We calculated length of stay from the date of hospital admission to the date of discharge. Bivariate analyses were performed to examine the correlation between individual factors and length of stay. Continuous variables were categorized as shown in Tables 1-3. Descriptive statistics were reported, and nonparametric signed-rank tests were used for group comparisons. We used a series of multivariate linear regression models to examine correlates for longer length of stay. We selected factors included in the multivariate analyses based on their statistical

significance in the bivariate analysis and their clinical relevance. Our first model included the demographic, historical, and comorbidity information available on admission. A second model included hospital-related variables. A third model included variables from the two previous models. Because analyses based on log-transformed length of stay showed similar results, we present only results based on actual length of stay. We also assessed interhospital variation in length of stay. To avoid unstable estimates, the 39 hospitals that had at least 20 patients eligible for the study were compared using unadjusted length of stay and length of stay adjusted for patient factors.

In general, missing values regarding medical history, comorbidity, medications, or clinical presentation were coded as "no event occurred." A binary variable was created to indicate missing values regarding vital signs or laboratory tests. Overall, fewer than 1% of the key variables had missing values. We performed all of the analyses using PC-SAS 6.12 (SAS, Cary, NC).

Table 2. Median and Mean Length of Stay by Hospital Factors

Variable	n (%)	Length of Stay		P Value*
		With Variable Mean (Median)	Without Variable Mean (Median)	
Admitted to ICU/CCU	145 (14)	5.19 (5.0)	4.84 (4.0)	0.07
Intubation on admission	24 (2)	6.75 (5.5)	4.85 (4.0)	0.007
Urinary catheter on admission	210 (20)	5.51 (5.0)	4.74 (4.0)	0.0005
New use of aspirin	281 (27)	4.78 (4.0)	4.93 (4.0)	0.56
New use of antiarrhythmic	50 (5)	6.46 (6.0)	4.81 (4.0)	0.0001
New use of β -blocker	77 (7)	5.29 (5.0)	4.86 (4.0)	0.06
New use of calcium channel blocker	101 (10)	5.01 (4.0)	4.88 (4.0)	0.68
New use of digoxin	223 (21)	5.42 (4.0)	4.75 (4.0)	0.001
New use of ACE inhibitor	324 (31)	5.26 (4.0)	4.73 (4.0)	0.001
New use of warfarin	98 (9)	5.96 (5.5)	4.78 (4.0)	0.0001
Major complications [†]	75 (7)	7.52 (7.0)	4.69 (4.0)	0.0001

ACE = angiotensin converting enzyme; ICU/CCU = intensive care unit/cardiac care unit.

*P value based on nonparametric Wilcoxon signed-rank test.

[†]Major complications include stroke, pulmonary embolism, pulmonary edema, myocardial infarction, digoxin toxicity, renal failure, pneumonia, and cardiac arrest.

... RESULTS ...

Of the 1046 patients in the primary study sample, 59% were women and 58% were aged 65 years or older. Forty percent of the patients had diabetes, and 36% had a history of myocardial infarction. [More than half of the patients (56%) were covered primarily by Medicare, 11% were covered by Medicaid, 17% were covered by a managed care or preferred provider, and 4% had no insurance coverage. Slightly more than one third of the patients (35%) had been hospitalized with heart failure within 1 year of the index admission. Only 14% of the cohort were admitted to an intensive care unit, and only 2% were intubated on admission.

Length of Stay

As shown in Figure 1, the length of stay for most patients (59%) was 2 to 5 days. Only about 8% of patients remained in the hospital for more than 10 days. The mean length of stay was 4.9±3.2 days (median, 4.0 days; interquartile range, 3.0 to 6.0 days). We found significant interhospital differences in the unadjusted length of stay among the 39 participating hospitals that submitted at least 20 cases between January 1 and June 30, 1996 (*P* < 0.0001) (Figure 2). The difference between the hospitals with the minimum and maximum average length of stay was 4.7 days.

Correlates of Length of Stay

In the bivariate analysis, several patient factors were significantly (*P* < 0.01) associated with a longer

Table 3. Multivariate Linear Regression Analysis of Length of Stay

Variable*	Model 1: Patient Factors R ² = 0.08		Model 2: Hospital Factors R ² = 0.09		Model 3: Patient Factors + Hospital Factors R ² = 0.16	
	Coefficient	P Value	Coefficient	P Value	Coefficient	P Value
Age (per year)	-0.010	0.232	—	—	-0.015	0.043
Female	-0.251	0.208	—	—	-0.313	0.101
Race, white	0.046	0.828	—	—	0.047	0.815
Admitted from SNF	0.955	0.078	—	—	0.639	0.224
Admitted from ED	-0.160	0.452	—	—	-0.354	0.092
Cardiologist attending	0.323	0.107	—	—	0.284	0.151
Prior renal failure	0.757	0.002	—	—	0.821	<0.001
Worsening heart failure	0.366	0.073	—	—	0.246	0.212
Peripheral edema	0.916	< 0.001	—	—	0.845	< 0.001
Atrial fibrillation	0.889	<0.001	—	—	0.729	0.003
Sodium < 135 mmol/L	0.850	0.002	—	—	0.830	0.001
BUN:creatinine > 20	0.219	0.294	—	—	0.231	0.250
Admitted to ICU/CCU	—	—	-0.125	0.664	-0.132	0.645
Urinary catheter on admission	—	—	0.610	0.014	0.680	0.009
New use of antiarrhythmic	—	—	1.539	< 0.001	1.343	0.002
New use of digoxin	—	—	0.327	0.182	0.426	0.081
New use of ACE inhibitor	—	—	0.223	0.302	0.377	0.077
New use of warfarin	—	—	1.241	< 0.001	0.976	0.003
Major complications	—	—	2.733	< 0.001	2.614	< 0.001

ACE = angiotensin converting enzyme; BUN = blood urea nitrogen; ED = emergency department; ICU/CCU = intensive care unit/cardiac care unit; SNF = skilled nursing facility.

*Intercept not shown.

Figure 1. Length of Stay Among 1046 Patients with Congestive Heart Failure Admitted to 49 Participating Hospitals

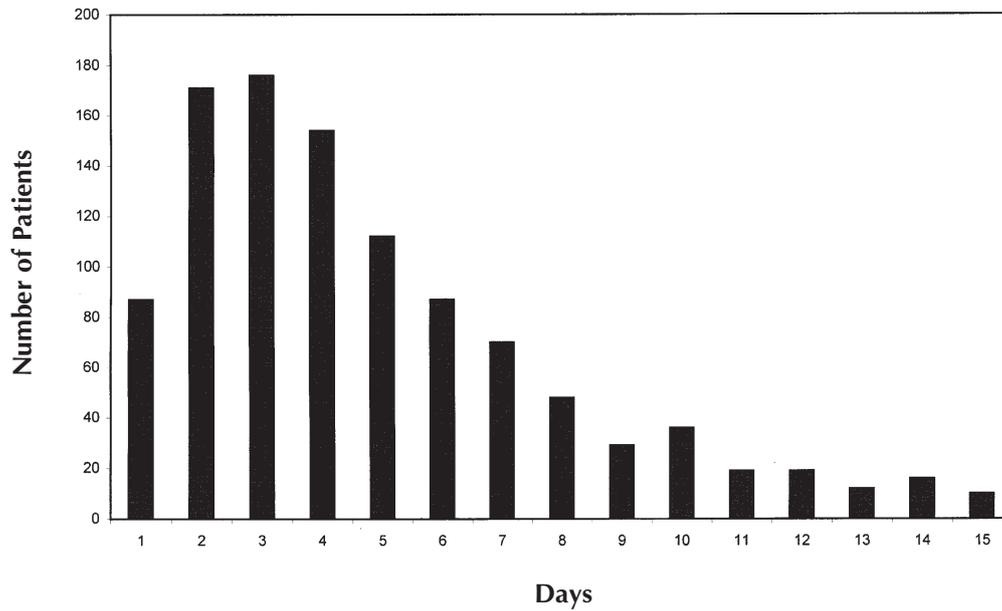
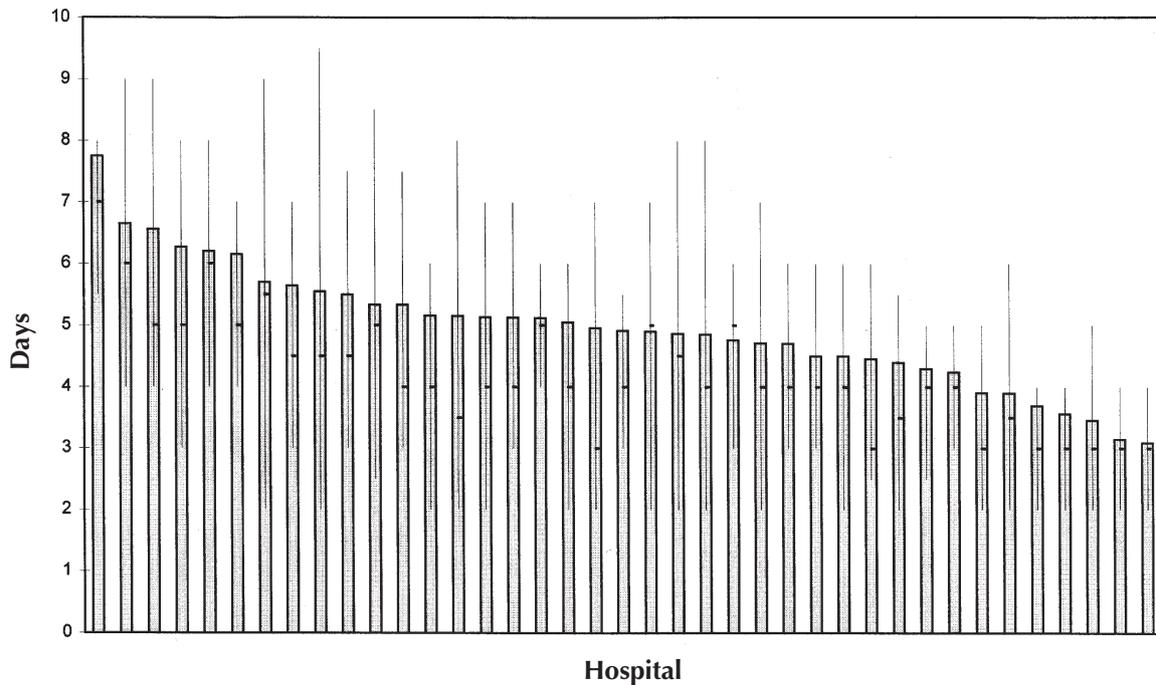


Figure 2. Unadjusted Median, Mean, and 25th and 75th Percentiles for Length of Stay Among 905 Patients with Congestive Heart Failure Admitted to 39 Participating Hospitals



Shaded bar = mean; vertical bar = interquartile range; horizontal bar = median.

length of stay (Table 1). These factors were admission from a skilled nursing facility, prior renal failure, worsening CHF not admitted through emergency department, peripheral edema, atrial fibrillation, and hyponatremia. Health insurance status was not associated with length of stay, although the mean length of stay was slightly longer among patients who did not have insurance (5.5 days) or had other insurance (5.1 days) compared with those who had Medicare (4.9 days), Medicaid (4.9 days), or capitated insurance (4.7 days). Selected patient characteristics were entered into a multivariable model as shown in Table 2. These patient characteristics explained 8% of the variation in the length of stay. The patient characteristics that remained significant after adjusting for each other included prior renal failure, peripheral edema, atrial fibrillation, and hyponatremia (Table 3).

All hospital variables had important associations with length of stay (Table 2). Major complications were associated with the greatest increase in length of stay but occurred in only 7% of the study sample. The initiation of new drug therapies (eg, antiarrhythmics, β -blockers, digoxin, angiotensin converting enzyme inhibitors, or warfarin) also was associated with an increase in the duration of the hospital stay. Placement of a urinary catheter on admission, which occurred in 20% of the cohort, was associated with more than an additional day in the hospital. Selected hospital variables were entered into a multivariable model as shown in Table 3. These hospital variables alone accounted for 9% of the variation in the length of stay. The hospital factors that remained significant included a urinary catheter on admission, new use of an antiarrhythmic or warfarin, and major complications.

When patient characteristics and hospital variables were both considered, the resulting multivariable model explained 16% of the variation in the length of stay (Table 3). The patient factors and hospital factors appeared to contribute independent information to the prediction of length of stay. The factors that were important in the patient characteristic model remained significant after adjusting for the hospital factors. Similarly, the factors that were significant in the hospital factors model remained significant after adjusting for patient factors.

When we added dummy variables for the hospitals to the model, the effect of 49 hospitals explained an additional 10% of the variation in lengths of stay, and this effect was statistically significant ($P < 0.0001$).

Adjusted Length of Stay

The overall average length of stay adjusted for patient factors was similar to the unadjusted value (4.9 ± 0.9 days). After adjusting for the patient and clinical predictors of length of stay available on admission, the differences in length of stay among hospitals remained significant ($P = 0.002$). The range for the average length of stay between the hospitals with the shortest and longest lengths of stay was 1.2 days.

... DISCUSSION ...

Length of hospital stay is a strong determinant of the cost of hospital care.⁷ For CHF, the most common Medicare discharge diagnosis, there is an obvious interest in decreasing cost by shortening length of stay. In this study, we used a large retrospective database of hospitalizations for CHF from 49 academic medical centers across the country to compare length of stay and to determine the factors that influence it. This knowledge may increase our understanding of the factors responsible for variation in length of stay and help us improve critical pathways or develop more effective interventions that would ultimately reduce length of hospital stay and cost. We restricted our study sample to patients with systolic dysfunction because practice guidelines and treatment strategies are more established for such patients.

Despite our efforts to understand the factors associated with length of stay in these patients, much unexplained variation remained. The patient and clinical factors known at admission explained only 8% of the variation in length of stay. This percentage is similar to that reported by Every et al⁸ in their analysis of length of hospital stay in patients with myocardial infarction in the Myocardial Infarction Triage and Intervention Project registry. In our study, the admission characteristics most strongly associated with hospital stay included prior renal failure, peripheral edema, atrial fibrillation, and hyponatremia, factors that may be indicators for disease severity and poor renal function. Their importance persisted after adjustment for process of care and hospital complications.

As expected, some hospital factors were strongly associated with length of stay. In a multivariate model adjusted for patient characteristics on admission, hospital factors that significantly increased the length of stay were urinary catheter on admission, new use of an antiarrhythmic or warfarin, and major complications, including stroke, pulmonary

embolism, pulmonary edema, myocardial infarction, digoxin toxicity, renal failure, pneumonia, and cardiac arrest. However, hospital factors explained only an additional 9% of the variation in length of stay. Consequently, the best predictive model, including both patient admission characteristics and hospital factors, could only explain 16% of the variation in length of stay.

Although there may be other unmeasured clinical factors that further explain the variation, differences in hospital stay may also depend on other factors, such as the floor location of the patient, the vigilance of the nursing team, and the views of the house staff and attending physician. Thus there may be opportunities to define best practices and lower costs by reducing some of these variations.

Few previous studies have evaluated factors associated with length of stay in patients with heart failure hospitalized in multiple institutions. Philbin et al⁹ studied 1402 patients, predominantly elderly patients with moderately severe or severe CHF, without restriction of left ventricular ejection fraction level in 10 community hospitals and reported that baseline characteristics explained only about 5% of the variation in hospital stay. After adding hospital process of care, only 15% of the variation was explained. Our results are consistent with these findings. Philbin et al⁹ also reported that longer length of stay was predicted by the following admission characteristics: older age, lower serum sodium, higher serum potassium, repetitive ventricular arrhythmia, and the use of diuretics and potassium supplements immediately before admission. In their study, longer length of stay was associated with hospital factors such as initiation of antiarrhythmic drugs, any oral diuretic given during hospitalization, more frequent measurement of hematocrit and erythrocyte sedimentation rate, and the more frequent performance of chest roentgenography.

Our study has several limitations. Because it focused on hospital length of stay and the factors that influence it, it does not provide information on long-term outcomes and was not intended to endorse an ideal length of stay. Judgments about the best approach to caring for patients hospitalized with CHF must consider the effect of decreasing length of stay on readmissions and resource consumption over time. Exuberant efforts to control the costs of an initial hospital admission may ultimately contribute to higher long-term costs. An investigation of this issue, however, is beyond the

scope of this article. Another limitation is that the study was restricted to academic medical centers, and the generalizability of our findings to other types of hospitals is not known. Furthermore, information about the accuracy of data abstraction was not available because re-abstraction of charts would have been logistically difficult and expensive. Nevertheless, a strength of the study is the geographic diversity and large number of the participating institutions. A final limitation is our study's retrospective design. Inadequate documentation could result in misclassification of patient characteristics and hospital process.

In conclusion, in a large sample of patients hospitalized for heart failure resulting from systolic dysfunction at 49 academic hospitals across the country, we found that only 16% of the variation in length of stay was explained by patient characteristics at admission and hospital factors. The effect of 49 hospitals explained an additional 10% of the variation. Much unexplained variation remained. Disease severity (peripheral edema, atrial fibrillation), poor renal function (prior renal failure, hyponatremia), initiation of new medications (antiarrhythmics or warfarin), and major complications during hospitalization were associated with a significant increase in length of stay. Strategies to improve critical pathways accounting for these patient and hospital factors may ultimately reduce length of hospital stay and costs.

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