Published in final edited form as:

J Med Econ. 2013 ; 16(1): 43–54. doi:10.3111/13696998.2012.726932.

The inpatient experience and predictors of length of stay for patients hospitalized with systolic heart failure: comparison by commercial, Medicaid, and Medicare payer type

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Abstract

Objective—Descriptions of the inpatient experience for patients hospitalized with systolic heart failure (HF) are limited and lack a cross-sectional representation of the US population. While length of stay (LOS) is a primary determinant of resource use and post-discharge events, few models exist for estimating LOS.

Research design and methods—MarketScan® administrative claims data from 1/1/2005–6/30/2008 were used to select hospitalized patients aged ≥18 years with discharge diagnoses for both HF (primary diagnosis) and systolic HF (any diagnostic position) without prior HF hospitalization or undergoing transplantation.

Results—Among 17,597 patients with systolic HF; 4109 had commercial; 2118 had Medicaid; and 11,370 had Medicare payer type. Medicaid patients had longer mean LOS (7.1 days) than commercial (6.3 days) or Medicare (6.7 days). In-hospital mortality was highest for patients with Medicaid (2.4%), followed by Medicare (1.3%) and commercial (0.6%). Commercial patients were more likely to receive inpatient procedures. Renal failure, pressure ulcer, malnutrition, a non-circulatory index admission DRG, receipt of a coronary artery bypass procedure or cardiac

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Transparency

Declaration of funding

Funding for this project was provided by Amgen, Inc.

Declaration of financial/other relationships

LAA was a consultant hired by Amgen and Johnson and Johnson, and has received grant funding from NIH, NHLBI, and K23 of the National Cancer Institute. KST is a former employee of Thompson Reuters, and has received funding from Amgen. KLW and DMS are current employees of Truven Health Analytics, formerly of Thompson Reuters, which was contracted by Amgen to work in collaboration on this study. IA is an employee and stockholder of Amgen, Inc.

The peer reviewers on this manuscript have disclosed that they have no relevant financial relationships.

catheterization, or need for mechanical ventilation during the index admission were associated with increased LOS; receipt of a pacemaker device at index was associated with shorter LOS.

Limitations—Selection of patients with systolic HF is limited by completeness and accuracy of medical coding, and results may not be generalizable to patients with diastolic HF or to international populations.

Conclusion—Inpatient care, LOS, and in-hospital survival differ by payer among patients hospitalized with systolic HF, although co-morbidity and inpatient procedures consistently influence LOS across payer types. These findings may refine risk stratification, allowing for targeted intensive inpatient management and/or aggressive transitional care to improve outcomes and increase the efficiency of care.

Keywords

Heart failure; Systolic; Hospitalization; Length of stay; Payer

Introduction

Heart failure (HF) is the primary diagnosis for more than 1 million hospitalizations in the US annually¹, making HF the most common cause of hospitalization and re-admission among older Americans². Annual direct medical costs for HF have been estimated at \$39.2 billion¹, of which more than 70% are attributable to inpatient care³.

Significant variation in the inpatient experience exists between patients hospitalized with HF. Among hospitals participating in Get With the Guidelines Heart Failure (GWTG-HF), HF LOS varied from 2 days at the 25th percentile to 6 days at the 75th percentile⁴. For the majority of patients with heart failure the only acute therapy delivered is intravenous diuretics⁵; however, for those patients who require vasoactive therapy and intensive care, costs and complications are much higher⁶. Inpatient experience can also vary by payer. GWTG-HF data show that patients lacking health insurance, with Medicaid, or with Medicare were less likely to receive a range of inpatient medications and procedures and had a longer length of stay (LOS) than those with commercial insurance⁷. Patients with Medicaid had the highest in-hospital mortality⁷.

LOS is the primary driver of HF hospitalization costs^{6,8}. Longer LOS is also associated with lower performance on quality-of-care measures⁹ and higher rates of subsequent readmission and mortality^{2,10}. Mean HF LOS in the US has decreased in recent years; however, this trend is at least partially representative of shifts in care, as an increase in discharges to skilled nursing facilities as well as an increase in 30-day readmission rates were seen in the same period¹¹.

The ability to accurately risk stratify patients for the length and complexity of hospitalization can help guide expectations for patients, clinicians, administrators, and even reimbursement policies. For example, identification during the hospital course of patients with HF who are likely to experience a longer and more complicated hospital stay may help to more appropriately tailor the level of inpatient care, timing of education, nature of discharge planning, and intensity of transitional programs.

Despite the relevance of such predictive information, existing studies of LOS and hospital course are limited^{4,6,12–14}. Data used in some of these LOS risk models have come from small non-US populations^{12,14}, where average HF LOS is much longer^{15,16}. Others have lacked a comprehensive cross-sectional sampling of the hospitalized US HF population^{4,6,13}. All of these studies grouped HF of any type into a single study population, ignoring the greater heterogeneity and less accurate identification of patients with HF and preserved left

ventricular ejection fraction (LVEF)^{17,18}. The specificity of ICD-9-CM algorithms in identifying heart failure is improved when it is confined to a diagnosis of systolic heart failure, the very population for whom many guideline recommendations are specifically indicated¹⁹. Perhaps because of these limitations, existing predictive models have failed to explain more than a limited portion of the variance in HF LOS (e.g., $R^2=4.8\%$ in GWTG-HF) and/or have failed to find common use in the management of these patients⁴.

Therefore, we set out to characterize the range of inpatient experience for patients hospitalized with systolic HF, including LOS and in-hospital mortality, and to identify predictors of LOS in terms of patient demographics, underlying disease burden, and inpatient events for a broad sampling of patients covered under three payer types: commercial, Medicaid, and Medicare. Development of models based on common administrative data from a variety of payer sources may be particularly helpful in creating automated measures of inpatient risk and resource utilization.

Patients and methods

A retrospective, observational study was conducted to select patients by payer type with a hospitalization for systolic HF using administrative claims from three Truven Health MarketScan[®] Research Databases—the Commercial Claims and Encounters Database (Commercial), the Medicaid Multistate Database (Medicaid), and the Medicare Supplemental and Co-ordination of Benefits Database (Medicare). The Commercial database, constructed from claims and enrollment data provided by large employer-sponsored health plans from across the US, contains the healthcare experience of over 35 million privately insured individuals (employees, their spouses, and dependents) covered under a variety of fee-for-service, fully capitated, and partially capitated health plans. The Medicaid database contains the pooled healthcare experience of ~10 million Medicaid enrollees each year from multiple geographically dispersed states. The Medicare database contains the healthcare experience of ~2.5 million individuals annually with Medicare Supplemental insurance paid for by employers.

Data include medical claims for healthcare services performed in both the inpatient and outpatient setting, as well as outpatient pharmacy claims and enrollment data including member demographic information, eligibility, and benefits data. The MarketScan[®] Research Databases include persons from all US States and are de-identified and are fully compliant with the Health Insurance Portability and Accountability Act of 1996 (HIPAA). Because this study did not involve the collection, use, or transmittal of individually identifiable data, Institutional Review Board (IRB) review or approval was not required.

Patient selection

Patients aged 18 years and older were selected based on the occurrence of a hospitalization containing discharge diagnoses for both HF (primary diagnosis) and systolic HF (any diagnostic position) during the January 1, 2005 through June 30, 2008 time period. HF was defined by International Classification of Diseases, 9th Revision, Clinical Modification (ICD-9-CM) diagnosis codes 402.01, 402.11, 402.91, 404.01, 404.03, 404.11, 404.13, 404.91, 404.93, and 428.xx, as used in the Hospital Compare method, approved by National Quality Forum and publicly reported by the Centers for Medicare and Medicaid Services (CMS)^{20,21}. Systolic HF was defined by ICD-9-CM diagnosis codes 428.1, 428.20, 428.21, 428.22, 428.23, 428.40, 428.41, 428.42, and 428.43. The first hospitalization meeting these diagnostic criteria (index admission) was used for the study analyses. Patients were required to have at least 12 months (pre-period) of continuous medical and pharmacy eligibility prior to the admission date (index date) of the index admission. Because LOS was to be evaluated for the first observed HF hospitalization, patients with evidence in the pre-period of a

hospitalization claim for HF were excluded. Patients were also excluded if the index admission claim included codes consistent with heart transplantation due to the rare and atypical nature of these admissions. Systolic HF case groups were selected for each of the three payer types: commercial, Medicaid, and Medicare.

Study variables

Demographic variables as of index date included mean age, age group, gender, insurance plan type (managed care, fee-for-service, and other/unknown), and health plan capitation. In addition, year of index admission was included in the multivariate models to account for any temporal changes in LOS during the time period.

Clinical variables evaluated during the pre-period included a measure of comorbidity: the Charlson Comorbidity Index (Deyo version) (DCI)^{22,23}. The DCI is a numeric scale based on the presence or absence of specific ICD-9-CM diagnosis codes consistent with 19 conditions, each assigned a weight, with higher scores indicating greater burden. Additional pre-period variables included the number and percentage of patients with specific cardiac-related diagnoses and procedures, with specific comorbidities, and with a hospitalization (any cause), in addition to inflation-adjusted mean overall healthcare expenditures.

Clinical variables evaluated for the index admission included the number and percentage of patients receiving care in specific hospital units such as the intensive care unit (ICU) and critical care unit (CCU) were also determined. In-hospital mortality was identified by a discharge status indicating death.

The LOS outcome variable, measured in days, was determined by subtracting the discharge date from the index date and then adding 1 day to ensure that all admissions were at least 1 day in length. Mean [standard deviation (SD)] and median LOS were reported for all patients as well as separately for those with and without death at discharge. LOS was also reported as a categorical variable centered on median LOS (the percentage of patients with a LOS $\leq$ 5 days and LOS > 5 days).

Statistical analyses

Descriptive statistics were reported by payer for demographic, co-morbid, and clinical variables in the pre-hospitalization period as well as for index admission (including LOS) characteristics. Because LOS is a skewed variable, the multivariate analyses of factors associated with LOS utilized a generalized linear model (GLM) with a log link and a gamma error distribution. All model fitting was done using SAS version 9.2 (SAS Institute Inc., Cary, NC). Since PROC GENMOD does not have a stepwise regression capability, to perform stepwise regression the forward selection option of PROC GLMSELECT was used with a log transformation of LOS to identify the best fitting model for each of the three databases separately (Commercial, Medicaid, and Medicare). Model fit was assessed by various goodness-of-fit criteria such as adjusted R^2 , Akaike's Information Criterion (AIC), and Schwartz's Bayesian Criterion (SBC). The final model resulting from the stepwise regression was then fitted again using PROC GENMOD.

For ease of understanding the relation between model variables and LOS, results were presented as additional days of LOS above a baseline LOS for a reference 'low risk' systolic HF patient for each of the three databases. PROC GENMOD was used to predict the reference LOS for each database, as well as a LOS multiplication factor, or predicted effect size, above this reference for each variable retained in the model. The reference patients were defined as follows: male, 35–49 years old (commercial and Medicaid) or 65–69 years old (Medicare), Caucasian (Medicaid only), urban, Southern region (commercial and

Medicare only), fee-for-service and non-capitated health plan, no study comorbidities, 10 3-digit ICD-9-CM codes in pre-period, HF DRG, no study inpatient procedures, no ICU or CCU stay, discharged alive. PROC GENMOD also produced the predicted additional days stay (shown in Tables 4–6 as ‘additional days’) from the reference LOS associated with a change in one variable (e.g., ‘no’ to ‘yes’), for a patient with one particular characteristic and all other factors the same as the reference. In addition to tables of additional predicted days, variables with a predicted change in LOS of 0.9 or greater (e.g., 0.9 more or fewer days than the low risk reference group) for at least one payer were highlighted.

Results

Demographic characteristics

A total of 17,597 patients had a hospitalization for systolic HF from January 1, 2005 through June 6, 2008 and met the selection criteria for age, eligibility, and exclusionary diagnoses (Figure 1). Counts by payer were 4109 patients, 2118 patients, and 11,370 patients for commercial, Medicaid, and Medicare payers, respectively (Table 1). Mean age was 55 years for commercial, 61 for Medicaid, and 79 years for Medicare systolic HF patients. A greater percentage of systolic HF patients were male in the commercial and Medicare payer groups, while the reverse was true in the Medicaid payer group, a finding consistent with the eligibility criteria for Medicaid. Within the commercial payer group 82.3% of systolic HF patients received care under a fee-for-service plan, while in the Medicaid and Medicare payer groups the majority received care under managed care plans (69.9% and 58.0%, respectively).

Comorbidities

The clinical characteristics of systolic HF patients differed among the three payers. Patients within the Medicaid payer group had higher mean DCI, Elixhauser Index, and more unique 3-digit ICD-9-CM codes in the pre-period than patients in either the commercial or Medicare payers (Table 2). Conditions occurring in at least 25% of systolic HF patients in at least one of the payer groups included renal failure, chronic obstructive pulmonary disease (COPD), pneumonia, diabetes and diabetes mellitus complications, peptic ulcer/hemorrhage/other GI disorders, and disorders of fluid/electrolyte/acid-base, with a greater percentage of Medicaid patients having each of these six conditions compared to the commercial and Medicare payer groups ($p < 0.001$ for all). In only one condition, diabetes and diabetes mellitus complications, was the rate at least 25% in all three of the payer groups. The most commonly occurring cardiovascular-related diagnoses in the pre-period were chronic atherosclerosis, arrhythmias, and valvular and rheumatic heart disease.

Only about half of all commercially-insured systolic HF patients had HF as the primary DRG upon their index admission, despite HF being the primary ICD-9 diagnosis, while 75% and 68% of systolic HF patients with Medicaid or Medicare payers, respectively, had a HF DRG (Table 2). Circulatory disorders were the next most common DRG, with remaining DRGs primarily representing procedures and complications. The most common non-HF DRGs were for circulatory or respiratory conditions including pneumonia and pleurisy, pulmonary edema and respiratory failure, and chronic obstructive pulmonary disease.

In-hospital events

During the index admission, a higher percentage of commercial systolic HF patients had cardiac catheterization than either Medicaid or Medicare systolic HF patients (31.0%, 16.0%, and 13.0%, respectively; $p < 0.001$) (Table 2). Other inpatient procedures (ICD/pacemaker, coronary artery bypass graft surgery (CABG), left ventricular assist device (LVAD), percutaneous coronary intervention (PCI)/stent) also differed substantially among

payers, with highest rates in patients with commercial insurance. Also, a lower percentage of Medicare systolic HF patients spent time in the ICU or CCU, compared to commercial and Medicaid systolic HF patients.

In-hospital death occurred infrequently regardless of payer group (Table 3), although the percentage of Medicaid systolic HF patients who died during the index admission (2.4%) was 4-times the percentage in the commercial payer group (0.6%) and nearly twice the percentage in the Medicare payer group (1.3%) ($p<0.001$).

Length of stay

Medicaid systolic HF patients had a longer mean LOS (7.1 days) than either commercial (6.3 days) or Medicare (6.7 days) systolic HF patients (Table 3). Median LOS was the same, regardless of payer type (5 days). A similar pattern for mean and median LOS was observed in the sub-set of patients alive at discharge. However, within the sub-set of patients who died during the index admission, systolic HF patients within the commercial payer group had the longest mean LOS (19.4 days) compared to that of Medicaid (12.4 days) and Medicare (10.2 days) systolic HF patients.

Multivariate predictors of LOS

The adjusted R^2 for LOS was 0.294 in the commercial payer model, 0.274 in the Medicaid payer model, and 0.232 in the Medicare payer model. Tables 4–6 present the results of the multivariate predictors of LOS by payer type. Female gender and age were only significant in the Medicare population; no demographic variables were significant in Medicaid or commercially insured patients. Several comorbidities in the 12-month pre-period also had a significant association with LOS. Presence of renal failure was associated with 1.08, 1.43, and 0.99 additional days LOS in commercial, Medicaid, and Medicare payer patients, respectively. Cardiorespiratory failure and shock was associated with 0.88, 0.43, and 0.87 additional days LOS in commercial, Medicaid, and Medicare payer patients, respectively. Indicators of frailty or disability were also associated with longer LOS.

Malnutrition was associated with additional days LOS of 1.66 and 1.55 in the commercial and Medicare payer patients, respectively. A history of pressure or decubitus ulcers was associated with increased LOS by 1.36 days in commercial systolic HF patients and 0.84 days in Medicare systolic HF patients. Saturated model results by payer, which include all demographic and clinical variables used in the multivariate analyses, are available as supplemental materials in Tables S1–S3.

The statistical models identified inpatient procedures during the index admission as being associated with the greatest increases in LOS (Figure 2), although the direction and magnitude of association was dependent on the procedure type, procedure timing, and payer type. For example, CABG during the index hospitalization was associated with an increase in LOS by as much as 3.75 days among Medicare patients following adjustment for other factors. In contrast, LOS was approximately half a day shorter among Medicare patients with CABG in the pre-period vs those without it. Cardiac catheterization was associated with a range of 0.95–1.73 additional days LOS across payer types. Conversely, receipt of an implantable cardioverter defibrillator (ICD) or pacemaker was associated with 0.63–1.44 fewer days LOS, depending on the payer. Initiation of mechanical ventilation was associated with 0.79–2.04 additional days LOS.

A circulatory DRG at index admission was associated with a decreased LOS of 1.02, 1.94, and 0.81 fewer days for commercial, Medicaid, and Medicare systolic HF patients, respectively. Patients who had a HF DRG at index admission had a shorter LOS compared

to patients with a non-HF DRG: 1.03 fewer days for commercial payer patients, 3.09 fewer days for Medicaid payer patients, and 1.04 fewer days for Medicare payer patients.

Discussion

This study of the inpatient experience during hospitalization for systolic HF identified important differences among payer types, including disease burden, care received, LOS, and mortality. Overall, renal failure, pressure ulcer, malnutrition, non-circulatory DRG, receipt of a CABG procedure or cardiac catheterization, or need for mechanical ventilation during the index admission were most significantly associated with increased LOS. Receipt of an ICD or pacemaker at index was the variable most strongly associated with a decreased LOS, which may be due to the likelihood that these were scheduled elective procedures despite a primary discharge diagnosis of HF. These models derived from administrative claims-based data had a modest predictive capacity for LOS, with adjusted R^2 ranging from 0.232–0.294. The longest LOS across all payer types was seen in patients who ultimately died during hospitalization, further highlighting the need for advanced and/or novel therapies for sicker patients, or early involvement of palliative care and hospice when appropriate.

These findings complement and extend other predictors of LOS and descriptions of HF hospitalization by payer type. The most comprehensive existing information comes from data on nearly 100,000 patients hospitalized between 2005–2009 at hospitals participating in the GWTG-HF quality improvement initiative^{4,7}. Although LOS risk models were developed in GWTG-HF, they were not developed by payer type and do not provide estimates of additional days of hospitalization, as performed in our study. The median LOS of 4 days in GWTG-HF⁴ was slightly shorter than seen in our data. Higher numbers of comorbidities, including renal impairment, cardiac and respiratory conditions, and diabetes, were associated with increased LOS, while performance of fewer procedures during the hospital stay was associated with decreased LOS. Not surprisingly, other studies have shown similar increases in LOS for patients with greater comorbidity and undergoing non-elective procedures^{6,12–14}.

The MarketScan databases-derived models presented here have important advantages over these prior data. Our data quantify the days added to LOS for specific comorbidities, DRG codes, and various procedures among this broad US systolic HF population of 17,597 patients representing commercial, Medicaid, and Medicare payers. The R^2 values here are notably higher than the R^2 of 0.048 identified in the GWTG-HF LOS model⁴. Our restriction to those patients with a diagnosis of systolic HF, while truncating sample size and generalizability to the wider HF population, reduces the variability found in the overall HF population without limiting diversity resulting from disease severity or treatment. This is likely to explain a portion of our superior model performance, despite reliance on administrative data. Many guideline-indicated HF therapies are confined to those with reduced LVEF (i.e., systolic HF)^{24–26}, potentially increasing the value of early risk stratification in this HF sub-group. Therefore, our focus on patients with systolic HF provides a clearer understanding of differences in inpatient care, LOS, and in-hospital mortality among those very patients most likely to benefit from HF-targeted care decisions.

Except for the oldest age group in the Medicare cohort (age ≥ 75 years in Medicare was associated with a modest 0.233 additional days LOS), age was not a significant predictor of LOS. Similarly, Medicare-insured females had a modestly longer LOS than males (predicted 0.304 additional days), and otherwise gender was not identified as a predictor of LOS in the commercial or Medicaid databases. These findings indicate that LOS is dictated by disease severity, comorbidities, and inpatient procedures to a much greater extent than usual demographic measures.

Ultimately, our model, like others, had only modest predictive capacity for LOS. This is likely due to a variety of reasons. LOS, like readmission, appears to be more difficult to predict than mortality²⁷. This may be due to failure to include those factors most closely associated with LOS in the model, such as symptomatology and social factors. It may also be that determinants of LOS are inherently more stochastic than the clinical course leading up to death. LOS is also more subjectively determined than death. Criteria for hospital discharge are multiple and not rigidly defined. The continental differences between HF LOS illustrate this point^{15,16}.

To derive our models we used both variables that can be assessed at the time of admission as well as inpatient events. Inpatient events—procedures, transfer to critical care, or even death—that are strongly associated with LOS may help our understanding of what determines LOS. However, it should be noted that inpatient events, and predictive models that use such variables, may be less helpful than variables present on admission for clinicians, nurses, case managers, and administrators who may be trying to triage patients to an appropriate intensity of care early in the hospital course.

Comparisons among payer type provide important insights into these distinct US systolic HF patient populations. Although different in study design, the findings of this study regarding the inpatient experience for systolic HF patients are similar to those in GWTG-HF of a broader HF cohort⁷ in that patients with Medicaid, followed by Medicare, were less likely to receive a variety of inpatient medications and procedures than those with commercial insurance. For example, in our study, rates of ICD/pacemaker, CABG, cardiac catheterization, and PCI/coronary stent were up to twice as high among commercially-insured patients than among patients with Medicaid or Medicare. Very rare procedures including left ventricular assist device, invasive hemodynamic monitoring, and intra-aortic pump balloon also were more common among commercially-insured than Medicare or Medicaid beneficiaries. In our analyses Medicaid patients had the highest comorbidity burden, longest LOS, and the highest rate of mortality. In GWTG-HF, Medicare, followed by Medicaid, patients had the greatest comorbidities and longest LOS, while, as in our study, in-hospital mortality was highest for those with Medicaid⁷. Among commercially-insured patients in our study, those with managed care plans had 0.274 days shorter hospital stay than those with fee-for-service plans. These differences raise questions regarding financial influences on treatment choices for patients among various payer types. In our study, models of LOS differed by payer type, but this may have been more a function of sample size and collinearity rather than actual differences in determinants of LOS among patients with different payer types.

Several additional limitations to the study should be noted. First, this was a retrospective, observational study based on administrative claims data, and therefore selection of patients with systolic HF is limited by completeness and accuracy of medical coding. Patients coded with ICD-9-CM 428.0 ‘Congestive heart failure, unspecified’, even if they had reduced LVEF, would have been excluded from the analysis. However, selection of patients was based on primary hospital discharge diagnosis codes which have been shown to have good specificity and positive predictive value for HF²⁸. Second, this study purposely focused on systolic HF in the US and thus is not generalizable to patients with diastolic HF or to international populations. Third, management, particularly outpatient and inpatient drug therapy, was not assessed. Therefore, the extent to which prescribing patterns are associated with characteristics of hospitalization and LOS is not examined in this study. Finally, the Medicare population in this study is for patients with employer-paid Medicare supplemental insurance, and the Medicaid population was not representative of the entire US Medicaid population. Therefore, the results are not generalizable to the overall US Medicare or Medicaid populations.

Conclusion

Our study identified notable differences in the inpatient experience across payer types (including disease burden, care received, LOS, and mortality) that warrant further consideration, which supports the results found in recent work. Presence of comorbidity and receipt of inpatient procedures had the greatest impact on LOS for patients with systolic HF hospitalizations for all payer types. These findings may refine risk stratification for the hospitalized systolic HF population, allowing for improved targeting of intensive inpatient management and/or aggressive transitional care designed to improve outcomes and increase the efficiency of care.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments

We gratefully acknowledge the programming assistance of Kelly Oh and Chandrasekar Balakrishnan of Truven Health Analytics, formerly of Thompson Reuters, and the input on the initial study concept from Matthew Gitlin of Amgen, Inc. and William Padula of University of Colorado, in addition to Michele Shaw of Naples, FL for her medical writing expertise.

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Figure 1.
Patient attrition.

Figure 2.
 Model predicted additional days by payer type.

Table 1

Demographic characteristics by payer type.

Characteristic	Commercial database (<i>n</i> =4109)	Medicaid database (<i>n</i> =2118)	Medicare database (<i>n</i> =11,370)	<i>p</i> -value
Age (years), <i>M</i> (SD)	55.4 (7.9)	61.3 (15.3)	79.4 (7.8)	<0.001
Gender, <i>n</i> (%)				<0.001
Male	2591 (63.1)	852 (40.2)	6144 (54.0)	
Female	1518 (36.9)	1266 (59.8)	5226 (46.0)	
Insurance plan type, <i>n</i> (%)				<0.001
Managed care	604 (14.7)	1480 (69.9)	6590 (58.0)	
Fee-for-service	3383 (82.3)	637 (30.1)	4654 (40.9)	
Other/unknown	122 (3.0)	1 (<0.1)	126 (1.1)	
Health plan capitation, <i>n</i> (%)				<0.001
Capitated	809 (19.7)	637 (30.1)	1497 (13.2)	
Non-capitated	3300 (80.3)	1481 (69.9)	9873 (86.8)	

Table 2

Clinical characteristics by payer type.

Characteristic	Commercial database (n =4109)	Medicaid database (n =2118)	Medicare database (n =11,370)	p-value
<i>During 12-month pre-period</i>				
Comorbidity Indicators, <i>M</i> (SD)				
Deyo Charlson Comorbidity Index	2.8 (2.0)	3.2 (2.0)	3.1 (2.0)	<0.001
Elixhauser Index	1.2 (1.5)	2.7 (1.9)	0.7 (1.1)	<0.001
Unique 3-digit ICD-9-CM codes	17.8 (9.8)	22.4 (11.2)	19.0 (9.1)	<0.001
Cardiovascular-related diagnoses/procedures, <i>n</i> (%)				
Coronary artery bypass graft (CABG)	266 (6.0)	151 (7.0)	567 (5.0)	<0.001
Acute coronary syndrome	692 (17.0)	306 (14.0)	1629 (14.0)	<0.001
Arrhythmias	1545 (38.0)	783 (37.0)	5920 (52.0)	<0.001
Cardiorespiratory failure and shock	767 (19.0)	493 (23.0)	1829 (16.0)	<0.001
Valvular and rheumatic heart disease	1141 (28.0)	752 (36.0)	3165 (28.0)	<0.001
Vascular or circulatory disease	740 (18.0)	404 (19.0)	2315 (20.0)	0.004
Chronic atherosclerosis	1671 (41.0)	852 (40.0)	5169 (45.0)	<0.001
Other and unspecified heart disease	755 (18.0)	560 (26.0)	1665 (15.0)	<0.001
Comorbidities, <i>n</i> (%)				
Stroke	119 (3.0)	94 (4.0)	516 (5.0)	<0.001
Dialysis	152 (4.0)	146 (7.0)	325 (3.0)	<0.001
Renal failure	798 (19.0)	563 (27.0)	2613 (23.0)	<0.001
Nephritis	70 (2.0)	59 (3.0)	74 (1.0)	<0.001
Other urinary tract disorders	390 (9.0)	303 (14.0)	1371 (12.0)	<0.001
Chronic obstructive pulmonary disease (COPD)	705 (17.0)	649 (31.0)	2677 (24.0)	<0.001
Asthma	216 (5.0)	127 (6.0)	287 (3.0)	<0.001
Pneumonia	921 (22.0)	580 (27.0)	2676 (24.0)	<0.001
Fibrosis of lung and other chronic lung disorders	226 (6.0)	127 (6.0)	621 (5.0)	0.610
Diabetes and diabetes mellitus complications	1514 (37.0)	839 (40.0)	3531 (31.0)	<0.001
Liver and biliary disease	211 (5.0)	130 (6.0)	287 (3.0)	<0.001
Peptic ulcer, hemorrhage, other GI disorders	796 (19.4)	559 (26.4)	2646 (23.3)	<0.001
Dementia, senility, psychiatric disorders	392 (9.5)	357 (1.2)	1179 (3.7)	<0.001
Drug/alcohol abuse/dependence/psychosis	377 (9.0)	346 (16.0)	155 (1.0)	<0.001
Cancer	463 (11.3)	113 (5.3)	1589 (14.0)	<0.001
Iron deficiency, anemias, hematologic disorders	648 (15.8)	431 (20.3)	2053 (18.1)	<0.001
Hemiplegia, paraplegia, paralysis, functional disability	65 (2.0)	77 (4.0)	190 (2.0)	<0.001
Decubitus ulcer or chronic skin ulcer	158 (4.0)	76 (4.0)	446 (4.0)	0.762
Protein-calorie malnutrition	52 (1.0)	71 (3.0)	129 (1.0)	<0.001
Disorders of fluid/electrolyte/acid-base	618 (15.0)	561 (26.0)	1450 (13.0)	<0.001
Utilization and Expenditures, <i>n</i> (%)				
Pre-period hospitalization, all-cause	957 (23.0)	489 (23.0)	2870 (25.0)	0.012
Overall healthcare expenditures, <i>M</i> (SD)	\$23,381 (\$50,467)	\$16,912 (\$30,853)	\$17,331 (\$32,095)	<0.001

Characteristic	Commercial database (n =4109)	Medicaid database (n =2118)	Medicare database (n =11,370)	p-value
<i>During index admission</i>				
DRG categories, n (%)				
Heart failure (HF) and shock	2090 (51.0)	1588 (75.0)	7784 (68.0)	<0.001
Circulatory systems diagnoses	850 (21.0)	269 (13.0)	1115 (10.0)	<0.001
Heart failure-related procedures, n (%)				
ICD or pacemaker	486 (12.0)	148 (7.0)	917 (8.0)	<0.001
Coronary artery bypass graft (CABG)	76 (2.0)	13 (1.0)	127 (1.0)	<0.001
Cardiac catheterization	1255 (31.0)	329 (16.0)	1514 (13.0)	<0.001
Left ventricular assist device	7 (<0.1)	0 (0.0)	1 (<0.1)	<0.001
Percutaneous coronary intervention/stent	159 (4.0)	31 (1.0)	299 (3.0)	<0.001
Mechanical ventilation	72 (2.0)	63 (3.0)	148 (1.0)	<0.001
Invasive hemodynamic monitoring	5 (<0.1)	0 (0.0)	8 (<0.1)	0.240
Intra-aortic pump balloon	59 (1.0)	10 (<0.1)	49 (<0.1)	<0.001
Dialysis	122 (3.0)	131 (6.0)	289 (3.0)	<0.001
Hospital care unit, n (%)				
Intensive Care Unit (ICU)	1435 (35.0)	812 (38.0)	3128 (28.0)	<0.001
Critical Care Unit (CCU)	949 (23.0)	590 (28.0)	1982 (17.0)	<0.001
Telemetry	187 (5.0)	120 (6.0)	478 (4.0)	0.011
General medicine	2134 (52.0)	1262 (60.0)	4908 (43.0)	<0.001

Table 3

Length of stay by payer type and live discharge status.

Measure	Commercial database (<i>n</i> =4109)	Medicaid database (<i>n</i> =2118)	Medicare database (<i>n</i> =11,370)	<i>p</i> -value
LOS, All patients, <i>n</i> (%)	4109 (100)	2118 (100)	11,370 (100)	
Mean (SD)	6.3 (6.2)	7.1 (7.4)	6.7 (7.0)	<0.001
Median (IQR)	5.0 (4.0)	5.0 (4.0)	5.0 (4.0)	1.000
LOS ≤ 5 days, <i>n</i> (%)	2412 (58.7)	1126 (53.2)	6095 (53.6)	<0.001
LOS >5 days, <i>n</i> (%)	1697 (41.3)	992 (46.8)	5275 (46.4)	<0.001
LOS, Alive at discharge, <i>n</i> (%)	4086 (99.4)	2068 (97.6)	11,224 (98.7)	<0.001
Mean (SD)	6.2 (5.7)	6.9 (7.2)	6.7 (7.0)	<0.001
Median (IQR)	5.0 (4.0)	5.0 (4.0)	5.0 (4.0)	1.000
LOS ≤ 5 days, <i>n</i> (%)	2406 (58.9)	1110 (53.7)	6050 (53.9)	<0.001
LOS >5 days, <i>n</i> (%)	1680 (41.1)	958 (46.3)	5174 (46.1)	<0.001
LOS, Death at discharge, <i>n</i> (%)	23 (0.6)	50 (2.4)	146 (1.3)	<0.001
Mean (SD)	19.4 (31.0)	12.4 (11.0)	10.2 (9.6)	<0.001
Median (IQR)	9.0 (9.0)	9.5 (11.0)	7.0 (7.0)	<0.001
LOS ≤ 5 days, <i>n</i> (%)	6 (26.1)	16 (32.0)	45 (30.8)	0.001
LOS >5 days, <i>n</i> (%)	17 (73.9)	34 (68.0)	101 (69.2)	<0.001

Table 4

Predictors of length of stay: Commercial database.

Variables	Commercial database (n =4109)					
	Reference category or value	LOS =3,955 days	Multiplication factor	95% CI		p-value
				Lower	Upper	
<i>Demographic variables</i>						
Managed care	Fee-for-service	0.931	0.888	0.976	-0.274	0.0028
Other/unknown health plan	“ ”	0.813	0.743	0.889	-0.740	<0.0001
Capitated health plan	Non-capitated	0.914	0.877	0.953	-0.339	<0.0001
<i>Clinical variables: 12-month pre-period</i>						
CABG surgery	None in pre-period	0.874	0.807	0.947	-0.497	0.001
Arrhythmias	“ ”	1.101	1.064	1.140	0.401	<0.0001
Circulatory disease	“ ”	1.157	1.107	1.210	0.621	<0.0001
Atherosclerosis	“ ”	0.940	0.907	0.974	-0.238	0.0008
Stroke	“ ”	1.185	1.075	1.307	0.732	0.0006
Cardiorespiratory failure and shock	“ ”	1.223	1.169	1.279	0.882	<0.0001
Pneumonia	“ ”	1.17	1.13	1.22	0.680	<0.0001
Renal failure	“ ”	1.273	1.217	1.331	1.079	<0.0001
Liver disease	“ ”	1.191	1.105	1.285	0.757	<0.0001
GI disease or ulcer	“ ”	1.179	1.125	1.235	0.707	<0.0001
Cancer	“ ”	1.148	1.085	1.215	0.585	<0.0001
Diabetes	“ ”	1.083	1.046	1.122	0.329	<0.0001
Malnutrition	“ ”	1.421	1.225	1.648	1.664	<0.0001
Pressure/decubitus ulcer	“ ”	1.344	1.232	1.466	1.360	<0.0001
<i>Clinical variables: Index admission</i>						
Treated in ICU	Not in ICU	1.109	1.071	1.149	0.431	<0.0001
Treated in CCU	Not in CCU	1.083	1.040	1.126	0.326	<0.0001
ICD or pacemaker	“ ”	0.833	0.781	0.889	-0.660	<0.0001
CABG procedure	“ ”	1.682	1.450	1.951	2.695	<0.0001
Cardiac catheterization	“ ”	1.438	1.357	1.525	1.734	<0.0001
Mechanical ventilation procedure	“ ”	1.201	1.055	1.367	0.794	0.0056

Variables	Commercial database (n =4109)				
	Reference category or value	Reference * LOS =3,955 days	Multiplication factor		p-value
			Lower	Upper	
Dialysis	" "		1.119	1.373	0.947 <0.0001

The following variables did not have a significant difference in LOS from the reference group for patients with commercial health insurance: age group, index year, gender, rheumatic heart disease, other heart disease, COPD, fibrosis of the lung, other urinary tract disorder, psychiatric disorder, and electrolyte disorder. Each of these variables was associated with a significant difference in LOS from the corresponding reference group for one of the other payers.

* Reference: 2005, male, 35–49 years old, fee-for-service and non-capitated health plan, no study comorbidities, 10 3-digit ICD-9-CM codes in pre-period, no study inpatient procedures, no ICU or CCU stay, discharged alive.

Predictors of length of stay: Medicaid database.

Variables	Medicaid database (n =2118)							
	Reference category or value	LOS	* LOS =3,837 days	Multiplication factor	95% CI		Additional days	p-value
					Lower	Upper		
Clinical variables: 12-month pre-period								
Arrhythmias	“ ”			1.122	1.067	1.180	0.468	<0.0001
Rheumatic heart disease	“ ”			1.082	1.030	1.137	0.314	0.0018
Circulatory disease	“ ”			1.155	1.086	1.228	0.594	<0.0001
Cardiorespiratory failure and shock	“ ”			1.112	1.044	1.183	0.428	0.0009
COPD	“ ”			1.100	1.044	1.159	0.383	0.0003
Pneumonia	“ ”			1.103	1.044	1.165	0.394	0.0005
Renal failure	“ ”			1.374	1.299	1.452	1.434	<0.0001
GI disease or ulcer	“ ”			1.137	1.073	1.204	0.525	<0.0001
Electrolyte disorder	“ ”			1.116	1.056	1.180	0.445	0.0001
Clinical variables: Index admission								
Treated in ICU	Not in ICU			1.281	1.217	1.348	1.078	<0.0001
Treated in CCU	Not in CCU			1.097	1.039	1.158	0.370	0.0008
ICD or pacemaker	“ ”			0.624	0.543	0.718	-1.442	<0.0001
Cardiac catheterization	“ ”			1.292	1.162	1.437	1.121	<0.0001
Mechanical ventilation procedure	“ ”			1.532	1.324	1.774	2.043	<0.0001

The following variables did not have a significant difference in LOS from the reference group for Medicaid eligible beneficiaries: age group, index year, gender, urbanization, plan type, capitation status, previous CABG surgery, atherosclerosis, other heart disease, stroke, fibrosis of the lung, other urinary tract disorder, liver disease, cancer, psychiatric disorder, diabetes, malnutrition, pressure/decubitus ulcer, index admission CABG surgery, and index admission dialysis. Each of these variables was associated with a significant difference in LOS from the corresponding reference group for one of the other payers.

* Reference: 2005, male, 35–49 years old, fee-for-service and non-capitated health plan, no study comorbidities, 10 3-digit ICD-9-CM codes in pre-period, HF DRG, no study inpatient procedures, no ICU or CCU stay, discharged alive.

Table 6

Predictors of length of stay: Medicare database.

Variables	Medicare database (n =11,370)						
	Reference category or value	* LOS =4,058 days	Multiplication factor	95% CI		Additional days	p-value
				Lower	Upper		
Demographic Variables							
Age group: <65	65–69		0.984	0.945	1.024	–0.172	0.4235
Age group: 70–74	“ ”		0.958	0.877	1.046	–0.066	0.3374
Age group: 75	“ ”		1.058	1.022	1.094	0.233	0.0013
Index year: 2006	2005		1.033	1.006	1.062	0.134	0.0186
Index year: 2007	“ ”		0.964	0.938	0.992	–0.145	0.0108
Index year 2008	“ ”		0.965	0.936	0.994	–0.144	0.0202
Female	Male		1.075	1.053	1.098	0.304	<0.0001
Capitated health plan	Non-capitated		0.870	0.843	0.898	–0.526	<0.0001
Clinical variables: 12-month pre-period							
CABG surgery	None in pre-period		0.862	0.816	0.909	–0.562	<0.0001
Arrhythmias	“ ”		1.094	1.071	1.117	0.380	<0.0001
Rheumatic heart disease	“ ”		1.026	1.002	1.049	0.104	0.0305
Circulatory disease	“ ”		1.132	1.103	1.162	0.535	<0.0001
Atherosclerosis	“ ”		0.954	0.934	0.975	–0.188	<0.0001
Other heart disease	“ ”		1.093	1.062	1.125	0.377	<0.0001
Stroke	“ ”		1.132	1.078	1.189	0.535	<0.0001
Cardiorespiratory failure and shock	“ ”		1.214	1.179	1.250	0.868	<0.0001
COPD	“ ”		1.087	1.061	1.113	0.352	<0.0001
Pneumonia	“ ”		1.164	1.135	1.193	0.665	<0.0001
Fibrosis of the lung	“ ”		1.205	1.152	1.261	0.832	<0.0001
Renal failure	“ ”		1.245	1.212	1.277	0.992	<0.0001
Other urinary tract disorder	“ ”		1.116	1.080	1.152	0.470	<0.0001
Liver disease	“ ”		1.164	1.091	1.242	0.666	<0.0001
GI disease or ulcer	“ ”		1.196	1.165	1.228	0.797	<0.0001
Cancer	“ ”		1.068	1.036	1.101	0.275	<0.0001

Variables	Medicare database (<i>n</i> =11,370)				
	Reference category or value	LOS =4,058 days	Multiplication factor	95% CI	
				Lower	Upper
Psychiatric disorder	“ ”		1.125	1.086	1.165
Diabetes	“ ”		1.031	1.009	1.055
Malnutrition	“ ”		1.382	1.255	1.522
Electrolyte disorder	“ ”		1.146	1.111	1.183
Pressure/decubitus ulcer	“ ”		1.207	1.144	1.272
<i>Clinical variables: Index admission</i>					
ICD or pacemaker	“ ”		0.844	0.806	0.884
CABG procedure	“ ”		1.925	1.714	2.162
Cardiac catheterization	“ ”		1.234	1.181	1.290
Mechanical ventilation procedure	“ ”		1.378	1.256	1.511
Dialysis	“ ”		1.218	1.138	1.303

The following variables did not have a significant difference in LOS from the reference group for Medicare eligible beneficiaries: health plan type, capitation status, ICU stay at index admission, and CCU stay at index admission. Each of these variables was associated with a significant difference in LOS from the corresponding reference group for one of the other payers.

* Reference: 2005, male, 65–69 years old, urban, fee-for-service and non-capitated health plan, no study comorbidities, 10 3-digit ICD-9-CM codes in pre-period, HF DRG, no study inpatient procedures, no ICU or CCU stay, discharged alive.