

A Case-Control Study of Length of Stay Outliers

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In 2016, there were 35.7 million hospital stays in the United States, with a rate of 104.2 stays per 1000 population. The estimated total cost for these stays was more than \$417 billion, with a mean cost per stay of \$11,700. Adult patients contributed to more than 80% of all inpatient stays in 2016.¹ As reported by CMS in 2016, of the 368.7 billion Medicare dollars spent, 28% were spent on inpatient hospitalizations. With increasing health care utilization and the cost of health care rising at unprecedented rates, hospital length of stay (LOS) is an important target for cost utilization and related reimbursements.

CMS and other third-party payers include diagnosis-related group (DRG)-predicted LOS as one of several benchmarks to determine hospital reimbursement. Inpatients with extended LOS, referred to as LOS outliers, pose a challenge to hospitals and health systems by contributing to high costs with lower reimbursements while assuming all the risks associated with hospital-acquired conditions. In a 2014 study, 2% to 5% of hospital discharges from medical and surgical services involved outlier patients whose severity-adjusted LOS exceeded 20 days.² More recently, a matched cohort study reported a link between the need for guardianship in a subset of adult inpatients and a mean LOS exceeding 30 days.³ European studies from Spain, Portugal, and the United Kingdom have reported on in-hospital outlier populations and the economic burden on national health system models. The European outlier populations range from 3.5% to 5%, accounting for 19% to 25% of total inpatient days and 15% of total hospital costs. Multiple comorbidities, surgical procedures, and perioperative complications, including infections, were predictors for their LOS outliers.⁴⁻⁶

In today's environment of value-based care and bundled payment models linked closely to quality and outcomes, LOS is an important determinant. Although LOS outliers are a small proportion of patients, they consume a disproportionately large amount of health care resources. Both modifiable and nonmodifiable risk factors are likely contributors. Limited research has been conducted within the US health system to better define this population in the setting of inpatient stays on adult medicine services. To further examine predictors of LOS outliers, we conducted a case-control single-center study of

ABSTRACT

OBJECTIVES: Inpatients with extended length of stay (LOS), referred to as LOS outliers, pose a challenge to health systems by contributing to high costs while assuming all the risks associated with hospital-acquired conditions. Limited research has been conducted within the US health system to better define LOS outliers and the risk factors for becoming an outlier in the setting of inpatient medicine stays.

STUDY DESIGN: This was a retrospective study on adult inpatient admissions to the general medicine service of a university hospital from September 2015 to August 2016. Cases were defined as patients with observed LOS 3 SD above predicted. Controls were defined as those who stayed within 3 SD of predicted LOS.

METHODS: A total of 108 LOS outliers were identified through the University Health System Consortium, and 72 were matched with inlier controls by principal diagnosis and disease severity.

RESULTS: Compared with their inlier controls, outliers stayed 32.41 days longer and cost \$77,228 more per stay. There were higher odds of being an outlier observed for patients with a history of smoking (odds ratio [OR], 29.5; 95% CI, 2.9-301.3), in-hospital complications (OR, 17.6; 95% CI, 3.5-88.6), hospital-acquired infections (OR, 7.2; 95% CI, 1.7-31.4), and discharge to a facility (OR, 11.5; 95% CI, 2.6-50.0).

CONCLUSIONS: In-hospital complications, hospital-acquired infections, and discharge to a facility are all predictors of not only increasing hospital days for patients but also increasing the risk of becoming LOS outliers, who stay disproportionately longer and use disproportionately more resources than predicted.

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inpatient admissions on the internal medicine service to determine significant predictors for the LOS outlier population, including patient characteristics, admission diagnoses, severity of illness, hospital-acquired infection rates, insurance status, and disposition at discharge.

TAKEAWAY POINTS

- ▶ Length of stay (LOS) outliers who stay greater than 3 SD above the predicted LOS result in a median increased cost of \$91,000 per stay.
- ▶ Hospital-acquired infections lead to 7 times greater odds of becoming a LOS outlier.
- ▶ In contrast to popular belief, all our LOS outliers were insured, showed no difference in mean number of comorbidities, and were not older than the inlier cohort.

METHODS

Study Design and Study Sample

We conducted a case-control study using the inpatient admission records of Robert Wood Johnson University Hospital (RWJUH) in New Brunswick, New Jersey. The study included adult (ie, 18 years or older) patients on the general medicine service who were admitted between September 2015 and August 2016. The Medicare Severity DRG (MS-DRG) and risk modeling were used to estimate patient-specific predicted LOS. The Academic Medical Center (AMC) hospitals data in the Vizient Clinical Data Base (CDB) were used in all risk models to predict MS-DRG-specific expected LOS for all inpatient admissions.⁷ In 2017, an estimated 95% of all AMC hospitals in the United States used the CDB for quality improvement.⁸

Cases were LOS outliers defined as patients with observed LOS greater than the 99th percentile of their predicted MS-DRG LOS at admission. Controls were inliers defined as adult patients admitted during the study period whose LOS was less than the 99th percentile of the predicted MS-DRG LOS. In the case of patients with multiple visits, the earliest admission was considered. We initially identified 81 internal medicine inpatient admissions as risk-adjusted LOS outliers and 8959 as inliers. The 81 outlier admissions were narrowed to 76 unique patients who met our inclusion criteria. The internal review board of RWJUH approved the study protocol.

Matching Procedure

We matched 1:1 potential outlier cases to potential inlier controls on the exact primary diagnosis at admission using the *International Classification of Diseases, Tenth Edition (ICD-10)* and the severity of illness (SOI) at admission. The SOI describes the extent of physiologic decompensation or organ system loss of function.⁹ We classified the SOI for all patients into 2 groups: minor and major. As such, we exactly matched 72 outlier cases to 72 inlier controls.

Study Variables

Patient records were obtained from the RWJUH administrative database. We conducted comprehensive chart reviews for all study subjects. Patients' demographics were collected at admission and included age, gender, race, type of health insurance, history of smoking, history of illicit drug use, history of mental illness, patients identified as homeless, patients identified as living alone, and the severity of illness and primary diagnosis category driven from the ICD-10 code of the primary cause of admission.

We queried hospitalization characteristics for all cases and controls at the end of their inpatient stays. Hospitalization characteristics

included the LOS, the total cost of stay per patient, inpatient cost per day, number of consultants, number of reported comorbidities, cardiac arrest during stay, and withdrawal of care during stay. We also identified patients' status of in-hospital complications, which included infections, venous thromboembolisms, acute kidney injury, arrhythmias, drug reactions, electrolyte abnormalities, encephalopathy, respiratory failure, ileus, gastrointestinal bleeding, congestive heart failure exacerbation, and chronic obstructive pulmonary disease exacerbation. Hospital-acquired infections included *Clostridium difficile*, pneumonia, skin infection, and urinary tract infection (UTI). We classified patients' discharge destinations into 3 groups: home, in-hospital death, and facility. Discharge facilities included hospice, long-term acute care hospitals, skilled nursing facilities, rehabilitation centers, and psychiatric facilities.

Statistical Analysis

Wilcoxon signed-rank tests were used to compare the differences between cases and controls on all continuous variables, and McNemar tests were used to examine the differences between cases and controls for dichotomous variables. Univariate conditional logistic regression models were used to test the associations between outlier status and categorical hospitalization characteristics. In turn, significant variables ($P < .05$) obtained from the univariate analyses were included in conditional logistic regression models adjusted for age, gender, and race to examine significant predictors of outlier LOS. In a sensitivity analysis, we further adjusted our conditional logistic regression models to include the type of health insurance in addition to age, gender, and race. We used general linear models (GLMs) adjusted for age, gender, race, and type of health insurance to examine the relative associations between significant predictors of outlier LOS vs (1) inpatient stay cost per day and (2) hospitalization duration in days. All GLMs were stratified by LOS outlier status, and gamma distributions were used for both the mean inpatient cost per day and the LOS in days. To ensure the robustness of our results, we quantified exact P values for all McNemar tests and conditional logistic regression models. SAS software edition 9.4 (SAS Institute) was used to perform all data analyses.

RESULTS

Between September 2015 and August 2016, 76 patients on the general medicine service line had outlier LOS, and 72 were exactly matched 1:1 to inlier controls on primary diagnosis and severity of illness at

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TABLE 1. Hospital Admission Characteristics of Study Sample for Matched^a Outlier and Inlier Patients

Patient characteristics at admission	Inliers ^b (n = 72)	Outliers ^c (n = 72)	P ^d
Age in years, mean (SD)	69.6 (13.9)	60.7 (11.9)	<.001
Age group in years, n (%)			.52
< 65	25 (34.7)	29 (40.3)	
≥ 65	47 (65.3)	43 (59.7)	
Gender, n (%)			.08
Male	42 (58.3)	32 (44.4)	
Female	30 (41.7)	40 (55.6)	
Race, n (%)			.48
White	49 (68.1)	48 (66.7)	
Black	8 (11.1)	14 (19.4)	
Asian	8 (11.1)	5 (6.9)	
Other	7 (9.7)	5 (6.9)	
Type of health insurance, n (%)			.76
Medicaid	10 (13.9)	11 (15.3)	
Medicare	54 (75.0)	56 (77.8)	
Private	8 (11.1)	5 (6.9)	
History of smoking, n (%)			<.001
Yes	2 (2.8)	33 (45.8)	
No	70 (97.2)	39 (54.2)	
Illicit drug use, n (%)			N/A
Yes	5 (6.9)	5 (6.9)	
No	67 (93.1)	67 (93.1)	
History of mental illness, n (%)			.002
Yes	6 (8.3)	23 (31.9)	
No	66 (91.7)	49 (68.1)	
Homeless, n (%)			.63
Yes	1 (1.4)	3 (4.2)	
No	71 (98.6)	69 (95.8)	
Lives alone, n (%)			.40
Yes	16 (22.2)	21 (29.2)	
No	56 (77.8)	51 (70.8)	
Severity of illness at admission, n (%)			N/A
Major	58 (80.6)	58 (80.6)	
Minor	14 (19.4)	14 (19.4)	
Primary diagnosis category, ^e n (%)			N/A
Cardiovascular	15 (20.8)	15 (20.8)	
Gastroenterology	6 (8.3)	6 (8.3)	
Hematology/oncology	2 (2.8)	2 (2.8)	
Renal disease	5 (6.9)	5 (6.9)	
Pulmonary disease	9 (12.5)	9 (12.5)	
Infectious diseases	29 (40.3)	29 (40.3)	
Other	6 (8.3)	6 (8.3)	

ICD-10, International Classification of Diseases, Tenth Revision; LOS, length of stay; N/A, not applicable due to exact matching or identical distribution between inliers and outliers.

^aOutliers were matched exactly 1:1 to inliers on disease severity and primary diagnosis (using ICD-10 codes) at admission.

^bInliers had an actual LOS for hospitalization within 3 SD of predicted. Percentages might not sum to exactly 100% due to rounding.

^cOutliers had an actual LOS for hospitalization greater than 3 SD of predicted. Percentages might not sum to exactly 100% due to rounding.

^dPaired *t* test for continuous variables; exact McNemar *P* values for binary variables; exact *P* values obtained from conditional logistic regression models for categorical variables.

^eClassified using ICD-10 codes.

admission. Compared with inlier controls, outlier cases were 8.8 (95% CI, 5.8-11.8) years younger ($P < .001$). The percentage of inlier male patients was higher compared with outliers (58.3% vs 44.4%). Cases had a higher proportion of Black/African American patients compared with controls (19.4% vs 11.1%); however, the relationship between race and LOS outlier status was not statistically significant ($P = .08$). History of smoking was significantly higher for cases vs controls (45.8% vs 2.8%; $P < .001$). Similarly, the prevalence of mental illness was significantly higher in cases compared with controls (31.9% vs 8.3%; $P = .002$). The association between type of health insurance and LOS outlier status was not significant (Table 1).

Compared with inlier controls, cases had 32.4 (95% CI, 25.5-39.3; $P < .001$) days longer LOS. During the inpatient stay, cases had 2.6 (95% CI, 2.0-3.2; $P < .001$) more consultants compared with controls. Cases also had 0.3 more comorbid conditions at admission compared with controls; however, the difference was not significant ($P > .05$). The mean cost of stay was \$94,462 for cases and \$17,234 for controls ($P < .001$). The difference between the mean cost per day for cases and controls was statistically insignificant (data not shown). During their inpatient stay, cases were more likely than controls to experience a complication (69.4% vs 23.2%) or have a hospital-acquired infection (43.1% vs 6.9%) (both $P < .001$). UTI was the most prevalent hospital-acquired infection among cases, at 15.3%. Discharge destination was significantly associated with LOS outlier status. An estimated 66.7% of cases were discharged to a facility, whereas only 34.7% of controls had a facility discharge (Table 2).

Significant predictors of outlier LOS included history of smoking, history of mental illness, in-hospital complications, hospital-acquired infections, and discharge destination. In the adjusted conditional logistic regression models, higher odds of being an outlier were observed for patients with a history of smoking compared with those without (adjusted odds ratio [aOR], 29.5; 95% CI, 2.9-301.3) and for patients with in-hospital complications (aOR, 17.6; 95% CI, 3.5-88.6) and hospital-acquired infections (aOR, 7.2; 95% CI, 1.7-31.4). Compared with those with a home discharge, we found higher odds of being an outlier for patients discharged to a facility (aOR, 11.5; 95% CI, 2.6-50.0). Compared with those without a history of mental illness, patients with such a history had 3.8 (95% CI, 1.1-13.6) higher odds of being outliers. However, the association was not statistically significant when we estimated the exact *P* value (Table 3). The significance levels for all OR estimates remained unchanged when we further adjusted for the type of health insurance.

The relative increase in the cost of stay per day among outliers was significantly associated with hospital-acquired infections and in-hospital complications (Figure 1). Namely, the inpatient stay cost per day among outliers was an adjusted rate ratio (aRR) of 1.2 (95% CI, 1.1-1.4) times higher for patients with vs without hospital-acquired infections. Similarly, the cost of stay per day aRR for outliers with in-hospital complications was 25% (95% CI, 9%-44%) higher than that for outliers without in-hospital complications. Among LOS outlier cases, discharge destination was the only significant predictor of increase in hospitalization duration (Figure 2). Outlier

patients who were discharged to a facility had 1.5 (95 CI, 1.1-2.0) times longer LOS compared with outliers with a home discharge.

DISCUSSION

Although several studies have looked at hospital stay factors related to increased LOS, our study is the one of the first to characterize inpatient adult medicine LOS outliers compared with their inlier cohort and to identify risk factors contributing to the increased LOS in the US population. As supported by findings of previous studies¹⁰⁻¹² from other countries and from trauma literature in the United States, in-hospital complications, particularly hospital-acquired infections, were a major contributor to increased LOS in our study population. Although it is well known that high infection rates lead to increased LOS,¹⁰⁻¹² the contributions of infection to the LOS outlier group have been less clear. Our data demonstrate that having a hospital-acquired infection led to almost 7 times higher odds of being an outlier. With the same median cost per day for inliers and outliers, this resulted in a median \$91,060 increase in cost per stay per outlier. In our analysis among the outliers, hospital-acquired infections and complications were not only more likely but also drove up the cost per day within the outlier group.

Outliers had much higher odds of being discharged to a facility rather than returning home after their hospital stay. Although increased length of inpatient stay leads to general debilitation with an increased need for physical therapy and rehabilitation, additional factors including waiting for placement to a facility due to delay in identifying discharge needs, levels of social work and case management support, and delays in insurance approval are additional contributors to the outlier status. Interestingly, we also found that outliers had higher odds of having a smoking history. It is possible, given the small sample size, that this is a chance finding. Active smoking and tobacco use are recognized risk factors for infections and therefore could be contributors to hospital complications and the resulting increase in LOS,^{13,14} although unlikely to the degree that the OR might suggest. Our data also captured ever-smokers, so it is unclear why those who had already quit smoking would still be more likely to be an outlier.

It is a common belief that lack of insurance is a significant contributor to LOS; however, all outliers in our study had some form of insurance. Medicaid insurance status has also previously been shown to be associated with increased LOS compared with private insurance.¹⁵ Our data found no significant differences in insurance status (Medicare, Medicaid, private pay/self-pay) between the inlier and outlier groups, although this could be due to lack of power. Other factors previously studied as contributors to increased LOS include age, gender, disease complexity, and hospital course.^{4,5} Little is known about their effects on the outlier group. We did find a significantly higher number of consultants on outlier cases, which may be a surrogate marker for medical complexity at or after admission to the hospital. There was also no significant difference in cardiac arrests between the 2 groups, which we also used as a

TABLE 2. Hospitalization Characteristics of Matched^a Outlier and Inlier Patients

Hospitalization characteristics	Inliers ^b (n = 72)	Outliers ^c (n = 72)	P ^d
Number of consultants, mean (SD)	1.9 (1.4)	4.5 (2.2)	<.001
Number of comorbidities, mean (SD)	6.3 (3.4)	6.6 (3.8)	.69
Number of comorbidities group, n (%)			.97
1-4	22 (30.6)	21 (29.2)	
5-6	20 (27.8)	21 (29.2)	
7-8	15 (20.8)	13 (18.1)	
≥ 9	15 (20.8)	17 (23.6)	
Number of complications, mean (SD)	0.4 (0.7)	1.4 (1.3)	<.001
In-hospital complications,* n (%)			<.001
Yes	17 (23.6)	50 (69.4)	
No	55 (76.4)	22 (30.6)	
Number of complications group, n (%)			<.001
0	56 (77.8)	22 (30.6)	
1	9 (12.5)	20 (27.8)	
2	5 (6.9)	20 (27.8)	
≥ 3	2 (2.8)	10 (13.9)	
Hospital-acquired infections, n (%)			<.001
Yes	5 (6.9)	31 (43.1)	
No	67 (93.1)	41 (56.9)	
Type of hospital-acquired infections, n (%)			<.001
None	67 (93.1)	41 (56.9)	
<i>Clostridium difficile</i>	0 (0.0)	1 (1.4)	
Pneumonia	2 (2.8)	10 (13.9)	
Skin	2 (2.8)	3 (4.2)	
Urinary tract	1 (1.4)	11 (15.3)	
Multiple	0 (0.0)	6 (8.3)	
Discharge destination, n (%)			<.001
Home	42 (58.3)	16 (22.2)	
Facility ^f	25 (34.7)	48 (66.7)	
In-hospital death	5 (6.9)	8 (11.1)	
Cardiac arrest during stay, n (%)			.45
Yes	4 (5.6)	7 (9.7)	
No	68 (94.4)	65 (90.3)	
Withdrawal of care, n (%)			.45
Yes	4 (5.6)	7 (9.7)	
No	68 (94.4)	65 (90.3)	

ICD-10, International Classification of Diseases, Tenth Revision; LOS, length of stay.

^aOutliers were matched exactly 1:1 to inliers on disease severity and primary diagnosis (using ICD-10 codes) at admission.

^bInliers had an actual LOS for hospitalization within 3 SD of predicted. Percentages might not sum to exactly 100% due to rounding.

^cOutliers had an actual LOS for hospitalization greater than 3 SD of predicted. Percentages might not sum to exactly 100% due to rounding.

^dExact McNemar *P* values for binary variables; exact *P* values obtained from conditional logistic regression models for categorical variables.

*Complications included infections, blood clots, acute kidney injury, arrhythmias, drug reactions, electrolyte abnormalities, encephalopathy, respiratory failure, ileus, gastrointestinal bleeding, congestive heart failure exacerbation, and chronic obstructive pulmonary disease exacerbation.

^fIncluding discharges to hospice, long-term acute care hospital, skilled nursing facility, rehabilitation facility, or psychiatric facility.

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TABLE 3. Association Between Patient Characteristics and Outlier^a Status

Patient characteristics	Unadjusted OR (95% CI)	P ^b	Adjusted ^c OR (95% CI)	P ^b
History of smoking		.001		.004
No	Reference		Reference	
Yes	32.0 (4.4-234.2)		29.5 (2.9-301.3)	
History of mental illness		.002		.04 ^d
No	Reference		Reference	
Yes	4.4 (1.7-11.6)		3.8 (1.1-13.6)	
In-hospital complications		<.001		.001
No	Reference		Reference	
Yes	9.3 (3.3-26.0)		17.6 (3.5-88.6)	
In-hospital infections		<.001		.008
No	Reference		Reference	
Yes	7.5 (2.6-21.2)		7.2 (1.7-31.4)	
Discharge destination		<.001		.01
Home	Reference		Reference	
Facility ^e	6.0 (2.3-15.6)	<.001	11.5 (2.6-50.0)	.001
In-hospital death	6.2 (1.2-32.3)	.03	5.1 (0.5-57.4)	.19

OR, odds ratio.

^aOutliers were matched exactly 1:1 to inliers on the primary diagnosis at admission and disease severity.

^bWald χ^2 obtained from conditional logistic regression models for the OR of being an outlier for each characteristic level vs the reference level.

^cConditional logistic regression models adjusted for age, gender, and race.

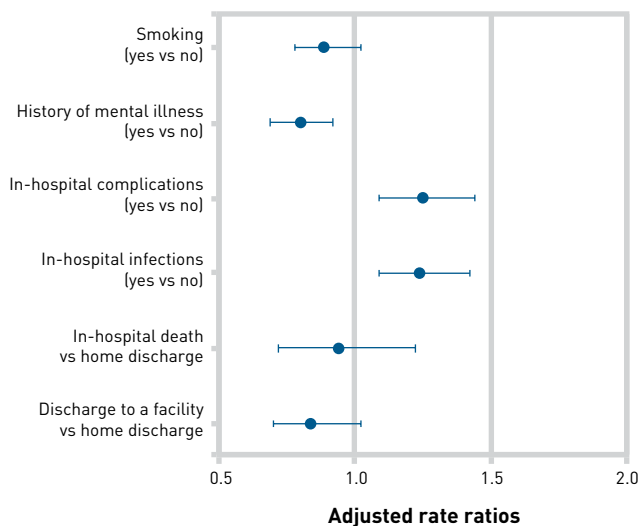
^dExact $P > .05$.

^eIncluding discharges to hospice, long-term acute care hospital, skilled nursing facility, rehabilitation facility, or psychiatric facility.

marker for medical complexity and disease severity. We also looked at homelessness as a marker of socioeconomic status and living alone as a possible inability to return home after hospitalization as possible reasons for increased LOS; however, there was no difference. History of mental illness had borderline statistical significance, but there was likely not enough power to detect a difference in this study. Mental illness may therefore still be clinically relevant to outlier status, as several studies in other countries have shown that patients with mental illness have increased LOS compared with those without.^{16,17}

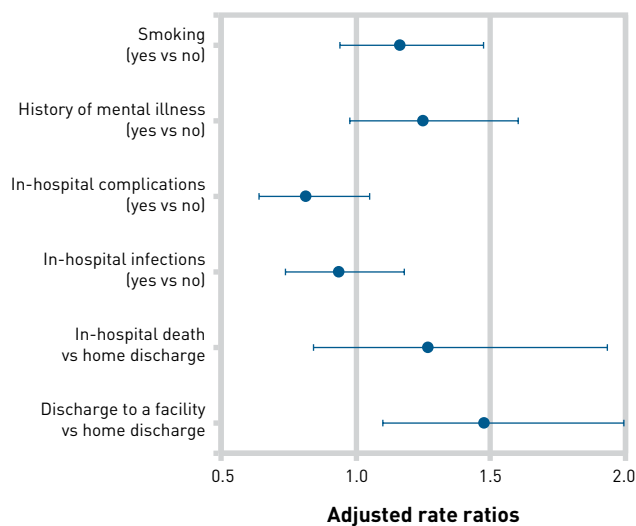
Our retrospective analysis points to several risk factors that help identify LOS outliers in the adult medicine inpatient population. In-hospital complications and infections remain the leading risk factors, likely due to the cyclical nature of infection leading to increased hospital days, which in turn increases risk of more infections. Early identification and redirection of hospital resources to target and prevent in-hospital complications, including infections, is an area of improvement to reduce hospital days. Prevention campaigns like the CDC's Clean Hands Count (to improve handwashing compliance) and health care personnel training on adherence to use of personal protective equipment and isolation precautions have been shown to be effective in preventing hospital-acquired infections.^{18,19} Our data show that prevention of infections would not only decrease LOS but would also likely decrease the number of patients categorized as LOS outliers. Given that outliers were also significantly more likely to be discharged to a facility, increasing physical therapy during hospitalization may allow more patients to return home even after a prolonged stay. Organizing social work and

FIGURE 1. Relationship Between Inpatient Stay Cost per Day and Patient Characteristics Among Cases With Outlier Length of Stay (n = 72)^a



^aAdjusted for age, gender, race, and the type of health insurance.

FIGURE 2. Relationship Between Hospitalization Duration (days) and Patient Characteristics Among Cases With Outlier Length of Stay (n = 72)^a



^aAdjusted for age, gender, race, and the type of health insurance.

case management teams to streamline facility discharges, as well as educating physicians on anticipating discharge needs earlier, could be targeted approaches to improve handoffs to outside facilities.

Limitations

There are several limitations to our study. Our sample size limits the generalizability of our findings, and some of the nonsignificant findings could be due to lack of power. Our data, although descriptive, also do not point to a definite causal relationship between identified risk factors and the outlier status. Nevertheless, our data do show significant associations with outlier status that are meaningful both clinically and systemwide. As with all studies using electronic health record (EHR)-abstracted data, the accuracy of the data and related details are dependent on physician, nursing, and social worker charting. This is a recognized weakness of EHR data, which are often either incomplete or inaccurate.²⁰ In our study, data taken directly from the EHR were also checked by manual chart review to ensure the highest accuracy possible. Despite these limitations, our study is one of the first to categorize adult medicine inpatient stay outliers as a cohort in which patient-related and hospital stay characteristics are associated with significantly increased LOS.

CONCLUSIONS

LOS outliers are a significant contributor to health care costs. In-hospital complications, hospital-acquired infections, and discharge to a facility are all predictors not only of increasing hospital days for patients but also of increased risk of becoming LOS outliers, who stay disproportionately longer and use disproportionately more resources than predicted. ■

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