

Revisiting Hospital Length of Stay: What Matters?

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Hospital length of stay (LOS) has long been a crucial barometer of hospital efficiency and quality of care. Longer stays result in higher costs and extra burdens on patients and their families. The clinical and financial ramifications have made LOS one of the most watched measures in all hospitals and healthcare systems.¹⁻⁵

Substantial literature has been focused on how LOS is affected by hospital teaching mission, for-profit status, hospitalists, facility physician involvement, nurse staffing, hospital volume, and patient insurance status.⁶⁻¹⁶ However, analyses of LOS to identify the contributing factors that can be acted on have been relatively sparse compared with analyses of other measures, such as hospital readmissions; for example, racial and income disparities in readmissions have been extensively analyzed and reported, but little has been done to analyze their possible effects on LOS.¹⁷⁻¹⁹

The primary aim of this study is to explore actionable information that can be used to reduce LOS; to do so, we focus on demographic and socioeconomic factors such as marital status and income, while comprehensively controlling for confounding factors such as case mix. The secondary aim is to assess racial and income disparities in LOS in an integrated healthcare network.

METHODS

Study Population and Data Sources

This study analyzed all of the 8718 patients hospitalized for acute care in fiscal year (FY) 2011 in Veterans Healthcare Network Upstate New York (VISN 2)—1 of the 21 integrated service networks of the Veterans Administration (VA). VISN 2, with 5 medical centers (4 providing inpatient services) and 31 outpatient clinics across upstate New York, serves 140,000 patients with an annual budget of over \$1 billion.

The VA's centralized National Patient Care Database (NPCD), hosted at the Austin Information Technology

ABSTRACT

Objectives

To explore actionable information that can be used to reduce hospital acute care length of stay (LOS) and to assess racial and income disparities in LOS in an integrated healthcare network.

Study Design and Methods

Retrospective analysis of 8718 inpatients in an integrated healthcare network. The LOS was examined by using linear, log-linear, Poisson, generalized Poisson, and negative binomial (NB) models to control for confounding factors. The performances of the 5 models were compared, and the NB model was selected for the final analysis and report.

Results

Over 50% of the inpatients were not married. The LOS was 22% longer for the unmarried patients compared with their married counterparts after controlling for confounding factors. No income or racial disparities were found.

Conclusions

The prolonged LOS of the unmarried patients and the potential lack of post discharge care support warrant greater attention from discharge planners at hospital level and from policy makers at both the national and local levels. Racial and income disparities are not unavoidable; the way in which care is paid for and delivered may play a role.

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TRENDS FROM THE FIELD

Center, was the primary data source, containing detailed patient demographic, socioeconomic, and clinical information (eg, marital status, income, and diagnoses).²⁰ For case mix or patient risk adjustment, we used the risk score produced by DxCG,²¹⁻²⁵ which has been used by the VA to systematically measure all of its 5.7 million patients' risks over the last decade.

Most of the data fields in the NPCD files, such as admission/discharge dates and *International Classification of Diseases, Ninth Revision, Clinical Modification* codes, are routinely and rigorously validated with strict business rules. Its income information is means tested. One exception is that race information is often incomplete because the VA does not mandate patients to report racial status. However, for the last several years, the VA has systematically gathered race information from other data sources (eg, Medicare and the Department of Defense), and as a result, the updated race status is deemed reliable.^{26,27}

Dependent and Independent Variables

The dependent variable is the LOS of the first hospitalization in FY 2011, excluding hospitalizations of the patients transferred from other hospitals. LOS is defined as discharge date minus admission date plus 1 (sensitivity analysis was conducted without adding 1).¹ Guided by the literature and based on data availability in the VA, the independent variables are extracted from 4 categories (as shown in **Table 1**): 1) demographic and socioeconomic variables, 2) prior year patient care cost (FY 2010), 3) hospital characteristics (captured by fixed effect), and 4) risk score and comorbidities.²⁰

In analyzing the effects of independent variables on dependent variables, proper patient risk adjustment is imperative for reliable results. In the literature, the use of case mix has been rather ad hoc, ranging from a few co-existing conditions to comprehensive measures such as Charlson Comorbidity Index scores.^{19,28-31} In this study, we used DxCG risk score as the aggregated case-mix measure. DxCG is a well-validated algorithm that most studies have found superior to others in predicting resource use.²²⁻²⁵ In spite of its superiority, we supplemented DxCG with a set of the most prevalent and/or expensive chronic conditions: hypertension, diabetes, congestive heart failure, chronic obstructive pulmonary disease, cancer, and depression.

This study only used existing data that include no identifiable patient private information, and therefore was exempt from Institutional Review Board review under VA Title 38, Section 16.101(b)(4).

Analyses

In this study, we first conducted univariate analyses by using 1-way ANOVA, and then we fitted multivariate regressions to control for the confounders.

In the literature, 5 regression models are often used to analyze LOS: ordinary least square (OLS),³²⁻³⁴ log-linear regression,^{10-16,35-37} Poisson,¹⁷ generalized Poisson, and Negative Binomial (NB) models.³⁸⁻⁴⁰ For reliable results, in this study we assessed the performances of the 5 models. We found OLS and log-linear regression were inappropriate because even the latter failed to produce an approximately normal distribution (**Figure**), and the normality of the log-linear regression residuals was also rejected by the Kolmogorov & Smirnov test ($P = .01$).

We selected the NB model for the final analysis because it outperformed Poisson and generalized Poisson models with Pearson overdispersion scales of 1.79 (NB), 6.99 (Poisson), and 1.83 (generalized Poisson), respectively.^{41,42} Further, to make sure the results were not affected by any potentially remaining overdispersion, we winsorized LOS at 3 weeks (21 days) and 4 weeks (28 days) as sensitivity analyses.⁴³

Sound model selection is necessary for obtaining reliable results, but does not guarantee them. The accuracy of the estimates heavily relies on how the confounding factors are controlled for; to ensure reliable results, we configured 3 NB regression models to control for confounding factors at different levels. In model 1, we included demographic/socioeconomic variables, prior year patient cost, and medical center characteristics (fixed effect: 4 dummy variables and 1 was omitted as the reference); in model 2, we added DxCG risk score as the total measure of disease severity; and in model 3, we further augmented DxCG risk score with 6 chronic conditions to be sure the results were not skewed by imperfect case-mix measurement.

We also conducted extensive sensitivity analyses, such as modeling age and income as categorical variables and reclassifying blacks and other minority groups to ensure the robustness of our results. All analyses were conducted by using Proc GLM and GLIMMIX of SAS 9.2 (Cary, North Carolina).

RESULTS

The results of the univariate and multivariate analyses are reported in **Table 1** and **Table 2**. Among the variables of importance, black patients appeared to have longer LOS in the univariate analysis: in the first quartile 9.9% were black, while in the fourth quartile, 12.2% were

black ($P = .1253$). However, this weak association faded in models 2 and 3 after controlling for patient risk and other confounders ($P = .1543$ and $.2622$). Equally important, there was no income disparity in LOS. The patient income changed little across the 4 quartiles ($P = .6525$) and there were hardly any associations between income and LOS in all 3 models ($P = .8726$, $.9449$, and $.8303$).

Of particular interest, unmarried patients were more likely to have longer LOS. In the univariate analysis, 56% of the patients were unmarried in the first quartile, while 65% were unmarried in the last quartile ($P < .0001$). After adjusting for different confounders, all 3 models confirmed that unmarried patients experienced longer LOS (all P values $< .0001$). The final model indicated that the LOS of the unmarried patients was 22% longer than that of their married counterparts.

The coefficient estimates of the confounders, such as age, comorbidities, and prior year cost, were consistent with prior findings.⁴⁴ In particular, patients enrolled in Medicare were more likely to experience longer LOS ($P = .2199$, $.0052$, and $.0058$). As expected, DxCG risk score was positively associated with LOS (all P values $< .0001$) while only depression among the 6 chronic conditions appeared to be associated with longer LOS ($P = .0254$ and $P = .0909$). Finally, patients in all 3 medical centers (A, B, and C) on average had longer LOS compared with patients in medical center D (omitted in the regression as the reference; all P values $< .0001$).

DISCUSSION

In this study, we used the NB model to analyze the LOS of 8718 patients in a veterans' integrated healthcare network. To ensure that the findings were reliable, we conducted extensive sensitivity analyses: 1) fitted 3 NB models with different levels of risk adjustments, and winsorized LOS at 21 and 28 days; 2) fitted log-linear, Poisson, and generalized Poisson regressions to confirm the findings; 3) regrouped racial status (ie, combined all minority groups together vs white); 4) reanalyzed the data by changing continuous variables such as age and income to categorical variables; 5) analyzed the data without adding 1 to LOS; and 6) examined the effect of readmissions. All of these analyses confirmed that the findings were consistent and robust.

Racial disparity has been found pervasive in other healthcare outcomes, such as readmissions^{18,19}; however, racial disparity in LOS has rarely been studied. In fact, we identified only 1 study that examined racial disparities in LOS for asthma, which found LOS was

one-fourth to one-third shorter for nonwhites versus whites.¹⁷ In this study, we found no racial disparities in LOS in an integrated healthcare network, which suggests that racial disparities are not necessarily universal and may be dependent on how healthcare is paid for and delivered. Unlike most US healthcare systems, patients in the VA system have few financial barriers; the VA clinicians are salaried and have no financial incentive to keep patients in the hospital for shorter or longer stays. More importantly, the VA has reformed itself to focus on patient-centered care since the inception of integrated healthcare networks in 1995.⁴⁵ These might be among the factors that could reduce disparities.

Income disparity in LOS was also not found in this study. Income disparity has not been well studied compared with racial disparity in the literature because, we speculate, income data are often unavailable. It also should be noted, without controlling for income, analyzing racial disparity could yield misleading results, since race and income are often correlated⁴⁶; as a result, what appears to be a racial issue could actually be an income issue.

Of importance, we found that unmarried patients had 22% longer LOS compared with married patients, which could offer actionable information for discharge planning. Lack of post discharge caregiver support could contribute to the prolonged LOS. To reduce unnecessary and prolonged hospital stays, social work services may be deployed proactively to arrange post discharge care/support for the unmarried patients. Especially given that 60% of the patients in this study were unmarried (Rosenthal et al reported 54% for non-VA patients),⁴⁷ 22% longer LOS warrants the attention of hospital managers and policy makers. Despite the magnitude, however, the relationship between marital status and LOS appears to be understudied. We only identified 1 published study that assessed the effect of marital status on LOS (among patients with colorectal resection).⁴⁸

Interestingly, patients enrolled in Medicare were more likely to have longer LOS compared with those who had private insurance (omitted in the regression as the reference). This could be attributed to the fact that patients with private insurance are more likely employed and pay closer attention to their health, which was not captured by the model. However, this is speculation, and further study may be warranted.

Our findings indicate that patients in medical center D (omitted as the reference in the regression) experienced shorter LOS. But this study was not designed to identify practice patterns because many hospital characteristics,

such as teaching mission and referral center status, were absorbed into the fixed effect.

Limitations

Despite our efforts, the limitations of this study should be noted. First, patients in this study could also seek care from non-VA providers, but we hope the effect is minimal because we analyzed LOS rather than number of hospitalizations. Second, the study population was from 1 geographic area (ie, upstate New York), which may not represent the whole VA or other healthcare systems well. Finally, all other nonblack minority patients comprised less than 1% of the study population; thus, they could not be analyzed separately in any reliable way.

CONCLUSIONS

In spite of the limitations, our findings may have meaningful policy implications. Given that more than half of the hospitalized patients are unmarried, the prolonged LOS warrants greater attention paid to post discharge care support by discharge planners and policy makers. Encouragingly, reducing LOS has not been linked to lower patient satisfaction.⁴⁹ In addition, our findings imply that racial and income disparities are not unavoidable; how care is paid for and delivered may make a difference. Finally, we hope the methods we used to analyze LOS can be informative to the analytical field.

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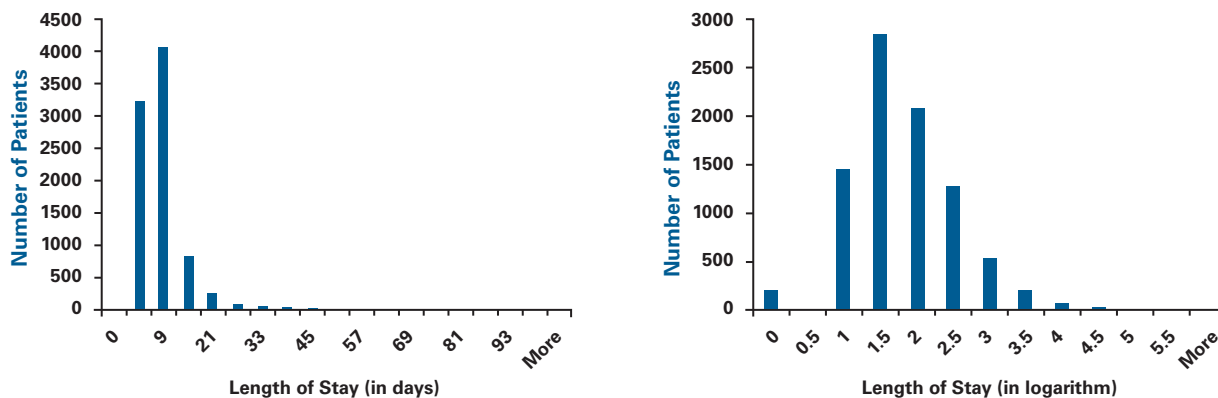
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Take-Away Points

- Over 50% of the inpatients were not married, and their length of stay (LOS) was 22% longer compared with their married counterparts after controlling for confounding factors.
- The prolonged LOS of the unmarried patients, and the potential lack of post discharge care support, warrant greater attention from discharge planners at the hospital level and from policy makers at the national as well as local levels.
- No racial and income disparities in LOS were found in an integrated healthcare network. How care is paid for and delivered may make a difference in reducing these disparities elsewhere.

■ **Figure.** Hospital Length of Stay Distributions



■ **Table 1.** Descriptive Statistics and Univariate Analysis (N = 8718)

Variable	Quartile 1 (LOS = 1 or 2 days) Mean (SD), n = 1654	Quartile 2 (LOS = 3 or 4 days) Mean (SD), n = 2846	Quartile 3 (LOS = 5, 6, or 7 days) Mean (SD), n = 2080	Quartile 4 (LOS = 8 or more days) Mean (SD), n = 2146	P
Length of stay (LOS)	1.876 (0.33)	3.446 (0.50)	5.808 (0.81)	15.051 (12.80)	<.0001
Racial status (black = 1, otherwise 0)	9.9% (0.30)	11.3% (0.32)	10.5% (0.31)	12.2% (0.33)	.125
Patient income	25,431 (34,674)	25,441 (45,489)	24,109 (37,070)	25,392 (42,625)	.653
Marital status (married = 0, otherwise 1)	56.1% (0.50)	58.2% (0.49)	61.1% (0.49)	65.0% (0.48)	<.0001
Age	64.503 (15.05)	66.209 (15.01)	66.672 (15.73)	68.378 (15.07)	<.0001
Sex (male = 1, otherwise 0)	93.3% (0.25)	94.0% (0.24)	94.9% (0.22)	95.5% (0.21)	.013
Number of dependents	0.22 (0.41)	0.206 (0.40)	0.194 (0.4)	0.198 (0.40)	.204
Service-connected disability rating (%)	25.969 (37.17)	24.722 (36.5)	24.928 (37.01)	23.074 (36.72)	.104
No insurance	30.3% (0.46)	25.8% (0.44)	27.3% (0.45)	23.2% (0.42)	<.0001
Enrolled in Medicaid	1.7% (0.13)	1.8% (0.13)	2.2% (0.15)	2.1% (0.14)	.704
Enrolled in Medicare	56.4% (0.5)	61.5% (0.49)	61% (0.49)	65.4% (0.48)	<.0001
Covered by private insurance	11.7% (0.32)	10.9% (0.31)	9.5% (0.29)	9.4% (0.29)	.053
Prior year patient cost (in logarithm)	8.747 (2.62)	8.746 (2.73)	8.843 (2.74)	8.718 (3.11)	.494
Medical center A	22.0% (0.41)	19.6% (0.4)	20.3% (0.40)	18.8% (0.39)	.091
Medical center B	42.7% (0.49)	33.0% (0.47)	29.6% (0.46)	35.7% (0.48)	<.0001
Medical center C	29.4% (0.46)	41.0% (0.49)	45.1% (0.50)	43.7% (0.50)	<.0001
Medical center D	6.0% (0.24)	6.4% (0.25)	5.1% (0.22)	1.9% (0.14)	<.0001
DxCg score	2.413 (2.21)	2.81 (2.31)	3.159 (2.50)	4.088 (3.16)	<.0001
Hypertension	49.0% (0.50)	46.4% (0.50)	44.8% (0.50)	43.1% (0.50)	.002
Diabetes	14.8% (0.35)	17.4% (0.38)	16.8% (0.37)	19.6% (0.40)	.001
Congestive heart failure	18.0% (0.38)	23.5% (0.42)	24.5% (0.43)	25.7% (0.44)	<.0001
Chronic obstructive pulmonary disease	28.0% (0.45)	30.8% (0.46)	30% (0.46)	28.9% (0.45)	.202
Cancer	19.8% (0.40)	22.9% (0.42)	23.3% (0.42)	26% (0.44)	<.0001
Depression	30.8% (0.46)	32.5% (0.47)	35.1% (0.48)	31.7% (0.47)	.025

■ **Table 2.** Negative Binomial Regression Parameter Estimates (N = 8718)

Variable	Model 1			Model 2			Model 3		
	Parameter Estimate	Adjusted Relative Risk	P	Parameter Estimate	Adjusted Relative Risk	P	Parameter Estimate	Adjusted Relative Risk	P
Intercept	1.272	3.568	<.0001	1.332	3.788	<.0001	1.285	3.613	<.0001
Racial status (black = 1, otherwise 0)	0.103	1.109	.000	0.037	1.038	.154	0.029	1.030	.262
Patient income	(0.000)	1.000	.873	0.000	1.000	.945	(0.000)	1.000	.830
Marital status (married = 0, otherwise 1)	0.217	1.242	<.0001	0.206	1.229	<.0001	0.200	1.222	<.0001
Age	0.005	1.005	<.0001	0.002	1.002	.011	0.003	1.003	<.0001
Sex (male = 1, otherwise 0)	0.025	1.025	.509	0.013	1.014	.713	0.027	1.027	.464
Number of dependents	0.051	1.052	.052	0.047	1.048	.062	0.052	1.053	.039
Service-connected disability rating (%)	0.001	1.001	.042	0.000	1.000	.293	0.000	1.000	.353
No insurance	(0.027)	0.973	.398	0.014	1.014	.645	0.010	1.010	.753
Enrolled in Medicaid	0.035	1.035	.605	0.081	1.084	.209	0.074	1.077	.247
Enrolled in Medicare	0.037	1.037	.220	0.081	1.084	.005	0.080	1.083	.006
Prior year patient cost (in logarithm)	(0.015)	0.985	<.0001	(0.027)	0.974	<.0001	(0.025)	0.976	<.0001
Medical center A	0.332	1.394	<.0001	0.283	1.327	<.0001	0.262	1.300	<.0001
Medical center B	0.459	1.582	<.0001	0.412	1.509	<.0001	0.393	1.481	<.0001
Medical center C	0.411	1.508	<.0001	0.355	1.427	<.0001	0.336	1.400	<.0001
DxCG score				0.089	1.093	<.0001	0.095	1.100	<.0001
Hypertension							(0.065)	0.937	.001
Diabetes							(0.024)	0.976	.274
Congestive heart failure							(0.114)	0.892	<.0001
Chronic obstructive pulmonary disease							(0.075)	0.928	<.0001
Cancer							(0.059)	0.942	.003
Depression							0.031	1.031	.091

Adjusted relative risk is calculated as the exponentiation of the parameter estimate.