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Risk factors for 30-day readmission following liver transplantation in Pennsylvania

Brittany Damazio[a], Qiang Hao[a], Juan D. Arenas[b], Thomas R. Riley III[c], Christopher S. Hollenbeak[a,*]

[a] Department of Health Policy and Administration, The Pennsylvania State University, University Park, Pennsylvania, USA
[b] Division of Transplantation, Department of Surgery, Penn State College of Medicine, Hershey, Pennsylvania, USA
[c] Division of Gastroenterology and Hepatology, Department of Medicine, Penn State College of Medicine, Hershey, Pennsylvania, USA

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ABSTRACT

Background: Readmissions after liver transplantation (LT) are common given the complexity of the procedure, the severity of illness of patients, and complications related to immunosuppression. The objectives of this research were to identify risk factors for 30-day readmission and length of stay (LOS) for patients undergoing LT in Pennsylvania (PA).

Methods: Data from the Pennsylvania Health Care Cost Containment Council (PHC4) were used to identify 1,163 patients admitted to 10 liver transplant centers in Pennsylvania for liver transplantation between 2010 and 2018. Logistic and generalized linear regression models were used to estimate risk factors for 30-day readmission and LOS, respectively, adjusting for patient, disease, and hospital characteristics.

Results: Of the 1,163 patients receiving LT, 361 (31.1%) required readmission within 30 days, most frequently for surgical complication (23.5%). Both 30-day readmission rates and LOS showed a decreasing trend from 2010 to 2018. Readmitted patients were more likely to be younger than 60, female, have had a longer LOS, have been discharged to a skilled nursing facility, and have concomitant comorbid renal disease. Longer LOS was associated with patients who had an emergent admission, were transferred from another acute care institution, had surgical complications, and were discharged to a skilled nursing facility. We also found that age, hospital volume, and comorbidities were associated with longer LOS.

Conclusions: Patient demographics, including age, sex, and race/ethnicity are associated with readmission and LOS following LT in PA. These results may be useful in guiding efforts to prevent readmissions.

Introduction

Hospital readmissions continue to be the focus of clinicians, hospitals, policy makers, and payers given their potential implications as a quality metric and target for cost containment efforts. Center for Medicare and Medicaid services (CMS) enacted a hospital readmission reduction program (RRP) as a part of the Affordable Care Act in 2011 [1]. RRP penalizes hospitals with excessive hospital readmission rates within 30 days of discharge by reducing overall CMS reimbursement. With the expansion of this program, more emphasis was placed to understand the quality of care in addition to avoiding payment penalties [1]. RRP was expanded to include additional medical conditions after its success [2]. All the previous studies were done on readmission after medical conditions such as chronic obstructive pulmonary disease (COPD) and other surgical conditions. Based on national Medicare data, the 30-day readmission rate after major surgeries (liver transplantation was not studied) was found to be 13% [3]. Results from a multi-institutional study by Wilson et al. on liver transplantation (LT) demonstrated significant variation in readmission rates among hospitals, but was unable to identify marked differences [4].

LT is a highly complex and resource-intensive intervention. Readmissions after liver transplantation are common and differ from other surgical procedures because of the complexity of the procedure, severity of illness, poor nutritional state, and complications related to immunosuppression [5]. Average total charge of a LT is estimated to be $739,000, with 17% incurred in the 180 days post-transplant discharge [6]. Most common indications requiring LT are hepatitis C, hepatocellular carcinoma, and alcoholic liver disease. In a retrospective study conducted between February 2002 and June 2016 by Baganate et al., among 64,977 who underwent LT, the incidence of 90-day mortality was 5% [7]. Within the first 21 days, death

* Corresponding author at: 604E Donald H. Ford Bldg, University Park, PA 16802.
E-mail address: chollenbeak@psu.edu (C.S. Hollenbeak).

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from cardiovascular, cerebrovascular, pulmonary, and hemorrhage were the leading causes of death (7-day: 53%) [7].

The objectives of this study were to use administrative discharge data from Pennsylvania to determine the risk factors for 30-day readmission and length of stay (LOS) for patients undergoing LT.

Methods

Data sources

Data for this analysis were administrative discharge data from the Pennsylvania Health Care Cost Containment Council (PHC4). PHC4 uses these data to provide public reports on hospital and healthcare quality in Pennsylvania, with a goal of addressing rising healthcare costs in the state. The PHC4 data include discharges from all hospitals and surgical facilities in the state, allowing us to examine outcomes for a large cohort of LT patients over nine years. The ten (10) transplant centers that perform liver transplantation were included in this analysis. The data are publicly available and deidentified, and this study was deemed exempt from Institutional Review Board approval.

Cohort

Patients over age 18 admitted to a hospital in Pennsylvania for a LT between 2010 and 2018 were included. LT was identified using principal International Classification of Diseases, 9th Revision, Clinical Modification (ICD-9-CM) procedure codes of 50.5x or International Classification of Diseases, 10th Revision Procedural Coding System (ICD-10-PCS) codes of 0FY0xxx. Patients were excluded if they were missing covariates or ineligible for readmission.

Outcomes

The primary outcome assessed was readmission within 30 days of discharge for LT. Readmissions to any hospital in Pennsylvania were captured, regardless of whether the readmission was to the hospital where the transplant was received. However, readmissions to hospitals outside of Pennsylvania were not included. A secondary outcome assessed was length of hospital stay for the transplant hospitalization. This included days both before and after the transplant surgery.

Covariates

Our analyses controlled for several important patient, disease, and hospital characteristics. Demographic characteristics included in the study were age (<50, 50–64, 65+), sex (male, female), race/ethnicity (white non-Hispanic, black non-Hispanic, Hispanic, other), payer (Medicare, Medicaid, commercial, other), admission type (emergent, urgent, elective), transfer, LOS, surgical complications, and discharge destination (home, home with home health, skilled nursing facility). Surgeon volume was stratified into low (0–4), medium (5–9), and high (10+). Hospital volume was stratified into low (0–19), medium (20–39), and high (40+). Comorbidities were also assessed using the Charlson comorbidity index (CCI) score of 0, 1, and 2+.

Statistical analysis

The statistical analyses were designed to identify significant predictors of readmission and length of hospital stay for patients undergoing LT. Univariate comparisons between characteristics of readmitted and non-readmitted patients were made using Student's *t* tests for continuous variables and chi-square tests for categorical variables. A logistic regression model was used to identify risk factors affecting the likelihood of readmission after LT, and odds ratios were reported from the logistic regression model. LOS after LT was modeled using a linear regression model. All analyses were performed with Stata statistical software (version 15; StataCorp, College Station, TX, USA), and statistical significance for all analyses was defined as P value < 0.05.

Results

Descriptive statistics

Of the 1163 patients who underwent LT in Pennsylvania between 2010 and 2018, 361 (31.1%) required a readmission within 30 days. Patient characteristics stratified by readmission status are summarized in Table 1. Compared with non-readmitted patients, readmitted patients were more likely to be female (30.5% versus 24.3%, P = 0.027). Readmitted patients were also more likely to have had a longer mean LOS (15.3 versus 13.5, P = 0.023). Although readmitted patients were more likely to be discharged to a skilled nursing facility (65.9% versus 63.6%), this was not statistically significant (P = 0.071). In addition, there was no significant difference in the distribution of the type of liver disease for which the patients required LT, with similar proportions of patients with cirrhosis, hepatitis, cancer, and chronic liver failure. Patient comorbidities stratified by readmission status are summarized in Table 2. Readmitted patients were more

Table 1
Demographics and characteristics of patients stratified by readmission status.

Variable	Not readmitted, *n* = 802	Readmitted, *n* = 361	*p* value
Age (years), mean	56.4	55.6	0.224
<50	18.5%	21.1%	
50–64	38.2%	41.0%	
65+	43.4%	38.0%	
Sex			0.027
Male	24.3%	30.5%	
Female	75.7%	69.5%	
Race/Ethnicity			0.053
White, Non-Hispanic	77.8%	72.6%	
Black, Non-Hispanic	13.2%	13.6%	
Hispanic	3.5%	5.5%	
Other	8.5%	13.0%	
Reason for Transplant			0.678
Chronic liver disease	10.6%	8.0%	
Cirrhosis	32.7%	31.9%	
Hepatitis	20.6%	22.4%	
Neoplasm	21.3%	21.9%	
Other	14.8%	15.8%	
Payer			0.185
Medicare	33.7%	37.7%	
Medicaid	16.7%	11.6%	
Commercial	47.5%	48.8%	
Other	2.1%	1.9%	
Admission type			0.1
Emergent	42.5%	37.4%	
Urgent	40.9%	45.4%	
Elective	16.6%	17.2%	
Transfer			0.253
Yes	5.2%	6.9%	
No	94.8%	93.1%	
Surgeon volume			0.626
Low (<5)	36.2%	37.7%	
Medium (5–9)	34.5%	35.2%	
High (10+)	29.3%	27.1%	
Hospital volume			0.166
Low (0–19)	46.8%	42.4%	
Medium (20–39)	75.8%	76.2%	
High (40+)	26.1%	31.3%	
LOS (days), mean	13.5	15.3	0.023
Surgical complications			0.245
Yes	29.3%	32.7%	
No	70.7%	67.3%	
Discharge destination			0.071
Home	28.9%	23.8%	
Home with home health	63.6%	65.9%	
Skilled nursing facility	7.5%	10.2%	

Table 2
Patient comorbidities stratified by readmission status.

Variable	Not readmitted, *n* = 802	Readmitted, *n* = 361	*p* value
Comorbidities			
Myocardial infarction	2.1%	2.2%	0.917
Congestive heart failure	3.5%	3.0%	0.697
Peripheral vascular disease	2.6%	1.7%	0.316
Cerebrovascular disease	0.7%	0.0%	0.099
Chronic pulmonary disease	10.2%	11.1%	0.659
Connective tissue/Rheumatic disease	1.1%	1.9%	0.269
Peptic ulcer disease	1.1%	2.2%	0.150
Mild liver disease	83.9%	81.7%	0.353
Diabetes without complications	26.2%	29.4%	0.260
Diabetes with complications	6.2%	8.3%	0.196
Paraplegia and Hemiplegia	0.1%	0.0%	0.502
Renal disease	11.6%	18.0%	0.003
Cancer	48.9%	44.0%	0.127
Moderate or severe liver disease	64.3%	62.6%	0.569
Metastatic carcinoma	0.6%	0.6%	0.887
AIDS/HIV	0.2%	0.6%	0.412
Charlson index, mean	2.6	2.7	0.625
0	4.4%	4.2%	
1	9.2%	9.1%	
2+	86.4%	86.7%	

likely to have a diagnosis of renal disease (18.0% versus 11.6%, $P = 0.003$). Overall, the mean CCI score was slightly higher in readmitted patients (2.7 versus 2.6), but this difference was not statistically significant ($P = 0.625$).

Readmission

Readmission rates by year are shown in Fig. 1. Readmission rates overall had a decreasing trend from 2010 to 2018. In 2010, readmission rates were around 40% compared to about 25% in 2018. Results from the logistic regression analysis of 30-day readmission are presented in Table 3. Patients who were over 60 years of age had 34% lower odds of being readmitted ($P = 0.038$) than patients between the ages of 18 and 49. Males had 34% greater odds of being readmitted ($P = 0.047$) compared to their female counterparts. Patients of "other" race had 75% greater odds of being readmitted ($P = 0.027$) compared to white non-Hispanic patients. Patients insured by Medicaid had 42% lower odds of being readmitted ($P = 0.011$) compared to commercially insured patients. The etiology of liver disease was not significantly associated with risk of readmission. Patients discharged to a skilled nursing facility had 51% greater odds of being readmitted compared to patients discharged home, but this was not statistically significant ($P = 0.13$).

Causes of readmission

Reasons for readmission are summarized in Fig. 3. Surgical complications accounted for the highest number of readmissions at 23.5%, followed by infection, with 15.5% of readmissions, and kidney failure, which accounted for 8.3% of readmissions. Rejection was the identified as the cause readmission for only 3.6% of readmitted patients.

Length of hospital stay

Average length of stay stratified by readmission status is summarized in Fig. 2. The largest disparity of average LOS between readmitted versus non-readmitted patients was in 2010. Readmitted patients stayed an average of 18 days while non-readmitted patients stayed an average of 12 days, a difference of about 6 days. In comparison, in 2018, patients who were readmitted stayed an average of 17 days

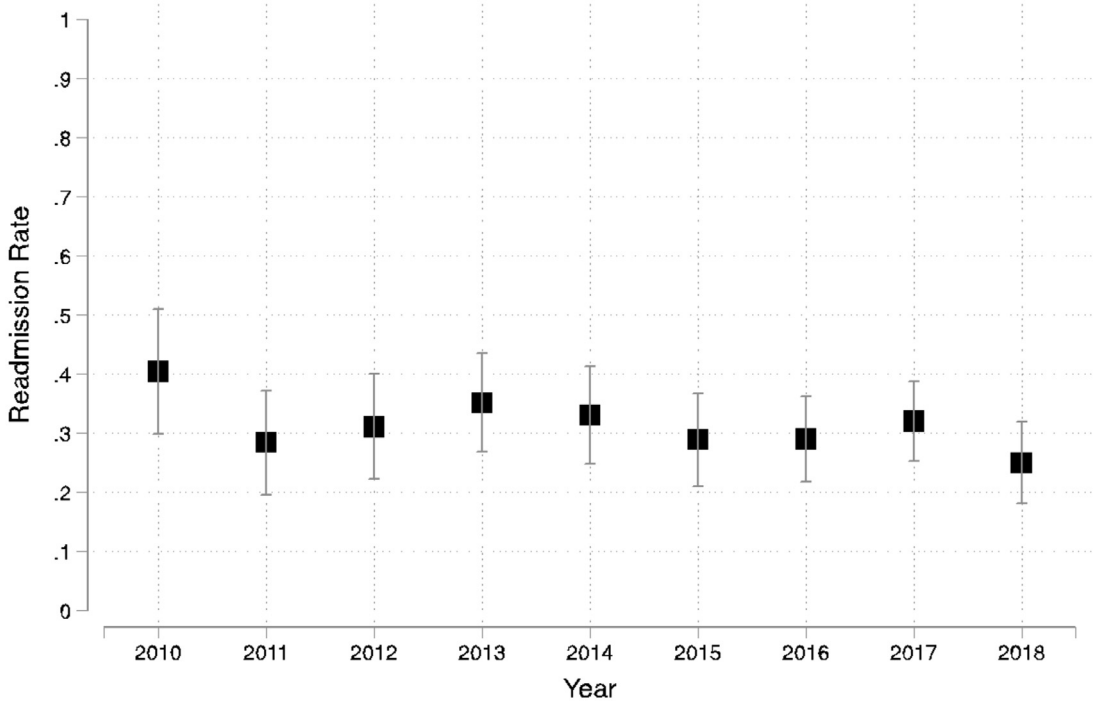

Fig. 1. Readmission rates by year.

Table 3
Factors affecting the likelihood of readmission after liver transplantation.

Variable	Odds Ratio	95% Confidence Lower	Upper	*p* value
Age				
18–49	Reference			
50–59	0.93	0.64	1.34	0.683
60+	0.66	0.45	0.98	0.038
Sex (male)	1.34	1.00	1.78	0.047
Race/Ethnicity				
White, Non-Hispanic	Reference			
Black, Non-Hispanic	1.21	0.82	1.80	0.34
Hispanic	1.05	0.51	2.17	0.899
Other	1.75	1.07	2.86	0.027
Reason for Transplant				
Neoplasm	Reference			
Chronic liver disease	0.72	0.43	1.20	0.206
Cirrhosis	0.87	0.60	1.25	0.443
Hepatitis	1.04	0.71	1.54	0.826
Other	0.91	0.58	1.43	0.671
Payer				
Commercial	Reference			
Medicare	1.10	0.82	1.48	0.538
Medicaid	0.58	0.39	0.88	0.011
Other	0.90	0.36	2.30	0.83
Admission type				
Elective	Reference			
Urgent	1.16	0.79	1.72	0.443
Emergent	0.72	0.47	1.08	0.115
Transfer (yes)	1.13	0.66	1.93	0.667
Surgeon volume				
High (10+)	Reference			
Medium (5–9)	1.14	0.76	1.72	0.522
Low (<5)	1.08	0.73	1.60	0.696
Hospital volume				
High (40+)	Reference			
Medium (20–39)	0.91	0.55	1.49	0.696
Low (0–19)	0.75	0.51	1.11	0.151
Surgical complications (yes)	1.04	0.78	1.39	0.786
Discharge destination				
Home	Reference			
Home to home health	1.33	0.96	1.84	0.087
Skilled nursing facility	1.51	0.89	2.56	0.127
Total comorbidities	1.05	0.94	1.17	0.414
Length of stay	1.01	1.00	1.02	0.078

while non-readmitted patients stayed an average of 14 days, accounting for a difference of only 3 days.

Results of the multivariable linear regression model of factors affecting LOS after LT are presented in Table 4. Patients receiving a transplant for cirrhosis spent nearly two days longer (1.94 days, $P = 0.048$), and patients with other etiology of disease had a LOS that was over a week longer (7.02 days, $P < 0.0001$), than patients receiving transplant for cancer. Patients who were transferred from another facility stayed an additional 4.52 days in the hospital ($P = 0.003$) compared to patients who were not transferred. Patients treated by medium volume (5–9 cases per year) surgeons had a shorter hospital stay of 4.59 days ($P < 0.0001$) compared to patients treated by high volume (10+ cases per year) surgeons. Patients who had a surgical complication required an additional 3.82 days in the hospital ($P < 0.0001$) compared to patients who did not have a surgical complication. Patients discharged home with home health incurred an additional 2.38 days ($P = 0.005$) while patients discharged to a skilled nursing facility incurred an additional 14.83 days ($P < 0.0001$) compared to patients who were discharged home.

Discussion

This study of patients undergoing LT in Pennsylvania found that 30-day readmission and LOS were significantly associated with a number of patient, disease, and hospital characteristics. Readmitted patients were more likely to be younger than 60, female, have had a longer LOS, have been discharged to a skilled nursing facility, and have a diagnosis of renal disease. Longer LOS was associated with patients who had an emergent admission, were transferred from another acute care facility, had a surgical complication, and who were discharged to a skilled nursing facility. We also found that age, hospital volume, and comorbidities were associated with longer LOS.

Readmission within 30 days is an important measure of quality since it reflects the quality of the transition between inpatient and outpatient status [8, 9]. In this study, the overall 30-day readmission rate for LT (31.1%) was consistent with prior studies. Mumtaz et al., using the

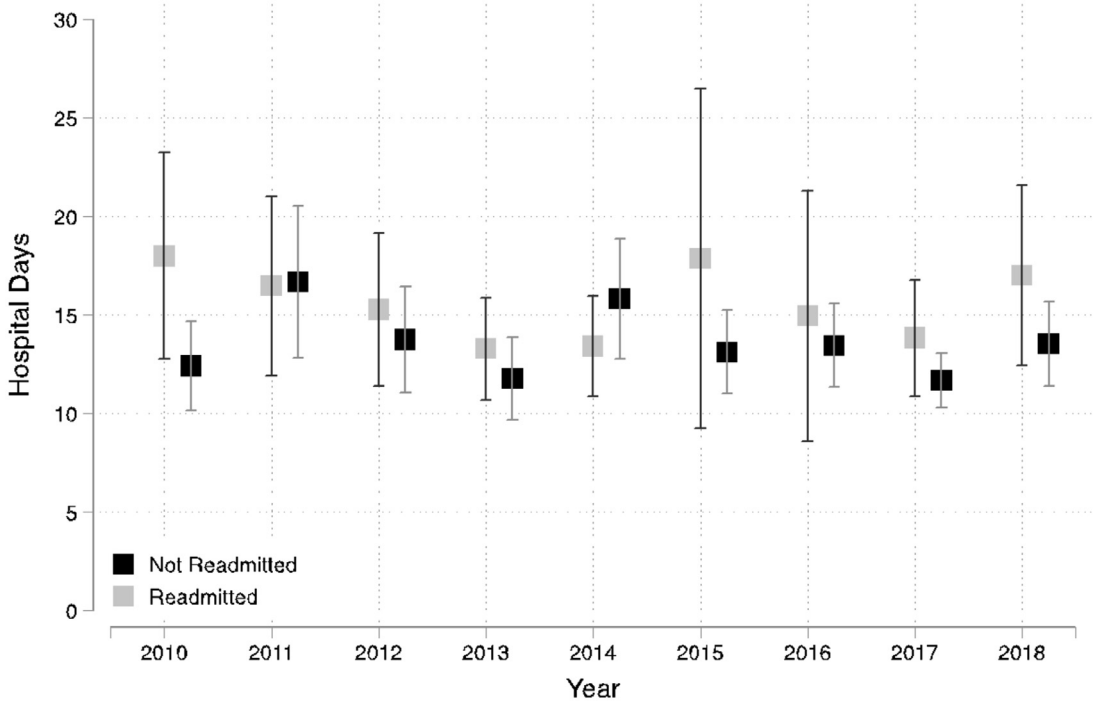

Fig. 2. Average length of stay stratified by readmission status.

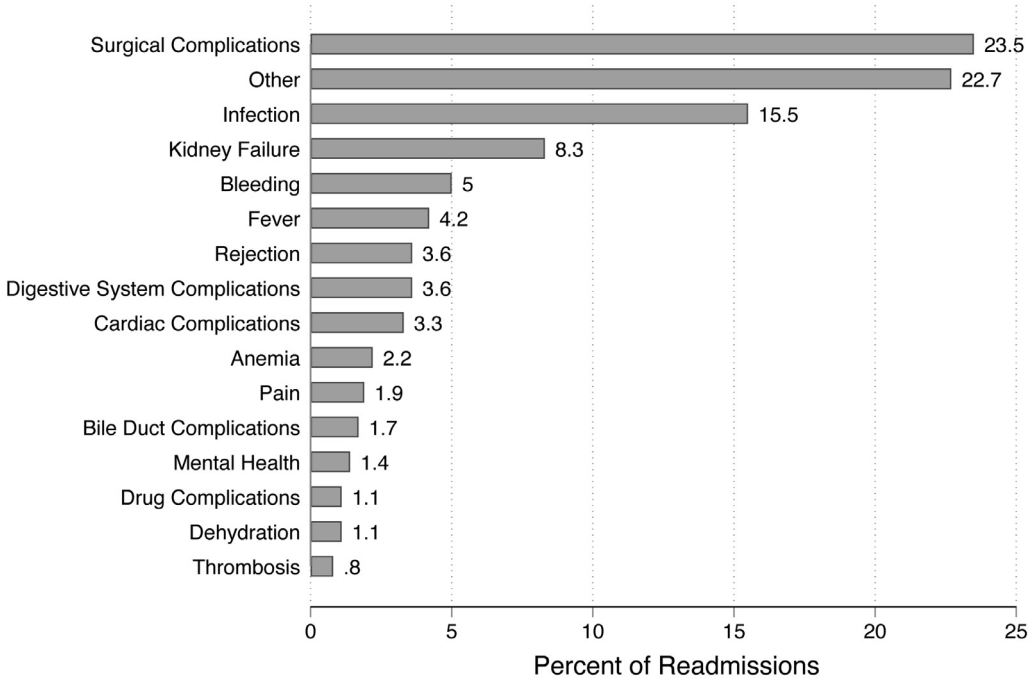

Fig. 3. Reasons for readmission.

Table 4
Multivariable model of factors affecting length of stay after liver transplantation.

Variable	Coefficient	95% Confidence Lower	95% Confidence Upper	*p* value
Age				
18–49	Reference			
50–59	−0.11	−2.08	1.86	0.912
60+	−1.03	−3.09	1.04	0.33
Sex (male)	1.05	−0.51	2.61	0.186
Race/Ethnicity				
White, Non-Hispanic	Reference			
Black, Non-Hispanic	1.56	−0.54	3.66	0.145
Hispanic	1.24	−2.80	5.28	0.548
Other	0.22	−2.50	2.93	0.877
Reason for Transplant				
Neoplasm	Reference			
Chronic liver disease	2.53	−0.09	5.16	0.058
Cirrhosis	1.94	0.01	3.86	0.048
Hepatitis	1.46	−0.62	3.54	0.169
Other	7.02	4.62	9.42	<0.0001
Payer				
Commercial	Reference			
Medicare	0.61	−0.98	2.19	0.453
Medicaid	0.85	−1.21	2.90	0.42
Other	−0.25	−5.08	4.57	0.918
Admission type				
Elective	Reference			
Urgent	−1.05	−3.14	1.04	0.325
Emergent	0.85	−1.33	3.04	0.444
Transfer (yes)	4.52	1.57	7.47	0.003
Surgeon volume				
High (10+)	Reference			
Medium (5–9)	−4.59	−6.73	−2.45	<0.0001
Low (<5)	−1.67	−3.74	0.41	0.115
Hospital volume				
High (40+)	Reference			
Medium (20–39)	−2.49	−5.08	0.09	0.059
Low (0–19)	1.48	−0.52	3.48	0.147
Surgical complications (yes)	3.82	2.28	5.36	<0.0001
Discharge destination				
Home	Reference			
Home to home health	2.38	0.71	4.06	0.005
Skilled nursing facility	14.83	12.09	17.58	<0.0001
Total comorbidities	−0.46	−1.06	0.14	0.132
Intercept	11.94	7.64	16.25	<0.0001

Nationwide Readmissions Database (NRD) to estimate 30-day readmission among LT recipients, estimates a 30-days readmission rate of 30.6% [8]. Similarly, Kothari et al., who studied inpatient rehabilitation after LT, found a 30-day readmission rate of 29.6% [10]. Pereira et al. examined clinical predictors of 30-day readmission for patients undergoing orthotopic LT and found a higher 30-day readmission of 45% [9]. The difference in readmission rates could be explained by differences in patient, disease, and hospital characteristics [8, 11-13].

Risk factors for readmission among patients undergoing LT have been found in previous studies [8, 11-13]. In our study, advanced age was significantly associated with lower risk of readmission. This finding was also reported by Mumtaz et al., who reported advanced age to be protective against readmission [8]. Additionally, Patel et al. found that readmission rate fell by 3% for each on-year increase in patient age [11]. In this study, men had 26% lower odds of being readmitted at 30 days relative to women, which differs somewhat from other studies. For example, Franchi et al. found no significant association between readmission within 3 months and sex [13]. In addition, Chen et al. and Shankar et al. have reported me to have 14% or 25% greater risk of being readmitted within the first year or 90 days after LT [11, 12]. It is possible that the difference between our result and prior studies is the time windows for readmission, and male sex may be a risk factor for early readmission but not later readmission.

Associations were found between risk of 30-day readmission and the patient's primary payer. Specifically, patients covered by Medicaid had lower risk of 30-day readmission. However, another study conducted by Mumtaz et al. reported that patients with Medicaid had 28% higher odds of readmission within 30 days, while Medicare patients had 21% greater odds, compared to patients covered by commercial payers [8]. Discharge destination has been found to be associated with risk of readmission in multiple studies, including this study. Acharya et al. showed that discharge to skilled nursing facilities significantly raises the risk of 30-day readmission [14]. Initial LOS has also been found to be significantly associated with risk of readmission [15–18].

The most common causes of 30-day readmission after LT were surgical complications, infection, kidney failure, bleeding, and fever. Previous studies have found different distributions of these causes, but surgical complications and infection were very common causes of readmission in other studies, as well [5, 12].

This study was limited by the administrative nature of the data set. First, there are several clinical variables that were not available and that we could not control for. For example, we were not able to determine whether rejection episodes were associated with readmission, or to estimate associations with MELD scores or other factors that have been identified as predictive of readmission [12]. Second, because the data are not longitudinal, we were not able to link the readmission episode with downstream outcomes, such as survival and graft survival [9]. Third, we are only able to estimate the relationship between total days for the index admission and risk of subsequent readmission within 30 days, and not whether pre-transplant LOS has a different association than post-transplant LOS. Fourth, although Pennsylvania has many features in common with other states, our results may not be generalizable to other states or to the rest of the country.

Conclusion

Several patient and care process variable are associated with 30-day readmission and LOS in patients receiving LT in Pennsylvania. Although readmission rates and LOS have both declined over the past few years, surgical complications were still the most common cause of readmissions after LT followed by infections and kidney failure. These findings should inform healthcare providers as they consider approaches to reduce readmissions and improve outcomes for LT.

Disclaimer

The Pennsylvania Health Care Cost Containment Council (PHC4) is an independent state agency responsible for addressing the problem of escalating health costs, ensuring the quality of health care, and increasing access to health care for all citizens regardless of ability to pay. PHC4 has provided data to Penn State College of Medicine in an effort to further PHC4's mission of educating the public and containing health care costs in Pennsylvania. PHC4, its agents, and staff, have made no representation, guarantee or warranty, expressed or implied, that the data - financial, patient, payor and physician specific information - provided, are error-free, or that the use of the data will avoid differences of opinion or interpretation. This analysis was not prepared by PHC4. This analysis was done by the authors. PHC4, its agents and staff, bear no responsibility or liability for the results of the analysis, which are solely the opinion of the authors.

Declaration of competing interest

The authors declare having no competing interests in link with this article.

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