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Change in Health Insurance Coverage After Liver Transplantation Can Be Associated with Worse Outcomes

Clifford Akateh^{1,2,9}, Dmitry Tumin^{6,8}, Eliza W. Beal^{1,2}, Khalid Mumtaz³, Joseph D. Tobias^{6,7}, Don Hayes Jr.^{4,5,8}, and Sylvester M. Black²

¹Division of General and Gastrointestinal Surgery, Department of Surgery, Ohio State University Wexner Medical Center, Columbus, OH 43210, USA

²Division of Transplantation, Department of Surgery, Ohio State University Wexner Medical Center, Columbus, OH 43210, USA

³Division of Gastroenterology, Hepatology and Nutrition, Department of Internal Medicine, Ohio State University Wexner Medical Center, Columbus, OH 43210, USA

⁴Division of Pulmonary, Allergy, Critical Care and Sleep Medicine, Department of Internal Medicine, Ohio State University Wexner Medical Center, Columbus, OH 43210, USA

⁵Section of Pulmonary Medicine, Department of Pediatrics, Nationwide Children's Hospital, Columbus, OH 43205, USA

⁶Department of Anesthesiology and Pain Medicine, Nationwide Children's Hospital, Columbus, OH 43205, USA

⁷Department of Anesthesiology and Pain Medicine, Ohio State University Wexner Medical Center, Columbus, OH 43205, USA

⁸Department of Pediatrics, Ohio State University College of Medicine, Columbus, OH 43210, USA

⁹Ohio State University Wexner Medical Center - Faculty Tower, 395 W 12th Ave, Room 654, Columbus, OH 43210-1267, USA

Abstract

Background—Health insurance coverage changes for many patients after liver transplantation, but the implications of this change on long-term outcomes are unclear.

Aims—To assess post-transplant patient and graft survival according to change in insurance coverage within 1 year of transplantation.

Correspondence to: Clifford Akateh.

Conflict of interest The authors declare that they have no conflict of interest.

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Methods—We queried the United Network for Organ Sharing for patients between ages 18–64 years undergoing liver transplantation in 2002–2016. Patients surviving > 1 year were categorized by insurance coverage at transplantation and the 1-year transplant anniversary. Multivariable Cox regression characterized the association between coverage pattern and long-term patient or graft survival.

Results—Among 34,487 patients in the analysis, insurance coverage patterns included continuous private coverage (58%), continuous public coverage (29%), private to public transition (8%) and public to private transition (4%). In multivariable analysis of patient survival, continuous public insurance (HR 1.29, CI 1.22, 1.37, $p < 0.001$), private to public transition (HR 1.17, CI 1.07, 1.28, $p < 0.001$), and public to private transition (HR 1.14, CI 1.00, 1.29, $p = 0.044$), were associated with greater mortality hazard, compared to continuous private coverage. After disaggregating public coverage by source, mortality hazard was highest for patients transitioning from private insurance to Medicaid (HR vs. continuous private coverage = 1.32; 95% CI 1.14, 1.52; $p < 0.001$). Similar differences by insurance category were found for death-censored graft failure.

Conclusion—Post-transplant transition to public insurance coverage is associated with higher risk of adverse outcomes when compared to retaining private coverage.

Keywords

Liver transplantation; Graft survival; Human; Medicaid; Survival; Insurance

Introduction

Liver transplantation (LT) is indicated for eligible patients with end-stage liver disease (ESLD), yet access to LT remains limited by the shortage of donor organs, barriers to timely diagnosis of ESLD and referral for evaluation, and significant financial burden of lifetime post-transplant care [1–6]. In the United States (US), means-tested Medicaid public insurance supports access to LT among low-income patients with ESLD, whereas Medicare public insurance supports LT access for both elderly and disabled patients [7]. Yet, public insurance coverage—particularly Medicaid coverage—has been persistently associated with increased risk of graft failure and lower patient survival after LT [8–10]. The association between public insurance coverage and worse LT outcomes has been partially attributed to higher disease severity at time of transplant (MELD) and longer wait time to transplant [9, 11–13]. Patients with public insurance also tend to have lower educational attainment and less social support, both of which are associated with adverse health outcomes [8, 14]. Nevertheless, disparities in LT outcomes persist for Medicaid and Medicare patients even after adjusting for other risk factors such as age and creatinine, as well as other measures of socioeconomic status (income and education) and transplant-related factors such as center expertise [8].

In recent years, expansions of Medicaid eligibility related to the Patient Protection and Affordable Care Act (ACA) have fostered greater Medicaid participation among LT candidates, as well as LT recipients who had previously been covered by private insurance [15, 16]. Increasing public insurance enrollment after LT compounds a pattern previously

noted in a single-center survey, where up to 52% of patients changed insurance after LT [17]. The frequent instability of insurance coverage after LT, and especially the incidence of private to public change in coverage, has led to the question of whether post-LT change in insurance is independently associated with long-term outcomes [18]. In other populations of organ transplant recipients, change from private to public insurance has been associated with increased mortality hazard [19], yet the applicability of these findings to the setting of LT is unclear. Therefore, we have used the US national transplant registry to test the hypothesis that early change from private to public insurance after LT is associated with lower patient and graft survival during long-term follow-up.

Methods

The study was deemed exempt from review by the local Institutional Review Board. Data were obtained from the United Network for Organ Sharing (UNOS), including follow-up through March 2017. First-time adult (age ≥ 18) recipients of orthotopic LT were included if they had undergone deceased donor LT alone between February 2002 and March 2016, to allow for at least 1 year of follow-up on insurance status, described below. Patients older than 64 at the time of LT were excluded, as universal Medicare coverage at ages 65 and older likely confounds any influences of change in insurance coverage past this age. To focus on long-term outcomes of LT, patients who died or experienced graft failure before the first transplant anniversary were excluded. Patients with missing data on study outcomes and patients without insurance follow-up data at the first transplant anniversary (described further below) were also excluded. Due to few LT being performed in patients with insurance other than private coverage, Medicaid, or Medicare, we excluded patients if they reported any coverage by other payors at the time of LT or on the first LT anniversary. Lastly, we excluded patients whose state of residence at the time of LT could not be determined, as we could not categorize these patients according to state participation in Medicaid expansion. The primary study outcomes were patient and graft survival conditional on survival to 1 year post-transplant.

Data on insurance coverage were mandatorily reported by transplant centers at the time of LT and at the first transplant anniversary [2]. We categorized patients according to their insurance coverage at the time of transplant and at the 1-year follow-up as: (1) continuous private, (2) continuous public, (3) private to public, and (4) public to private. To distinguish between Medicaid and Medicare, supplemental analyses differentiated among patients in categories (2) and (3) by their type of public insurance at the 1-year transplant anniversary (e.g., private-to-Medicaid change vs. private-to-Medicare change). Univariate Cox and Kaplan–Meier analyses were performed to characterize the association between insurance coverage change or continuity and long-term patient and graft survival. A sub-analysis was performed for patients in states with expanded Medicaid coverage [20], whose first LT anniversary fell on or after January 2014, when ACA was fully implemented (i.e., LT performed January 2013–March 2016).

Descriptive analysis using ANOVA and Chi-square tests was performed to characterize differences in potential confounders among categories of health insurance coverage. Covariates in the analysis included recipient age, gender, race, educational attainment, work

participation, ABO blood type, body mass index (BMI), laboratory MELD score at time of transplant, indication for LT, history of diabetes, dialysis, transjugular intrahepatic portosystemic shunt (TIPSS), previous abdominal surgery, ascites, and portal vein thrombosis. Additionally, we adjusted for donor risk index (DRI), dichotomized with DRI > 1.9 representing high-risk donors; [21, 22] total center volume of LT over the study period; postoperative hospital length of stay (LOS); year of LT; residence in a state that expanded Medicaid eligibility; and UNOS region where patients had undergone LT. In a supplemental analysis, we examined whether the association between insurance coverage pattern and study outcomes varied according to UNOS region.

Multivariable Cox proportional hazards models were fitted for the study outcomes to examine confounding of the association between insurance coverage and LT outcomes. Multiple imputation using chained equations was used to complete missing data for multivariable analysis. Categorical variables were imputed using multinomial logistic regression models, and continuous variables were imputed using linear regression models. Independent variables in imputation models included study outcomes of patient and graft survival (including time to death or graft failure), in addition to all study covariates. Ten imputed data sets were created, and estimates were combined across imputations as previously described [23, 24].

Results

There were 59,026 adults ages 18–64 receiving first-time isolated LT during the study period, of whom 7635 were excluded due to death or graft failure within 1 year of transplant, 12,163 were excluded due to lack of follow-up data on insurance coverage at 1 year post-transplant, 3009 were excluded due to unknown or ineligible location of residence at the time of transplant, and 1732 were excluded due to an uncommon type of insurance coverage at transplant or the 1-year anniversary. The final sample included 34,487 patients, of whom 4188 comprised the Medicaid expansion subgroup (underwent LT in a state that expanded Medicaid eligibility, with 1-year transplant anniversary in 2014 or later). In the overall cohort, the most common type of insurance coverage was continuous private coverage (58%), followed by continuous public coverage (29%), private to public change in coverage (8%), and public to private change in coverage (4%).

Patient, donor, procedure, and center characteristics were compared across categories of insurance coverage in Table 1. (Descriptive statistics according to a more detailed classification of public insurance types are presented in Supplemental Table 1). Compared to patients with continuous private insurance, those who switched from private to public insurance were distinguished by higher unemployment, lower educational attainment, greater prevalence of diabetes, longer post-transplant LOS, and greater likelihood of residence in a Medicaid expansion state. Whereas Table 1 shows the proportion of patients from each region in a given category of insurance coverage (column percentage), we also calculated the proportion of each coverage type by UNOS region (row percentage) to determine which regions had the highest rates of private to public insurance change. This change in coverage was most common in Region 1 (104/1208; 9%), Region 2 (396/3488;

11%), Region 3 (618/5754; 11%), and Region 9 (288/2337; 12%), representing New England, the Mid-Atlantic, and the Southeastern US.

In univariate analysis of patient survival, outcomes significantly differed across patterns of insurance coverage (Fig. 1; log-rank test $p < 0.001$), with the highest mortality hazard seen among patients with continuous public insurance (HR relative to continuous private insurance = 1.40; 95% CI 1.33, 1.48; $p < 0.001$), followed by change from private to public insurance (HR 1.30; 95% CI 1.19, 1.41; $p < 0.001$) and change from public to private insurance (HR 1.23; 95% CI 1.09, 1.39; $p = 0.001$). We observed similar differences in graft survival across these insurance categories (Supplemental Fig. 1; log-rank $p < 0.001$), with the highest hazard of graft failure seen among patients with continuous public insurance (HR 1.32; 95% CI 1.25, 1.39; $p < 0.001$), followed by private to public change (HR 1.27; 95% CI 1.17, 1.38; $p < 0.001$) and public to private change (HR 1.25; 95% CI 1.11, 1.41; $p < 0.001$). In the Medicaid expansion subgroup, the increased hazard of mortality and graft failure among patients switching from private to public insurance did not reach statistical significance on univariate analysis (mortality HR 1.39; 95% CI 0.89, 2.15; $p = 0.147$; graft failure HR 1.48; 95% CI 0.96, 2.29; $p = 0.077$).

Results from multivariable analysis of patient survival using multiply imputed data are summarized in Table 2. Continuous public insurance, transition from private to public coverage, and transition from public to private coverage all remained associated with greater mortality hazard when compared to continuous private insurance. When disaggregating coverage according to public insurance type (Supplemental Table 2), a higher mortality hazard was associated with transition from private to Medicaid insurance (HR 1.32; 95% CI 1.14, 1.52; $p < 0.001$), continuous Medicaid coverage (HR 1.31; 95% CI 1.21, 1.42; $p < 0.001$), and continuous Medicare coverage (HR 1.28; 95% CI 1.20, 1.37; $p < 0.001$). In region-specific analysis, the association between private to public change and greater mortality hazard only reached statistical significance in Region 3 (Supplemental Table 3, although in 5 of the 11 regions, the magnitude of this association exceeded the HR estimated for the national cohort.

After adjustment for coverage type, college completion and pre-transplant employment remained associated with improved post-transplant survival, while Black race was associated with greater mortality hazard (Table 2). Similarly to the findings for patient survival, the hazard of graft failure remained elevated among patients with continuous public insurance or change between private and public insurance after multivariable adjustment (Table 3). When disaggregating HRs for graft failure according to public insurance type (Supplemental Table 2), transition from private insurance to Medicaid was associated with the highest hazard of graft failure (HR 1.33; 95% CI 1.16, 1.53; $p < 0.001$), compared to HRs of 1.23 (95% CI 1.14, 1.32) and 1.23 (95% CI 1.15, 1.32) for continuous Medicaid and continuous Medicare coverage, respectively.

Discussion

Patterns of discontinuous insurance coverage are emerging as important predictors of surgical outcomes, particularly in the setting of solid organ transplantation [19], where

survival depends on maintaining a costly regimen of immunosuppression and specialized follow-up care. In the context of LT, recent reports highlighting increased public insurance participation tied to the ACA Medicaid expansion have raised the question whether changes from private to public coverage among LT recipients would influence clinical outcomes in this population [15, 16]. Our study demonstrates that in a national cohort of LT recipients, transition from private to public insurance after LT is associated with worse long-term outcomes after accounting for recipient, donor, and transplant center characteristics. Particularly, transition from private insurance to Medicaid was associated with elevated hazards of mortality and graft failure. Although existing data remain insufficient to confirm this pattern specifically among LT recipients affected by ACA Medicaid expansion, our results suggest that protecting continuity of coverage for LT recipients with private insurance may be important for improving outcomes in this group.

Many explanations have been advanced as to why patients with public insurance have worse survival after solid organ transplantation. Public insurance (Medicare and Medicaid) has been associated with limited access to specialty care, including access to gastroenterology and liver transplantation [3, 12, 25, 26]. Additionally, Medicaid beneficiaries face restrictions in access to more expensive medications and therapies, such as antivirals for hepatitis C [27, 28]. This is concerning as hepatitis C is a leading cause of graft loss post-liver transplant [29]. Medicaid insurance may also be a surrogate for lower socioeconomic status, and a transition to Medicaid may be associated with financial hardship due to losing a job that previously provided employer-sponsored coverage. Below age 65, transition to Medicare may also be associated with onset of disability. Above age 65, however, transition to Medicare is typically related to age-based eligibility. Therefore, our results are unlikely to be generalizable to changes in insurance coverage among patients age 65 years or older.

As many LT recipients experience loss of employment after transplant [30], so, too, many report switching insurance coverage after transplantation. In a survey by Rongey et al. 34% of respondents reported having switched health insurance post-transplant, with 19% of the respondents losing or being denied insurance at some point [17]. With expanded Medicaid eligibility in participating states after ACA implementation, our group has previously noted increasing likelihood of LT recipients to switch from private to public insurance [16]. The clinical implications of this change in coverage are controversial [18], but our present study provides some evidence that keeping private coverage is preferable to switching to Medicaid insurance with respect to long-term LT outcomes. Indeed, our analysis may have underestimated the impact of private coverage loss, as it did not capture any early (< 1 year) mortality or graft failure attributable to such changes in coverage. Yet, our sub-analysis of patients specifically affected by ACA Medicaid expansion was underpowered to confirm these findings in the particular context of private-to-Medicaid change in coverage after this policy was implemented.

A growing literature has described how implementation of the ACA has increased access to surgical care by previously uninsured patients [31–35]. However, the consequences of the ACA Medicaid expansion for surgical outcomes remain unclear. Charles et al. reported a decreased risk of morbidity and mortality after cardiac surgery in Michigan Medicaid patients after the ACA Medicaid expansion [32]. However, in a 2015 survey, members of the

American College of Surgeons (ACS) Board of Governors observed that after ACA implementation, a higher percentage of patients were delaying elective surgery and presenting at a later stage of disease [33]. This was believed to be due to increased premiums among some of the participants. In the context of LT, Medicaid expansion increased the number of LT candidates using Medicaid as the primary payment type for transplant [15], as well as the number of LT recipients switching to Medicaid coverage post-transplant [16]. Our results suggest that such changes are associated with worse outcomes, relative to keeping private coverage. The reasons why patients change insurance after transplant are complex, and driven by changes in labor markets, as well as patients' health, level of education, income, location and overall socioeconomic status. Yet, given our findings, interventions that mitigate the risk of losing private coverage after LT may be warranted.

Racial and socioeconomic disparities in surgical outcomes are well documented [36–40] but the mechanisms underlying these disparities are poorly understood. Various facets of socioeconomic status have been examined in surgical outcomes research, including insurance coverage, race, educational attainment, and ZIP code or county characteristics. LT recipients represent a unique cohort of surgical patients, insofar as patients presenting for LT are required to have proof of insurance prior to listing and transplantation, and transplant patients tend to be located near a transplant center. The uninsured rate among transplant patients is about 1–2% [41], much lower than the general population [42]. Because outright lack of insurance is relatively rare among LT recipients, continuity and change in insurance coverage may be especially informative in this population. In our analysis of mortality, the HR associated with change from private to Medicaid insurance (1.32) is almost as large as the (adjusted) Black-White disparity (HR 1.35), and exceeds adjusted HRs of high DRI (1.23) and dialysis (1.28). Notwithstanding prior evidence that public coverage at transplantation is associated with worse outcomes, this result indicates that adjusting surgical quality metrics for insurance coverage at a single point in time is inherently problematic, due to the lack of information on subsequent continuity or change of coverage.

Our conclusions are constrained by some limitations of the data and analysis. Most of the insurance transitions examined in this study occurred prior to the ACA Medicaid expansion. Due to limited data in the post-Medicaid expansion period, there were too few cases of death or graft failure in this period to confirm or refute the patterns found on multivariable analysis of the overall study cohort. Similarly, outside of Region 3, which accounted for the most patients in our cohort, our UNOS region sub-analysis may have been underpowered to confirm region-specific associations between private to public change in coverage and higher mortality hazard. Nevertheless, our results suggest that the impact of private insurance loss may vary across geographical areas, and could be highest where such change in coverage is especially common. As previously noted, UNOS data on LT only includes patients who have been listed for transplant, meaning that some disparities in access to care, including disparities addressed by the ACA, could not be adequately evaluated in this data set. Additionally, our focus on Medicaid expansion participation potentially underestimates state variability in outcomes as it may relate to long-standing differences in health care provision, public insurance eligibility criteria, or other relevant factors. Lastly, our analysis may have been biased by incorrectly entered data, exclusion of patients who were lost to

follow-up within 1 year, or unobserved confounders that could have accounted for the associations between discontinuous insurance coverage and poor long-term outcomes.

In summary, transition from private to public insurance after LT was associated with worse long-term outcomes when compared to retaining private insurance coverage. Among patients who had a change from private to public insurance coverage, transition to Medicaid was associated with especially high hazards of mortality and graft failure. Transition to Medicaid participation after LT is common and related to high rates of post-transplant unemployment, as well as recent policies expanding Medicaid eligibility. As the debate on reforming the health care system continues, policies to help transplant recipients maintain appropriate insurance coverage should be considered. In the interim, it is important for clinicians to recognize post-transplant insurance changes as a significant risk factor for graft failure and mortality, and take steps to mitigate this risk, such as closer surveillance and early referral to social work for help with finding and maintaining appropriate insurance.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Abbreviations

LT	Liver transplantation
ESLD	End-stage liver disease
MELD	Model for end-stage liver disease
ACA	Patient Protection and Affordable Care Act
US	United States of America
UNOS	United Network for Organ Sharing
ANOVA	Analysis of variance
TIPSS	Transjugular intrahepatic portosystemic shunt
DRI	Donor risk index
LOS	Length of stay
HR	Hazard ratios
CI	Confidence interval
ACS	American College of Surgeons

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Number at risk				
Continuous private insurance	20075	14623	10270	6508
Transition to private insurance	1375	955	649	393
Continuous public insurance	10128	6900	4546	2645
Transition to public insurance	2909	1981	1324	808

Fig. 1.

Kaplan–Meier curves of patient survival by insurance trajectory 1 year after Liver transplantation (N = 34,487)

Table 1

Liver transplant recipient and donor characteristics, by insurance trajectory (public insurance types combined), for patients surviving at least 1 year post-transplant (n, %, or mean, standard deviation)

Covariate	Missing data	Continuous private insurance (N = 20,075)	Continuous public insurance (N = 10,128)	Transition from private to public insurance (N = 2909)	Transition from public to private insurance (N = 1375)	P value [*]
Age ^a (y)	0	52 (9)	52 (9)	54 (10)	51 (10)	< 0.001
Male gender	0	13,989 (70%)	6483 (64%)	1971 (68%)	955 (69%)	< 0.001
Race	0	–	–	–	–	< 0.001
White		15,506 (77%)	6466 (64%)	2135 (73%)	933 (68%)	
Black		1641 (8%)	1143 (11%)	310 (11%)	153 (11%)	
Other		2928 (15%)	2519 (25%)	464 (16%)	289 (21%)	
Education	4571	–	–	–	–	< 0.001
High school or less		7508 (43%)	6010 (68%)	1350 (55%)	756 (63%)	
Some college		4741 (27%)	1853 (21%)	632 (26%)	275 (23%)	
College degree		5188 (30%)	967 (11%)	467 (19%)	169 (14%)	
Employed	831	8255 (42%)	591 (6%)	599 (21%)	142 (11%)	< 0.001
BMI ^a (kg/m ²)	9	28 (6)	29 (6)	29 (6)	29 (6)	< 0.001
ABO blood type	0	–	–	–	–	0.006
A		7573 (38%)	3641 (36%)	1057 (36%)	508 (37%)	
B		2668 (13%)	1361 (13%)	393 (14%)	179 (13%)	
AB		1035 (5%)	469 (5%)	134 (5%)	86 (6%)	
O		8799 (44%)	4657 (46%)	1325 (46%)	602 (44%)	
MELD score at transplant ^a	37	21 (10)	22 (10)	22 (10)	23 (10)	< 0.001
Etiology of liver failure	0	–	–	–	–	< 0.001
Viral		4683 (23%)	2977 (29%)	770 (26%)	416 (30%)	
Cryptogenic		978 (5%)	424 (4%)	135 (5%)	65 (5%)	
Autoimmune		2265 (11%)	742 (7%)	234 (8%)	96 (7%)	
NASH		1331 (7%)	510 (5%)	206 (7%)	71 (5%)	
Alcoholic		3381 (17%)	2118 (21%)	527 (18%)	272 (20%)	
HCC		4554 (23%)	2298 (23%)	661 (23%)	293 (21%)	

Covariate	Missing data	Continuous private insurance (N = 20,075)	Continuous public insurance (N = 10,128)	Transition from private to public insurance (N = 2909)	Transition from public to private insurance (N = 1375)	P value [*]
Other		2883 (14%)	1059 (10%)	376 (13%)	162 (12%)	
Comorbid conditions	–	–	–	–	–	–
Diabetes	405	4110 (21%)	2410 (24%)	719 (25%)	320 (24%)	< 0.001
Dialysis	0	1590 (8%)	889 (9%)	241 (8%)	128 (9%)	0.034
TIPSS	201	1736 (9%)	1333 (13%)	331 (11%)	135 (10%)	< 0.001
Previous abdominal surgery	154	9096 (45%)	4865 (48%)	1410 (49%)	613 (45%)	< 0.001
Ascites	287	14,681 (74%)	8089 (80%)	2230 (77%)	1116 (82%)	< 0.001
Portal vein thrombosis	637	1509 (8%)	963 (10%)	268 (9%)	127 (9%)	< 0.001
DRI > 1.9	1785	8944 (47%)	4646 (49%)	1371 (49%)	610 (47%)	0.013
Center total LT volume ^a (×100 cases)	0	11.7 (6)	10.5 (6)	11.8 (6)	11.9 (6)	< 0.001
Postop LOS ^a (days)	37	13 (17)	15 (18)	16 (22)	15 (17)	< 0.001
Transplant year ^a	0	2009 (3)	2009 (3)	2009 (3)	2009 (3)	0.240
Resident in a Medicaid expansion state	0	11,297 (56%)	6010 (59%)	1766 (61%)	846 (62%)	< 0.001
UNOS/OPTN region	0					< 0.001
1		632 (3%)	422 (4%)	104 (4%)	50 (4%)	
2		1997 (10%)	890 (9%)	396 (14%)	205 (15%)	
3		3265 (16%)	1670 (16%)	618 (21%)	201 (15%)	
4		2198 (11%)	884 (9%)	198 (7%)	101 (7%)	
5		2672 (13%)	1612 (16%)	341 (12%)	203 (15%)	
6		689 (3%)	306 (3%)	82 (3%)	45 (3%)	
7		1606 (8%)	850 (8%)	204 (7%)	76 (6%)	
8		1590 (8%)	790 (8%)	189 (7%)	86 (6%)	
9		1255 (6%)	706 (7%)	288 (8%)	88 (6%)	
10		2001 (10%)	946 (9%)	342 (12%)	116 (8%)	
11		2170 (11%)	1052 (10%)	207 (7%)	204 (15%)	

BMi body mass index, *MELD* model for end-stage liver disease, *NASH* nonalcoholic steatohepatitis, *HCC* hepatocellular carcinoma, *TIPSS* transjugular intrahepatic portosystemic shunt, *DRI* donor risk index, *LT* liver transplant *LOS* length of stay

^{*} P-value by ANOVA for continuous variables and Chi-square test for categorical variables

^a Mean and standard deviation

Table 2

Multivariable Cox proportional hazards model of long-term patient survival after liver transplantation, conditional on survival to 1 year (N = 34,487)

Covariate	HR	95% CI	P
Continuous private insurance	Ref.	–	–
Continuous public insurance	1.29	(1.22, 1.37)	< 0.001
Transition from private to public insurance	1.17	(1.07, 1.28)	< 0.001
Transition from public to private insurance	1.14	(1.00, 1.29)	0.044
Age (years)	1.01	(1.00, 1.01)	< 0.001
Male	1.12	(1.06, 1.18)	< 0.001
Race	–	–	–
White	Ref.	–	–
Black	1.36	(1.25, 1.47)	< 0.001
Other	0.76	(0.71, 0.82)	< 0.001
Education	–	–	–
High school or less	Ref.	–	–
Some college	0.97	(0.90, 1.04)	0.358
College degree	0.89	(0.83, 0.96)	0.003
Employed	0.88	(0.83, 0.94)	< 0.001
BMI (kg/m ²)	1.00	(0.99, 1.00)	0.072
ABO blood type	–	–	–
A	Ref.	–	–
B	0.91	(0.84, 0.98)	0.016
AB	0.97	(0.87, 1.09)	0.617
O	0.97	(0.92, 1.02)	0.264
MELD at transplant	0.99	(0.990, 0.996)	< 0.001
Etiology	–	–	–
Viral	Ref.	–	–
Cryptogenic	0.73	(0.64, 0.82)	< 0.001
Autoimmune	0.61	(0.55, 0.69)	< 0.001
NASH	0.67	(0.59, 0.78)	< 0.001
Alcoholic	0.95	(0.89, 1.02)	0.193
HCC	1.23	(1.14, 1.31)	< 0.001
Other	0.82	(0.75, 0.90)	< 0.001
Comorbid conditions	–	–	–
Diabetes	1.32	(1.25, 1.40)	< 0.001
Dialysis	1.28	(1.15, 1.42)	< 0.001
TIPSS	1.05	(0.97, 1.13)	0.188
Previous abdominal surgery	1.11	(1.05, 1.17)	< 0.001
Ascites	1.01	(0.94, 1.07)	0.848
Portal vein thrombosis	0.94	(0.85, 1.04)	0.209
DRI > 1.9	1.24	(1.17, 1.30)	< 0.001

Covariate	HR	95% CI	P
Center total LT volume	1.00	(0.99, 1.00)	0.052
Postop LOS	1.01	(1.00, 1.01)	< 0.001
Transplant year	0.99	(0.98, 1.00)	0.041
Resident in medicaid expansion state UNOS/OPTN region	0.98	(0.91, 1.05)	0.494
1	0.99	(0.84, 1.15)	0.849
2	1.18	(1.06, 1.31)	0.003
3	Ref.	—	—
4	1.07	(0.97, 1.18)	0.199
5	0.97	(0.87, 1.08)	0.591
6	0.73	(0.62, 0.87)	< 0.001
7	0.95	(0.85, 1.06)	0.353
8	0.91	(0.82, 1.02)	0.102
9	1.10	(0.97, 1.24)	0.126
10	1.02	(0.92, 1.13)	0.734
11	0.99	(0.89, 1.09)	0.798

HR hazard ratio, *CI* confidence interval, *BMI* body mass index, *MELD* model for end-stage liver disease, *NASH* nonalcoholic steatohepatitis, *HCC* hepatocellular carcinoma, *TIPSS* transjugular intrahepatic portosystemic shunt, *DRI* donor risk index, *LT* liver transplant, *LOS* length of stay

Table 3

Multivariable Cox proportional hazards model of long-term graft survival after liver transplantation, conditional on survival to 1 year (N = 34,487)

Covariate	HR	95% CI	P
Continuous private insurance	Ref.	–	–
Continuous public insurance	1.23	(1.16, 1.30)	< 0.001
Transition from private to public insurance	1.17	(1.07, 1.27)	< 0.001
Transition from public to private insurance	1.17	(1.03, 1.31)	0.012
Age (years)	1.00	(1.00, 1.01)	0.353
Male	1.11	(1.05, 1.18)	< 0.001
Race	–	–	–
White	Ref.	–	–
Black	1.38	(1.28, 1.49)	< 0.001
Other	0.79	(0.73, 0.84)	< 0.001
Education	–	–	–
High school or less	Ref.	–	–
Some college	0.98	(0.92, 1.05)	0.606
College degree	0.91	(0.84, 0.98)	0.010
Employed	0.91	(0.85, 0.97)	0.002
BMI (kg/m ²)	1.00	(0.99, 1.00)	0.062
ABO blood type	–	–	–
A	Ref.	–	–
B	0.92	(0.86, 1.00)	0.047
AB	0.99	(0.89, 1.11)	0.876
O	0.98	(0.93, 1.03)	0.397
MELD at transplant	0.99	(0.99, 1.00)	< 0.001
Etiology	–	–	–
Viral	Ref.	–	–
Cryptogenic	0.71	(0.63, 0.81)	< 0.001
Autoimmune	0.70	(0.63, 0.77)	< 0.001
NASH	0.68	(0.60, 0.77)	< 0.001
Alcoholic	0.92	(0.86, 0.97)	0.020
HCC	1.19	(1.11, 1.28)	< 0.001
Other	0.79	(0.73, 0.86)	< 0.001
Comorbid conditions	–	–	–
Diabetes	1.28	(1.21, 1.35)	< 0.001
Dialysis	1.20	(1.08, 1.33)	0.001
TIPSS	1.02	(0.95, 1.10)	0.578
Previous abdominal surgery	1.10	(1.05, 1.16)	< 0.001
Ascites	1.00	(0.94, 1.06)	0.980
Portal vein thrombosis	0.98	(0.89, 1.07)	0.634
DRI > 1.9	1.27	(1.20, 1.33)	< 0.001

Covariate	HR	95% CI	P
Center total LT volume	0.99	(0.99, 1.00)	0.016
Postop LOS	1.01	(1.00, 1.01)	< 0.001
Transplant year	.097	(0.96, 0.98)	< 0.001
Resident in medicaid expansion state	0.96	(0.90, 1.03)	0.245
UNOS/OPTN region	–	–	–
1	0.99	(0.85, 1.15)	0.862
2	1.15	(1.04, 1.28)	0.009
3	Ref	–	–
4	1.05	(0.95, 1.16)	0.377
5	0.96	(0.87, 1.07)	0.484
6	0.70	(0.59, 0.83)	< 0.001
7	0.99	(0.89, 1.10)	0.839
8	0.96	(0.86, 1.07)	0.455
9	1.14	(1.02, 1.28)	0.025
10	1.03	(0.93, 1.14)	0.565
11	1.02	(0.92, 1.12)	0.707

HR hazard ratio, *CI* confidence interval, *BMI* body mass index, *MELD* model for end-stage liver disease, *NASH* nonalcoholic steatohepatitis, *HCC* hepatocellular carcinoma, *TIPSS* transjugular intrahepatic portosystemic shunt, *DRI* donor risk index, *LT* liver transplant, *LOS* length of stay