Outcomes of Liver Transplantation by Insurance Type in the United States

Maria Stepanova, PhD; Saleh Al Qahtani, MD; Alita Mishra, MD; Issah Younossi, MPH; Chapy Venkatesan, MD; and Zobair M. Younossi, MD, MPH

Liver transplantation is a life-saving treatment for patients with end-stage liver disease. In the United States, patients who are on the waiting list for liver transplantation are prioritized based on their Model for End-Stage Liver Disease (MELD) scores.[1] In that model, higher scores are assigned to patients with higher estimated risks of pretransplant mortality. The ultimate aim of prioritization is to minimize wait-list mortality in the setting of limited organ supply.[2,3] Despite this strategy, at present, there is a major organ shortage in the country resulting in substantial on-list mortality, which, despite recent decline, still exceeds 10 per 100 patient-years.[4] In addition, recent trends in transplant and mortality rates reported by the US Organ Procurement and Transplantation Network (OPTN) suggest that there is notable geographic difference in wait-list outcomes and that those outcomes are influenced by factors other than organ availability; these factors may include referral and wait-list registration practices across the country, pretransplant patient management, and quality of care.[4]

Prior epidemiologic reports suggest that a number of patient clinical and demographic parameters could be associated with wait-list and posttransplant outcomes even after accounting for patients' MELD scores.[5-10] In this context, prior study findings regarding a number of high-cost treatments suggest the presence of an association between poorer outcomes and lower socioeconomic status and/or having publicly sponsored insurance.[11-17] In fact, having a publicly sponsored plan has been reported as a significant risk factor in risk-adjustment models developed by the Scientific Registry of Transplant Recipients (SRTR).[18] Further, the association of socioeconomic status and, in particular, insurance type with wait-list and transplantation outcomes has been reported for liver and nonliver transplant candidates and recipients.[15,17,19-21] The aim of this study was to use recent national registry data to compare the outcomes of both liver transplant candidates and recipients covered by different types of insurance in the United States.

ABSTRACT

OBJECTIVES: The outcomes of liver transplantation may vary according to socioeconomic factors such as insurance coverage. The aim of this study was to assess the association between the type of insurance payer and outcomes of liver transplant candidates and recipients in the United States.

STUDY DESIGN: This was a retrospective cohort study of a national database.

METHODS: The US Scientific Registry of Transplant Recipients was used to select adults (≥18 years) wait-listed for liver transplantation in the United States (2001-2017); patients were followed until March 2018.

RESULTS: There were 177,862 liver transplant candidates with payer and outcomes data: The mean (SD) age was 54.1 (10.4) years, 64% were male, 39% had chronic hepatitis C with or without alcoholic liver disease (ALD), 19% had ALD alone, 17% had nonalcoholic steatohepatitis, and 16% had hepatocellular carcinoma. Fifty-nine percent were primarily covered by private insurance, 21% by Medicare, and 16% by Medicaid. After listing, 56% eventually received transplants (mean wait time of 229 days) and 22% dropped off the list. In multivariate analysis, adjusted for demographic and clinical factors, being covered by Medicare (odds ratio [OR], 0.81; 95% CI, 0.78-0.84) or Medicaid (OR, 0.76; 95% CI, 0.73-0.79) was independently associated with a lower chance of receiving a transplant (reference: private insurance). Posttransplant mortality was 11.6% at 1 year, 20.1% at 3 years, 26.8% at 5 years, and 41.6% at 10 years. Having Medicare (adjusted hazard ratio [aHR], 1.24; 95% CI, 1.17-1.31) or Medicaid (aHR, 1.14; 95% CI, 1.06-1.21) was independently associated with higher posttransplant mortality (P <.001) but not with the risk of graft loss (P >.05).

CONCLUSIONS: Liver transplant candidates covered by Medicare or Medicaid have poorer wait-list outcomes and higher posttransplant mortality.

Am J Manag Care. 2020;26(4):e121-e126. doi: 10.37765/ajmc.2020.42839

TAKEAWAY POINTS

- The outcomes of liver transplantation may vary according to socioeconomic factors such as insurance coverage.
- In this study, we have shown that liver transplant candidates covered by Medicare or Medicaid have poorer wait-list and transplant outcomes, including higher on-the-list and posttransplant mortality, even after adjustment for clinicodemographic confounders.
- Because the proportion of such patients in the United States is increasing, providers may need to consider more vigilant management and follow-up of these patients to optimize their outcomes.

METHODS

Study Cohort

This study used data from the SRTR. The SRTR data system has been described elsewhere; it includes data submitted by the members of the OPTN on all donors, wait-listed candidates, and transplant recipients in the United States. The Health Resources and Services Administration within HHS provides oversight of the activities of the OPTN and SRTR contractors.

For the purpose of this study, we included all wait-listed candidates and transplant recipients 18 years or older who were listed for or underwent liver transplantation with any listing diagnosis between 2001 and 2017 and had their primary payer data available. Patients' demographic and clinical parameters were collected from SRTR candidate and transplantation records. For transplant recipients' records, their donors' characteristics were also extracted; high-risk donors were recorded according to the CDC criteria.[22,23] Posttransplant follow-up data were collected 6 months after the transplantation and then annually. Patients' outcomes (receiving a transplant, wait-list dropout owing to mortality or deterioration, posttransplant mortality, and graft loss) were recorded as of March 1, 2018.

Statistical Analysis

Patients were grouped based on their primary payer included in the SRTR database: private insurance, Medicare, Medicaid, or other (Veterans Affairs healthcare system, other government-sponsored, self-pay, donation). Clinicodemographic parameters were compared across the 4 groups using χ^2 or Kruskal-Wallis nonparametric tests. The trends in outcomes over time were statistically assessed using Kendall correlation coefficients and were compared among payer groups using a linear trend regression model. Independent predictors of wait-list and posttransplant outcomes were studied using logistic (binary outcomes) and Cox proportional hazard (time-to-event outcomes) regression models.

All analyses were run in SAS version 9.4 (SAS Institute; Cary, North Carolina). The study was granted a nonhuman subject research status by the Inova Institutional Review Board.

RESULTS

There were 177,862 wait-listed candidates in SRTR who were 18 years or older, were listed between 2001 and 2017, and had payer data available. Of those, 59% had private insurance, 21% had Medicare, 16% had Medicaid, and 4% had another type of coverage. Over time, the proportion of privately insured candidates significantly decreased (from 67% in 2001 to 52% in 2017) while the proportions of both Medicaid (from 14% in 2001 to 17% in 2017) and especially Medicare (from 14% in 2001 to 27% in 2017) increased (all P <.01).

Wait-listed candidates had a mean (SD) age of 54 (10) years, 64% were male, 71% were white, 24% had a college degree, 23% were employed at listing, 70% were listed in 1 of 50 high-volume centers (>1500 listings for the study period), 19% had type 2 diabetes, and 6% underwent retransplantation (**Table 1**). Patients with private insurance were the most likely to be white, have a college degree, and be employed; had the highest functional status at listing; and had the lowest rates of ascites, bacterial peritonitis, hepatic encephalopathy, and dialysis (P <.0001) (Table 1). Patients with Medicare were the oldest and had the highest proportions of diabetes and hypertension (P <.0001) (Table 1). Patients with Medicaid were the most likely to be Hispanic and had the lowest rate of having a college degree, the lowest functional status, the highest MELD scores, and the highest rate of having bacterial peritonitis and variceal bleeding (P <.0001) (Table 1).

The most prevalent listing diagnosis in all patient groups was hepatitis C (31%-35%), followed by alcoholic cirrhosis (17%-23%) and nonalcoholic steatohepatitis (NASH) (11%-22%) (**Table 2**). In addition, between 15% and 20% had hepatocellular carcinoma (HCC). The greatest difference among the patient groups was in the proportion of NASH: It was 2-fold higher in those covered by Medicare than by Medicaid (P <.0001) (Table 2).

Of all candidates, 56% eventually underwent transplant after a mean waiting time of 229 days. The transplant rate was the highest in the privately insured group (58%) and the lowest among the Medicaid group (51%) (P <.0001) (**Table 3**). On the other hand, privately insured patients experienced the longest waiting time (mean of 243 days vs 203-214 days in the other groups; P <.0001) (Table 3). Over time, there were no changes in the transplant rates in all payer groups (all P >.05) (**Figure** [A]). The rate of wait-list dropout (death or deterioration) was the highest in Medicare-insured patients at 26% versus 21% in privately insured patients (P <.0001) (Table 3). Over the study period, the dropout rates decreased significantly in the privately insured and Medicaid-insured groups (Kendall $\tau = -0.48$ and -0.43, respectively; both P <.05) and borderline significantly in the Medicare group ($\tau = -0.28$; P = .12) (Figure [B]).

In multivariate regression analysis, compared with having private insurance, having Medicare and having Medicaid were independently associated with a lower chance of receiving a transplant after adjustment for the year of listing, demographics, and clinical parameters (Medicare: odds ratio [OR], 0.81; 95% CI, 0.78-0.84; Medicaid: OR, 0.76; 95% CI, 0.73-0.79; both P <.0001) (**Table 4**). Other predictors of a lower chance of receiving a transplant included older age, Hispanic

TABLE 1. Demographics and Clinical Characteristics of US Liver Transplant Candidates by Primary Payer[a]

	Private	Medicare	Medicaid	Other	All
n	104,735	37,893	27,694	7540	177,862
Age in years, mean (SD)	53.2 (9.9)	59.6 (9.6)	50.3 (10.7)	53.5 (10.9)	54.1 (10.4)
Male, n (%)	68,671 (65.6)	23,301 (61.5)	16,596 (59.9)	5893 (78.2)	114,461 (64.4)
White, n (%)	78,996 (75.4)	26,731 (70.5)	15,476 (55.9)	5016 (66.5)	126,219 (71.0)
Black, n (%)	8104 (7.7)	3495 (9.2)	3169 (11.4)	892 (11.8)	15660 (8.8)
Asian, n (%)	4658 (4.4)	1283 (3.4)	1586 (5.7)	330 (4.4)	7857 (4.4)
Hispanic, n (%)	11,927 (11.4)	5943 (15.7)	6952 (25.1)	1126 (14.9)	25,948 (14.6)
Other race, n (%)	1050 (1.0)	441 (1.2)	511 (1.8)	176 (2.3)	2178 (1.2)
US citizen, n (%)	102,034 (97.4)	36,871 (97.3)	25,129 (90.7)	6870 (91.1)	170,904 (96.1)
College degree, n (%)	26,210 (29.7)	6527 (19.9)	2370 (10.0)	1199 (22.3)	36,306 (24.2)
Employed at listing, n (%)	27,899 (34.5)	2200 (6.8)	1390 (6.1)	758 (15.0)	32,247 (22.8)
BMI in kg/m^2, mean (SD)	28.5 (5.9)	28.7 (5.7)	28.3 (6.0)	28.4 (5.5)	28.6 (5.8)
Overweight, n (%)	36,775 (35.3)	13,115 (34.8)	9408 (34.2)	2782 (37.1)	62,080 (35.1)
Obese, n (%)	36,871 (35.4)	14,096 (37.4)	9411 (34.2)	2614 (34.8)	62,992 (35.6)
On life support, n (%)	4445 (4.2)	1181 (3.1)	1375 (5.0)	401 (5.3)	7402 (4.2)
In ICU, n (%)	6448 (8.1)	1601 (6.1)	1960 (9.8)	569 (11.1)	10,578 (8.1)
Functional status (0-100), mean (SD)	67.6 (23.5)	64.1 (21.5)	61.8 (23.4)	67.4 (23.7)	65.9 (23.2)
MELD score, mean (SD)	20.3 (10.3)	20.2 (9.9)	21.6 (10.7)	21.3 (10.4)	20.5 (10.3)
Status 1, n (%)	3722 (3.6)	677 (1.8)	1021 (3.7)	361 (4.8)	5781 (3.3)
Ascites, n (%)	77,433 (77.4)	28,932 (80.1)	21,603 (81.9)	5841 (81.6)	133,809 (78.8)
Bacterial peritonitis, n (%)	5624 (5.5)	2228 (6.0)	2317 (8.7)	522 (7.3)	10,691 (6.2)
Hepatic encephalopathy, n (%)	65,879 (63.0)	25,068 (66.2)	19,095 (69.0)	5287 (70.2)	115,329 (64.9)
Portal vein thrombosis, n (%)	4348 (4.3)	2000 (5.5)	1214 (4.6)	271 (3.8)	7833 (4.6)
Variceal bleeding, n (%)	3078 (4.2)	1024 (4.2)	1013 (5.5)	179 (4.0)	5294 (4.4)
TIPSS, n (%)	6977 (6.9)	3263 (8.9)	2356 (8.9)	504 (7.1)	13,100 (7.6)
Type 2 diabetes, n (%)	16,760 (17.2)	9778 (27.6)	4531 (17.4)	1187 (17.3)	32,256 (19.4)
Dialysis, n (%)	25,177 (24.2)	10,753 (28.5)	7408 (26.8)	2561 (34.2)	45,899 (26.0)
Drug-treated hypertension, n (%)	16,931 (23.2)	7858 (32.1)	3888 (21.0)	1186 (25.5)	29,863 (24.8)
History of any cancer, n (%)	11,631 (11.6)	6016 (16.4)	2619 (9.8)	1064 (15.0)	21,330 (12.5)
Prior liver transplant, n (%)	6261 (6.0)	2428 (6.4)	1488 (5.4)	325 (4.3)	10,502 (5.9)
High-volume listing center, n (%)	77,306 (73.8)	25,748 (67.9)	17,792 (64.2)	3524 (46.7)	124,370 (69.9)

BMI indicates body mass index; ICU, intensive care unit; MELD, Model for End-Stage Liver Disease; TIPSS, transjugular intrahepatic portosystemic shunt.
[a]All P <.0001 among the payer groups.

ethnicity, being on life support, having hepatic encephalopathy, and history of a prior liver or nonliver transplantation (P <.001). Factors independently associated with a higher chance of receiving a transplant were listing in a high-volume center, male gender, having a college degree, having listing status 1 (the most medically urgent candidates), having HCC, having ascites, having bacterial peritonitis, having a higher MELD score, and being on dialysis (all P <.02) (Table 4). Of the most common diagnostic groups (prevalence >3%), having NASH or primary biliary cirrhosis was associated with a higher chance of receiving a transplant with reference to hepatitis C, whereas patients with alcoholic cirrhosis had a lower chance of eventually receiving a transplant (all P <.0001) (Table 4).

Payer and outcomes data were available for 99,531 liver transplant recipients. Clinicodemographic presentation of transplant recipients was similar to that of wait-listed candidates. Posttransplant noncompliance with medical treatment as reported in SRTR follow-up data was substantially higher in the Medicaid group at 11.2% versus 5.2% in private and 5.8% in Medicare groups (P <.0001). Posttransplant survival was the highest in the privately insured group (mortality: 10.8% at 1 year, 18.6% at 3 years, 24.7% at 5 years) followed by Medicaid (mortality: 12.2%, 21.5%, and 28.7%, respectively) and the lowest in the Medicare group (mortality: 13.0%, 23.1%, and 31.1%, respectively). Over time, mortality similarly and significantly decreased in all payer groups (Kendall τ <−0.54; all P <.01) (**eAppendix Figure** [eAppendix available at **ajmc.com**]).

In multivariate survival analysis, both Medicare and Medicaid insurance were associated with increased posttransplant mortality after adjustment for age and other clinicodemographic parameters

TABLE 2. Primary Listing Diagnoses of US Liver Transplant Candidates by Primary Payer

	Private	Medicare	Medicaid	Other	*P*	All
Hepatitis C, n (%)	29,665 (30.8)	11,557 (33.1)	8673 (33.7)	2406 (34.8)	<.0001	52,301 (31.9)
Alcoholic cirrhosis, n (%)	17,742 (18.4)	5997 (17.2)	5884 (22.8)	1175 (17.0)	<.0001	30,798 (18.8)
Nonalcoholic steatohepatitis or cryptogenic cirrhosis, n (%)	15,670 (16.3)	7805 (22.3)	2748 (10.7)	894 (12.9)	<.0001	27,117 (16.5)
Alcoholic cirrhosis with hepatitis C, n (%)	5055 (5.2)	2025 (5.8)	2709 (10.5)	774 (11.2)	<.0001	10,563 (6.4)
Acute liver disease, n (%)	5495 (5.7)	1157 (3.3)	1638 (6.4)	488 (7.1)	<.0001	8778 (5.4)
Primary sclerosing cholangitis, n (%)	5833 (6.0)	1106 (3.2)	550 (2.1)	246 (3.6)	<.0001	7735 (4.7)
Primary biliary cirrhosis, n (%)	3420 (3.5)	1335 (3.8)	542 (2.1)	135 (2.0)	<.0001	5432 (3.3)
Autoimmune hepatitis, n (%)	3203 (3.3)	923 (2.6)	782 (3.0)	168 (2.4)	<.0001	5076 (3.1)
Hepatitis B, n (%)	2968 (3.1)	814 (2.3)	880 (3.4)	215 (3.1)	<.0001	4877 (3.0)
Alpha-1 antitrypsin deficiency, n (%)	946 (1.0)	298 (0.9)	108 (0.4)	38 (0.5)	<.0001	1390 (0.8)
Other/unspecified cirrhosis, n (%)	768 (0.8)	299 (0.9)	145 (0.6)	57 (0.8)	.0003	1269 (0.8)
Hemochromatosis, n (%)	567 (0.6)	223 (0.6)	52 (0.2)	30 (0.4)	<.0001	872 (0.5)
Benign liver tumor, n (%)	586 (0.6)	217 (0.6)	45 (0.2)	14 (0.2)	<.0001	862 (0.5)
Hepatitis B and C, n (%)	378 (0.4)	143 (0.4)	138 (0.5)	37 (0.5)	.0068	696 (0.4)
Cholangioma or cholangiosarcoma, n (%)	524 (0.5)	101 (0.3)	35 (0.1)	11 (0.2)	<.0001	671 (0.4)
Budd-Chiari syndrome, n (%)	476 (0.5)	56 (0.2)	80 (0.3)	24 (0.3)	<.0001	636 (0.4)
Metabolic liver diseases (eg, maple syrup urine; tyrosinemia), n (%)	308 (0.3)	107 (0.3)	75 (0.3)	31 (0.4)	.22	521 (0.3)
Copper metabolism disorders, n (%)	328 (0.3)	45 (0.1)	93 (0.4)	22 (0.3)	<.0001	488 (0.3)
Secondary biliary cirrhosis, n (%)	288 (0.3)	114 (0.3)	69 (0.3)	12 (0.2)	.15	483 (0.3)
Biliary atresia or hypoplasia, n (%)	276 (0.3)	50 (0.1)	113 (0.4)	17 (0.2)	<.0001	456 (0.3)
Drug-induced hepatitis, n (%)	238 (0.2)	108 (0.3)	66 (0.3)	20 (0.3)	.26	432 (0.3)
Other liver malignancy, n (%)	302 (0.3)	37 (0.1)	32 (0.1)	15 (0.2)	<.0001	386 (0.2)
Cholestatic liver disease, n (%)	233 (0.2)	57 (0.2)	59 (0.2)	12 (0.2)	.05	361 (0.2)
Congenital fibrosis or cystic fibrosis, n (%)	230 (0.2)	63 (0.2)	42 (0.2)	11 (0.2)	.0330	346 (0.2)
Hepatitis A, n (%)	30 (0.0)	9 (0.0)	8 (0.0)	0 (0.0)	.50	47 (0.0)
Other/unspecified diagnosis, n (%)	9128 (8.7)	3201 (8.4)	2116 (7.6)	677 (9.0)	<.0001	15,122 (8.5)
Hepatocellular carcinoma (as a primary or secondary listing diagnosis), n (%)	16,125 (15.4)	7629 (20.1)	4092 (14.8)	1261 (16.7)	<.0001	29,107 (16.4)

TABLE 3. Outcomes of US Liver Transplant Candidates by Primary Payer

	Private	Medicare	Medicaid	Other	*P*	All
Transplanted, n (%)	61,196 (58.4)	20,078 (53.0)	14,166 (51.2)	4332 (57.5)	<.0001	99,772 (56.1)
Died while listed, n (%)	12,916 (12.3)	5479 (14.5)	4064 (14.7)	1102 (14.6)	<.0001	23,561 (13.2)
Removed as medically unsuitable, n (%)	4 (0.0)	5 (0.0)	2 (0.0)	1 (0.0)	.25	12 (0.0)
Deteriorated; too sick to transplant, n (%)	8585 (8.2)	4446 (11.7)	2727 (9.8)	644 (8.5)	<.0001	16,402 (9.2)
Refused transplant, n (%)	623 (0.6)	410 (1.1)	165 (0.6)	38 (0.5)	<.0001	1236 (0.7)
Improved, n (%)	5053 (4.8)	1417 (3.7)	1311 (4.7)	276 (3.7)	<.0001	8057 (4.5)
Removed for other causes, n (%)	9768 (9.3)	3406 (9.0)	3125 (11.3)	730 (9.7)	<.0001	17,029 (9.6)
Still wait-listed, n (%)	6590 (6.3)	2652 (7.0)	2134 (7.7)	417 (5.5)	<.0001	11,793 (6.6)
Wait until transplant in days, mean (SD)	243.1 (440.9)	202.5 (333.6)	214.8 (391.8)	203.1 (360.7)	<.0001	228.9 (411.2)

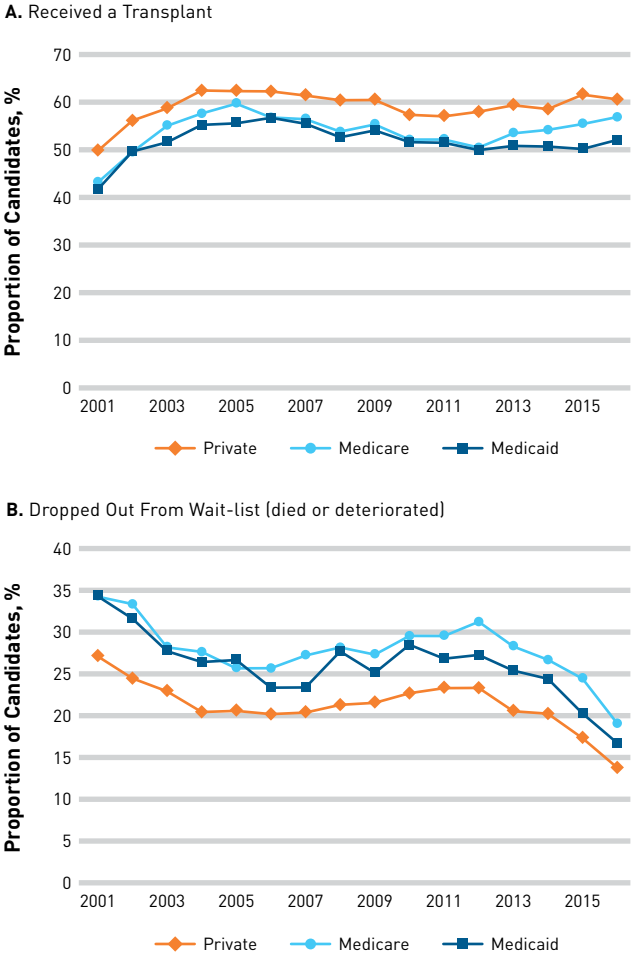
and the year of transplantation (Medicare: adjusted hazard ratio [aHR], 1.24; 95% CI, 1.17-1.31; Medicaid: aHR, 1.14; 95% CI, 1.06-1.21; both P <.001). Other significant predictors of higher posttransplant mortality were an earlier year of transplantation, older age, being black, being on life support, higher MELD score, pretransplant diabetes, retransplant, noncompliance with posttransplant medical treatment in posttransplant follow-up data, and pretransplant HCC (all P <.01) (**eAppendix Table**). On the other hand, there was no association of payer type with posttransplant graft loss risk (both Medicare and Medicaid P >.30).

TABLE 4. Independent Predictors of Receiving a Transplant in US Liver Transplant Candidates

Predictor	Odds Ratio (95% CI)	*P*
Calendar year, per year	0.994 (0.990-0.998)	.0042
Payer		
Private	1.00 (reference)	
Medicare	0.81 (0.78-0.84)	<.0001
Medicaid	0.76 (0.73-0.79)	<.0001
Age, per year	0.986 (0.985-0.988)	<.0001
Race		
White	1.00 (reference)	
Black	1.14 (1.07-1.20)	<.0001
Asian	0.94 (0.86-1.02)	.12
Hispanic	0.77 (0.74-0.81)	<.0001
Male gender	1.31 (1.27-1.36)	<.0001
US citizen	1.12 (1.04-1.21)	.0048
College degree	1.06 (1.02-1.10)	.0025
Functional status, per 1 point	0.992 (0.991-0.992)	<.0001
On life support	0.61 (0.55-0.68)	<.0001
Status 1	1.86 (1.45-2.37)	<.0001
Ascites	1.51 (1.44-1.59)	<.0001
Bacterial peritonitis	1.15 (1.09-1.22)	<.0001
Hepatic encephalopathy	0.84 (0.81-0.88)	<.0001
MELD score, per 1 point	1.014 (1.012-1.02)	<.0001
Type 2 diabetes	0.98 (0.94-1.01)	.23
Dialysis	1.17 (1.13-1.22)	<.0001
History of cancer	1.21 (1.15-1.27)	<.0001
History of nonliver transplant	0.71 (0.59-0.87)	.0008
History of liver transplant	0.75 (0.69-0.82)	<.0001
Listing diagnosis		
Hepatitis C	1.00 (reference)	
Hepatitis B	0.96 (0.88-1.05)	.35
NASH	1.11 (1.07-1.16)	<.0001
Autoimmune	1.01 (0.93-1.09)	.91
Alcoholic cirrhosis	0.82 (0.79-0.85)	<.0001
Alcoholic cirrhosis and hepatitis C	0.82 (0.78-0.87)	<.0001
Primary biliary cirrhosis	1.32 (1.22-1.42)	<.0001
Hepatocellular carcinoma	2.34 (2.23-2.45)	<.0001
High-volume listing center	1.24 (1.20-1.28)	<.0001

MELD indicates Model for End-Stage Liver Disease; NASH, nonalcoholic steatohepatitis.

FIGURE. Outcomes of US Liver Transplant Candidates by the Year of Listing



DISCUSSION

In this study, we summarized the outcomes of patients wait-listed for liver transplantation by insurance type in the United States. Because SRTR data include all candidates listed in the United States, the sample is nationally representative, allowing us to draw population-based conclusions. The main finding of the study is that, compared with privately insured patients, patients with Medicare and Medicaid had poorer wait-list outcomes, such as lower transplant and higher dropout rates, even after adjustment for age and other demographic factors, education, the year of listing, listing diagnoses, MELD scores, and a number of other clinical risk factors and comorbidities. In particular, although patients on Medicare were expectedly older than the rest of the cohort, age and age-related comorbidities such as diabetes could not explain the reported difference in outcomes. Similarly, patients on Medicaid had the highest average MELD score and the highest prevalence of alcoholic cirrhosis, but again, these factors alone did not explain the observed outcomes distribution. The exact reasons for this require further study. Possible factors not assessed in our study would include income level, psychiatric and other comorbidities, continuity of access to healthcare and of insurance coverage both pre- and post listing and transplantation, and center- and donor-related factors; all those factors may additionally affect both wait-list and posttransplant outcomes. Interestingly, the higher transplant rate in patients with private insurance was accompanied by longer wait times (ie, these patients are able

to survive longer while waiting); notably, longer survival alone would improve chances of receiving a transplant. Higher-quality management while wait-listed, possibly owing to easier access to healthcare providers, procedures, or medications, or other clinical factors not measured in our study, may account for this observation.

In patients who eventually received a transplant, the difference in posttransplant mortality is similarly pronounced and could not be explained by age or recorded comorbidities or noncompliance with treatment in posttransplant follow-up data despite substantial confounding of the outcome by those factors. On the other hand, there was no similar association of the type of insurance with the risk of graft loss. This indirectly suggests that factors outside of post-transplant care are responsible for the observed mortality disparity. Given the lack of more detailed clinical and sociodemographic data, we recommend that wait-listed and posttransplant patients with publicly sponsored insurance should be considered as being at higher risk and carefully followed for any socioclinical factors that could potentially be addressed.

Limitations

An important limitation of our study is the lack of systematic quality control in SRTR data; there is a chance of inconsistencies of medical history tracking across different transplant centers and changes in recording practices and diagnostic criteria with time. In addition, there was a notable proportion of missing or incomplete data, predominantly in the earliest and the most recent study years, which might have caused an unknown systematic bias. The duration of follow-up might be insufficient to track the most recent trends in outcomes following ongoing changes in US healthcare legislation, such as expansion of Medicaid, which started in 2014 in some states.

CONCLUSIONS

The outcomes of patients in need of a liver transplant and those who have received a liver transplant are poorer in those who have publicly sponsored insurance. Because the proportion of such patients is steadily increasing, providers may need to consider more vigilant management and follow-up of these patients to optimize their outcomes. Further studies are required to determine the exact reasons for the reported outcome disparities. ■

Acknowledgments

The data reported here have been supplied by the Minneapolis Medical Research Foundation as the contractor for the Scientific Registry of Transplant Recipients (SRTR). The interpretation and reporting of these data are the responsibility of the author(s) and in no way should be seen as an official policy of or interpretation by the SRTR or the US government.

Author Affiliations: Center for Outcomes Research in Liver Diseases (MS, IY), Washington, DC; Betty and Guy Beatty Center for Integrated Research, Inova Health System (MS, AM, CV, ZMY), Falls Church, VA; Division of Gastroenterology, Johns Hopkins University (SAQ), Baltimore, MD; Center for Liver Diseases, Department of Medicine, Inova Fairfax Hospital (AM, CV, ZMY), Falls Church, VA.

Source of Funding: This study was supported by the Beatty Liver and Obesity Research Fund, Liver Outcomes Research Fund (Inova Health System, Falls Church, VA), and Center for Outcomes Research in Liver Disease (Washington, DC).

Author Disclosures: Dr Stepanova and Mr Younossi are employed by the Center for Outcomes Research in Liver Disease. Dr Al Qahtani is employed by The Johns Hopkins Hospital. Drs Mishra, Venkatesan, and Younossi are employed by Inova Health System.

Authorship Information: Concept and design (SAQ, AM, CV, ZMY); acquisition of data (MS); analysis and interpretation of data (MS); drafting of the manuscript (MS); critical revision of the manuscript for important intellectual content (MS, SAQ, AM, IY, CV, ZMY); statistical analysis (MS); obtaining funding (IY, ZMY); administrative, technical, or logistic support (IY); and supervision (SAQ, AM, CV, ZMY).

Address Correspondence to: Zobair M. Younossi, MD, MPH, Betty and Guy Beatty Center for Integrated Research, Claude Moore Health Education and Research Building, 3300 Gallows Rd, Falls Church, VA 22042. Email: zobair.younossi@inova.org.

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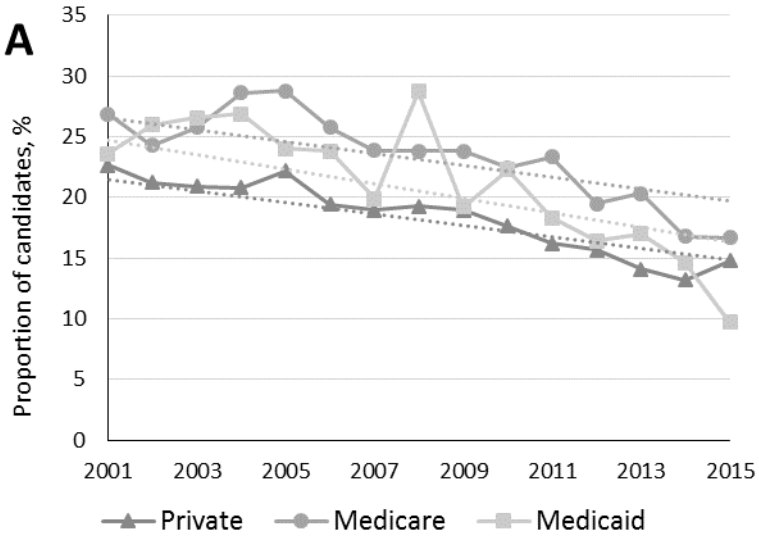
eAppendix Table. Independent Predictors of Posttransplant Mortality

	Adjusted hazard ratio (95% CI)	**p**
Calendar year, per year	0.944 (0.937 - 0.952)	<.0001
Payer: private	1.00 (reference)	
Payer: Medicare	1.24 (1.17 - 1.31)	<.0001
Payer: Medicaid	1.14 (1.06 - 1.21)	0.0002
Age, per year	1.020 (1.017 - 1.023)	<.0001
White race	1.00 (reference)	
Black race	1.31 (1.21 - 1.41)	<.0001
Asian race	0.91 (0.78 - 1.06)	0.21
Hispanic race	0.76 (0.70 - 0.81)	<.0001
Male gender	1.01 (0.96 - 1.07)	0.68
College degree	0.96 (0.90 - 1.01)	0.12
Functional status, per 1 point	0.996 (0.995 - 0.998)	<.0001
On life support	1.22 (1.09 - 1.36)	0.0004
Status 1	0.71 (0.52 - 0.96)	0.0277
Ascites	0.99 (0.91 - 1.09)	0.86
Hepatic encephalopathy	1.01 (0.95 - 1.07)	0.86
MELD score, per 1 point	1.003 (1.000 - 1.006)	0.046
Type 2 diabetes	1.26 (1.19 - 1.34)	<.0001
History of cancer	1.12 (1.03 - 1.21)	0.0082
History of non-liver transplant	1.86 (1.47 - 2.36)	<.0001
History of liver transplant	1.27 (1.13 - 1.43)	<.0001
Listing diagnosis: Hepatitis C	1.00 (reference)	
Hepatitis B	0.52 (0.44 - 0.61)	<.0001
NASH	0.75 (0.70 - 0.80)	<.0001
Autoimmune	0.78 (0.69 - 0.89)	0.0002
Alcoholic cirrhosis	0.83 (0.78 - 0.88)	<.0001
Alcoholic cirrhosis and hepatitis C	1.02 (0.94 - 1.10)	0.68
Primary biliary cirrhosis	0.55 (0.49 - 0.63)	<.0001
Hepatocellular carcinoma	1.17 (1.08 - 1.26)	0.0002
Non-compliance in follow-up	1.50 (1.39 - 1.63)	<.0001
High-volume listing center	0.96 (0.91 - 1.01)	0.10
High-risk donor (CDC criteria)	0.91 (0.84 - 0.98)	0.0162

eAppendix Figure. Posttransplant Mortality of Liver Transplant Recipients by the Year of Transplant

(A) 3-year mortality



(B) 5-year mortality. Dotted lines represent modeled linear trends.