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Multiple Listings as a Reflection of Geographic Disparity in Liver Transplantation

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Abstract

BACKGROUND—Geographic disparity in access to liver transplantation (LT) exists. This study sought to examine Model for End-Stage Liver Diseaseeera multiply listed (ML) LT candidate (ie, candidates who list at 2 or more LT centers to receive a liver transplant).

STUDY DESIGN—Data on adult, primary, nonestatus 1 LT candidates (n = 59,557) listed from January 1, 2005 to December 31, 2011 were extracted from the United Network for Organ Sharing's Standard Transplant Analysis and Research files. Comparisons of ML vs singly listed LT candidates were performed, with additional analysis performed at the donor service area (DSA) and regional level, as well as assessment of the donor population used.

RESULTS—There were 1,358 (2.3%) ML candidates during the 7-year study period. Multiply listed candidates compared with singly listed candidates were more often male, white, blood type O, nondiabetic, college educated, and privately insured. The odds of pursuing ML increased considerably as time on the waitlist increased. Of the ML candidates, 918 (67.6%) went on to receive a liver transplant (ML-LT), 767 (83.6%) at the secondary listing DSA, which was a median of 588 miles (range 229 to 1095 miles) from the primary listing DSA. When compared with the primary listing DSA, the secondary listing DSA had significantly lower match Model for End-Stage Liver Disease scores, as well as shorter wait times. Regional analysis demonstrated significantly higher odds for pursuing ML from LT candidates located within regions 1, 5, and 9.

CONCLUSIONS—A small and distinctive cohort of LT candidates pursue ML, indicating willingness and means to travel to receive a liver transplant. Efforts toward equalizing LT access across regional disparities are warranted, and can help obviate the need for ML.

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Author Contributions

Study conception and design: Vagefi, Roberts Acquisition of data: Vagefi, Dodge
Analysis and interpretation of data: Vagefi, Feng, Dodge, Markmann, Roberts
Drafting of manuscript: Vagefi, Feng, Dodge, Markmann, Roberts
Critical revision: Vagefi, Feng, Dodge, Markmann, Roberts

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With the demonstration of excellent survival after liver transplantation (LT), the demand for liver allografts has quickly outpaced the supply, and has generated a persistent gap between organ supply and patient demand. Despite the 2002 implementation of Model for End-Stage Liver Disease (MELD) score allocation, which allowed for allocation to address medical need through objective criteria, there remains geographic inequity because patients in certain donor service areas (DSAs) receive a deceased donor liver transplant before their sicker counterparts in other DSAs.[1] These geographic differences in deceased donor organ availability within the United States shape the current clinical practice of LT, as exemplified by the increased use of living donor liver transplants in highly competitive regions,[2] as well as the increased use of imported liver grafts and extended donor criteria liver grafts.[3-5] Another approach to address the growing waitlisted population, pursued by candidates located in competitive DSAs, is multiple listing (ML). These candidates undergo evaluation and listing at another center located in a different DSA that allocates transplants at lower MELD scores and with shorter waiting times.

Multiply listed LT candidates have only been characterized previously in the pre-MELD era.[6] From 1997 to 2000, 3.3% of all liver candidates were listed at >1 center. Since then, there have been extensive changes in liver allocation policy, including the application of MELD and the subsequent “Share 15” provision,[7-9] which have sought to allocate liver allografts more equitably. To date, there does not exist an examination of ML practices for LT candidates during the MELD era of allocation. We hypothesize that the persistent geographic disparities drive some patients to continue to ML at centers located in DSAs with shorter waitlist times, thereby redistributing the waitlisted population. We sought to characterize MELD-era ML candidates, including those who receive a transplant (ML-LT) and those who do not receive a transplant (ML-NT), comparing them with singly listed candidates (SL) at the DSA and regional level, as well as investigate the donor population used.

METHODS

Data about adult, primary, nonestatus 1 LT candidates (n = 59,557) listed from January 1, 2005 to December 31, 2011 were extracted from the United Network for Organ Sharing (UNOS) Standard Transplant Analysis and Research file created on December 31, 2011. Candidates who were ML within the same DSA, traveled <50 miles between centers, or lacked time overlap between listings, were excluded. For patients with listings at ≥3 DSAs (n = 131), we evaluated the primary DSA and 1 additional listing DSA. If the patient received a transplant at the secondary, tertiary, or quaternary DSA, we selected the DSA where transplant occurred as the secondary DSA. If the patient did not receive a transplant, we selected the chronologic secondary listing DSA.

Trends in multiple listing

Using MELD-era primary listings from January 1, 2005 to December 31, 2011, we assessed for trends in ML during the study period by calculating the proportion of all new listings per year attributed to ML during 2005 to 2011 and applied the Cochran-Armitage trend test.

Comparison with single listing

Demographic and clinical characteristics of SL and ML (both ML-NT and ML-LT) patients were described with frequency (percent) and median (interquartile range [IQR];). Distance in miles between primary and secondary listing centers was calculated using the centroid of the ZIP code for each center. Characteristics of SL vs ML and ML-NT vs ML-LT were compared using chisquare and Wilcoxon rank sum tests, as appropriate.

Donor service area–level characteristics and calculation of donor service area time to transplantation

Median match MELD and median Donor Risk Index (DRI) scores for ML patients at both their primary and secondary listing DSAs were analyzed. Differences in these median values were calculated for each ML patient. The signed-rank test determined if the difference in median MELD and DRI scores between primary and secondary DSAs were significantly different from 0.

We estimated the time from listing until 25% of waitlist candidates received transplants within the DSA by year of listing using the Kaplan-Meier method per Merion and colleagues.[6] Time on the waiting list was defined as the number of days from listing to transplantation, with patients who did not receive transplants censored at waitlist removal or last follow-up. In 6 DSAs, 25% of their waitlist did not receive transplants for 1 calendar year (range 18% to 24% of waitlist received transplants). For the latter 6 DSAs, we imputed the number of days from listing to the last censored observation, slightly underestimating the time to LT of the 25% of waitlisted candidates for the DSA.

Odds of multiple listing

The likelihood of ML was evaluated by logistic regression. Demographic and clinical characteristics with $p < 0.1$ in univariate comparisons were evaluated in multivariate models. Final model covariates were selected with backward elimination using $p > 0.05$ for exclusion from the model.

Post-transplantation survival

Graft survival was estimated using the Kaplan-Meier method and compared between SL and ML with the log-rank test. Survival time was measured in years from transplantation to the earliest of death, retransplantation, or last follow-up. Deaths and retransplantations were considered graft loss. Transplant recipients without death or retransplantation were censored at the date of last follow-up. When death dates were available from the Social Security Death Master File for patients noted as alive at last follow-up, patient status and follow-up date were updated accordingly. To determine if ML was independently associated with graft survival, we developed a multivariate Cox proportional hazards model adjusted for recipient (ie, ethnicity, ICU stay, portal vein thrombosis, previous abdominal surgery, dialysis, hepatitis C virus [HCV]; diagnosis, malignant neoplasm other than hepatocellular carcinoma, age at transplantation, life support, and functional status), donor (ie, ethnicity, age, partial or split liver, DDAVP (1-deamino-8-D-arginine vasopressin), donation after cardiac death, cold ischemic time, height, and HCV diagnosis by donor age interaction), and

characteristics significantly associated with 1-year graft loss in the Scientific Registry of Transplant Recipients report (April 30, 2012 data release).

Regional comparison

The percentage of listings exported from and imported to each region was assessed as a percent of the total listings per region. We classified ML patients as exported listings in the region of primary listing and imported listings in the region of secondary listing. Export percentages were subtracted from import percentages to determine net export (negative values) and net import (positive values) regions. To assess whether UNOS regions remained independently associated with ML after adjusting for disease severity, inter-regional comparisons were performed using region 8 as the reference region because it represented the region with the lowest net change between importing and exporting of candidates. All statistical analyses were conducted with SAS software (version 9.3, SAS Institute, Inc).

The study was deemed exempt by the Massachusetts General Hospital Institutional Review Board.

RESULTS

During the 7-year study period, there were 58,199 SL and 1358 (2.3%) ML candidates. The percentage of ML candidates remained stable between 2005 and 2011 (mean 2.6% MLs per year; p trend = 0.84), but increased between 2009 to 2011 (from 2.2% to 3.0%; p trend = 0.001) (Fig. 1). For ML candidates, median age at initial listing was 54 years (IQR 48 to 60 years). The most common cause of liver disease was HCV (36%), followed by cholestatic liver disease (16%), and alcoholic cirrhosis (11.9%) (Table 1).

Primary vs secondary donor service area of listing for multiply listed candidates

Comparison of primary and secondary DSA characteristics for ML candidates elucidated the rationale to pursue ML as a strategy to expedite LT. Although the median match MELD score was 26 (IQR 23 to 27) at the primary DSA, the median match MELD was 22 (IQR 22 to 25) at the secondary DSA ($p < 0.001$). Median time required for 25% of all waitlisted patients to receive a transplant was 120 days (IQR 51 to 170 days) at the primary DSA and 39 days (IQR 21 to 103 days) at the secondary DSA ($p < 0.001$). Finally, the DRI at the primary vs secondary DSA was statistically different but clinically similar (median 1.39 [IQR 1.33 to 1.47]; vs median 1.37 [IQR 1.32 to 1.45];; $p < 0.001$).

Multiply listed candidates vs singly listed candidates

Multiply listed compared with SL candidates were more often male (70.6% vs 66.2%; $p = 0.001$), white (80.5% vs 70.9%; $p < 0.001$), blood type O (51.8% vs 46.1%; $p < 0.001$), nondiabetic (80.6% vs 74.7%; $p < 0.001$), college educated (55.5% vs 39.0%; $p < 0.001$), and privately insured (75.6% vs 58.9%, $p < 0.001$) (Table 1). Although the prevalence of HCV diagnosis was similar between ML and SL candidates (35.9% vs 36.4%; $p = 0.71$), ML candidates were less likely to have alcoholic cirrhosis (11.9% vs 16.1%; $p < 0.001$), nonalcoholic steatohepatitis (5.7% vs 7.3%; $p = 0.02$), and hepatocellular carcinoma (6.4% vs 9.4%; $p < 0.001$), but more frequently had cholestatic liver disease (16% vs 9.8%; $p <$

0.001) and metabolic liver disease/biliary atresia (11.9% vs 8.2%; p < 0.001). Singly listed candidates, when compared with ML candidates, were more likely to have ascites (74.6% vs 68.9%; p < 0.001) and encephalopathy (59.5% vs 51.8%; p < 0.001), and to require dialysis (5.0% vs 1.6%; p < 0.001) and have exception points (15.1% vs 9.2%; p < 0.001).

Multiply listed compared with SL candidates had longer waitlist times (median 402 days [IQR 194 to 835 days]; vs 151 days [IQR 37 to 463 days];; p < 0.001) (Fig. 2A). For ML candidates, secondary listing occurred at a median of 243 days (IQR 106 to 538 days) after primary listing, at a median MELD score of 16 (IQR 12 to 21), and for a median of 86 days (IQR 26 to 246 days) (Table 1). Of the 1,358 ML candidates, 918 (67.6%) ultimately underwent LT (ML-LT), and 30,612 (52.6%) of SL candidates underwent LT. In our study population, significantly more SL candidates (19%) were removed from the waitlist due to reasons coded as “death” and “too sick for transplant” when compared with ML candidates (13%) (p < 0.001). This remained true for waitlist removals coded as “condition improved” (SL 2% and ML 0.9%; p = 0.004).

Multivariate logistic regression model for the odds of ML is presented in Table 2, with increased odds of ML demonstrated among male, white, blood type O candidates with a college education, private insurance, and without exception points. In addition, there was a higher likelihood of ML for LT candidates with cholestatic liver disease or metabolic liver disease/biliary atresia, but decreased odds of ML for those candidates with diabetes or the need for dialysis. Finally, candidates demonstrated significantly higher odds of pursuing ML as time on the waitlist increased (Fig. 2B).

Multiply listed candidates: receiving transplants vs not receiving transplants

In comparison with the ML-LT group, patients in the ML group who did not receive transplants (ML-NT) (440 patients [32.4%];) were more often female (33.6% vs 27.3%; p = 0.02) and more likely to lack exception points at primary listing (93.2% vs 81.5%; p :≤ 0.001) (Table 1). Patients in the ML-NT group, when compared with the ML-LT group, were less likely to be college educated (50.7% vs 57.8%; p = 0.01) and less likely to have private insurance (72.0% vs 77.3%; p = 0.03). In addition, patients in the ML-NT group compared with patients in the ML-LT group appeared to have more evidence of hepatic decompensation, as demonstrated by the considerably higher proportion of patients with encephalopathy and need for dialysis before primary listing (Table 1).

Although the initial laboratory MELD at primary listing was a median of 14 for both ML-LT and ML-NT, the median laboratory MELD score at the time of secondary listing increased to 17 (IQR 13 to 21) for the ML-LT group, but remained at 14 (IQR 11 to 18) for the ML-NT group (p < 0.001) (Table 1). When compared with the ML-LT group, the ML-NT candidates spent more time on the waitlist at both the primary DSA (median 678 days [IQR 277 to 1,290 days]; vs 330 days [IQR 169 to 655 days];; p < 0.001) and secondary DSAs (median 259 days [IQR 93 to 644 days]; vs 53 days [18 to 131 days];; p < 0.001). Distance traveled between primary and secondary centers was greater for the ML-LT group when compared with the ML-NT group (median 588 miles [IQR 229 to 1,095 miles]; vs 356 miles [167 to 1009 miles];; p < 0.001) (Table 1).

Multiply listed candidates who received liver transplants vs singly listed candidates who received liver transplants

Nine hundred and eighteen (67.6%) ML candidates received liver transplants, 767 (83.6%) at the secondary listing center. Median match MELD at transplantation for ML-LT recipients was 22 (IQR 18 to 26) vs 24 (IQR 21 to 29) for SL-LT recipients ($p < 0.001$) (Table 1). Complete analysis of donor use between the ML-LT and SL-LT groups is demonstrated in Table 3. Overall, DRI for ML-LT and SL-LT recipients was comparable (median 1.39 [IQR 1.14 to 1.69]; vs median 1.39 [1.13 to 1.69];; $p = 0.83$) (Table 2). For the ML-LT group, median DRI was comparable for both primary and secondary listing DSA (data not shown).

Graft survival after LT is shown in Figure 3. After adjusting for variables significantly associated with graft loss in the Scientific Registry of Transplant Recipients report (see Methods), no difference in post-LT graft survival was detected by ML status vs SL status (hazard ratio = 0.72; 95% CI, 0.46–1.13; $p = 0.16$) (Fig. 3).

Regional perspective on exporting/importing

Net exporters of ML candidates were regions 1, 2, 5, 7, and 9; net importers were regions 3, 4, 6, 8, 10, and 11 (Fig. 4). After adjusting for disease severity and demographic factors, the likelihood of ML remained significantly associated with UNOS region. Compared with region 8, odds of ML were significantly increased for region 1 (odds ratio [OR]; = 1.8; 95% CI, 1.3–2.5), 5 (OR = 1.6; 95% CI, 1.3–2.1), and 9 (OR = 1.5; 95% CI, 1.2–2.0) (Table 2).

DISCUSSION

The success of LT has been limited by the number of deceased donors and by the sparse application of living donor LT. The disparity between supply and demand is accentuated by geographic inequity in access to LT. In response to local constraints, clinicians and patients have altered practice patterns with differential rates of marginal liver use,[3,5] living donor LT,[2] and ML. The differential use of ML across regions has represented a strategy to expedite LT, with migration of patients from areas of poor access to those with improved access.

We demonstrate that a distinct cohort of LT candidates pursue ML to accelerate LT. Multiply listed candidates come disproportionately from regions 1, 5, and 9, broadly recognized as the geographic areas that perform LTs at the highest match MELD scores. Successful ML candidates receive transplants at lower match MELD scores and within DSAs with shorter wait times than their originating DSA. Multiply listed candidates, compared with SL candidates, have less ascites, encephalopathy, and need for dialysis, which might allow for the greater capability to migrate to a secondary DSA. However, when compared with successful ML candidates, ML candidates who fail to achieve LT appear to have a greater degree of clinical decompensation, with evidence of more ascites, encephalopathy, and need for dialysis. The latter group represents a component of the liver transplant waitlist that remain underserved because they are unable to undergo LT despite migrating to secondary centers.

The previous investigation of ML in LT predates MELD allocation.[6] Between 1997 and 2000, white, male, more educated, privately insured, and blood type O candidates were more likely to pursue ML. Secondary listing sites had mean wait times 109 days shorter than primary listing sites and 77% of ML patients received transplants.[6] Despite the complete reconfiguration of allocation represented by MELD and Share 15 policies, the demographic and socioeconomic profile of the ML candidate has remained constant. A comparable proportion of ML candidates continue to receive transplants at the secondary listing center (76.8% pre-MELD vs 83.6% MELD era). However, MELD ML candidates traveled, on average, 148 miles farther in their pursuit of obtaining a liver transplant when compared with their pre-MELD counterparts.

Another recent analysis relevant to our work examined “inter-DSA travel,” defined as candidates who delist at their initial DSA and subsequently relist in a different DSA.[10] Inter-DSA travel candidates emanated predominantly from regions 1, 5, and 11 and shared similar demographic and socioeconomic characteristics as ML candidates. Notably, travel achieved reductions in waitlist mortality. Although at first, inter-DSA travel and ML candidates might appear to be largely overlapping, careful consideration indicates that they are distinct populations. Within our study period, only 253 candidates on the national waitlist fit the inter-DSA travel definition compared with 1,358 candidates who fit the ML definition. In addition, the sequential nature of the 2 listings required for inter-DSA travel compared with the overlapping nature of the 2 listings required for ML suggests that inter-DSA travel might be motivated by reasons other than organ access, including job and/or family relocation.

Although the percentage of ML candidates increased significantly during the latter portion of our study period, from 2009 to 2011, ML still represents a small fraction of LT listings. Given current geographic disparity in LT access and the benefit offered by ML, it is surprising that ML is not undertaken more frequently. It might be instructive to specifically query and determine which factors–patient, provider, and/or insurer–pose the greatest obstacle(s) to ML. The physical limitations imposed by decompensated end-stage liver disease might present the first and foremost obstacle to broad use of ML. Ironically, we have shown that the waitlisted candidate perhaps best suited for ML from a clinical perspective–the compensated cirrhosis patient with hepatocellular carcinoma–has a low likelihood of ML because they are often granted rapid and sure access to deceased donor livers through MELD exception points. This is similar to the decreased use of living donors in this population.

However, as ML remains used by few, and the profile of ML candidates suggests that these few are socioeconomically privileged, then the question is whether ML should continue to exist, a question that has been debated extensively.[6] Abolishing ML might not alter practice substantially, as demonstrated previously when ML for kidney transplantation candidates was banned in New York.[11] In the latter case, although banning ML resulted in a reduction of the overall rate of ML, it did not result in a more equitable and improved access to kidney transplantation. Multiply listed candidates can readily meta-morphose into inter-DSA travelers. It is evident that ML represents neither the solution nor the problem, but simply reflects the geographic disparity in liver allocation. Focus should remain on optimizing

allocation policy to improve equity in access to deceased donor livers rather than wider promotion and/or propagation of ML, as it is easier for an organ to travel than a patient.

This study is an observational, retrospective review using a national registry database. The assimilated data were not collected for the purpose of investigating ML, which is a limitation of this study. In addition, ML candidates represented only a small fraction (2.3%) of the total waitlist during the study period. To identify and isolate candidates who list at >1 transplantation center with the aim of expediting LT, we excluded those candidates who multiply listed within the same DSA; lacked overlap between their multiple listings; and traveled <50 miles between DSA listings. However, there is no algorithm to capture those patients who traveled to a distant center without first listing at their local center, and we excluded those who delisted before relisting at a secondary center–the inter-DSA travelers who have been studied recently.[10] It should be noted that an additional limitation rests in the potential inaccuracies within the UNOS database. Also, the dataset does not characterize a candidate's reason for pursuing ML, or document factors that influence this decision, for example, insurers, transplantation centers, patient finances, or secondary center proximity.

CONCLUSIONS

A discrete subset of LT candidates with distinct racial and socioeconomic characteristics list at multiple transplantation centers in disparate DSAs as a strategy to overcome geographic inequities inherent in access to deceased donor livers to expedite LT. The profile of ML candidates has remained stable for >15 years, despite wide-sweeping changes in allocation policy. Multiple listing, accessible to only a small and select segment of the entire waitlist, yields individual but not communal benefit. As mandated by the Organ Procurement and Transplantation Network Final Rule,[12] which states that nationwide geographic disparities must be minimized, we must continue to develop strategies to better level access to deceased donor livers across regional boundaries. The latter should be carefully explored and pursued, as they can benefit a broad swath of the waitlist and resonate with principles of equity and justice.

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Abbreviations and Acronyms

DRI	Donor Risk Index
DSA	donor service area
HCV	hepatitis C virus
IQR	interquartile range

LT	liver transplantation
MELD	Model for End-Stage Liver Disease
ML	multiple listing
NT	no transplantation
OR	odds ratio
SL	single listing
UNOS	United Network for Organ Sharing

REFERENCES

1. Yeh H, Smoot E, Schoenfeld DA, Markmann JF. Geographic inequity in access to livers for transplantation. Transplantation. 2011; 91:479–486. [PubMed: 21200366]
2. Vagefi PA, Ascher NL, Freise CE, et al. Use of living donor liver transplantation varies with the availability of deceased donor liver transplantation. Liver Transpl. 2012; 18:160–165. [PubMed: 22006378]
3. Lai JC, Roberts JP, Vittinghoff E, et al. Patient, center and geographic characteristics of nationally placed livers. Am J Transplant. 2012; 12:947–953. [PubMed: 22300591]
4. Renz JF, Kin C, Kinkhabwala M, et al. Utilization of extended donor criteria liver allografts maximizes donor use and patient access to liver transplantation. Ann Surg. 2005; 242:556–563. discussion 563–565. [PubMed: 16192816]
5. Halldorson JB, Paarsch HJ, Dodge JL, et al. Center competition and outcomes following liver transplantation. Liver Transpl. 2013; 19:96–104. [PubMed: 23086897]
6. Merion RM, Guidinger MK, Newmann JM, et al. Prevalence and outcomes of multiple-listing for cadaveric kidney and liver transplantation. Am J Transplant. 2004; 4:94–100. [PubMed: 14678039]
7. Organ Procurement and Transplantation. Assessing Current Policies and the Potential Impact of the DHHS Final Rule: Committee on Organ Procurement and Transplantation Policy, Division of Health Sciences Policy, Institute of Medicine. National Academy Press; Washington, DC: 1999.
8. Merion RM, Schaubel DE, Dykstra DM, et al. The survival benefit of liver transplantation. Am J Transplant. 2005; 5:307–313. [PubMed: 15643990]
9. Washburn K, Pomfret E, Roberts J. Liver allocation and distribution: possible next steps. Liver Transpl. 2011; 17:1005–1012. [PubMed: 21634007]
10. Dzebisashvili N, Massie AB, Lentine KL, et al. Following the organ supply: assessing the benefit of inter-DSA travel in liver transplantation. Transplantation. 2013; 95:361–371. [PubMed: 23250334]
11. White AJ, Ozminkowski RJ, Hassol A, et al. The effects of New York state's ban on multiple listing for cadaveric kidney transplantation. Health Serv Res. 1998; 33:205–222. Pt 1. [PubMed: 9618668]
12. Organ Procurement and Transplantation Network-HRSA. Final rule with comment period. Fed Regist. 1998; 63:16296–16338. [PubMed: 10177763]

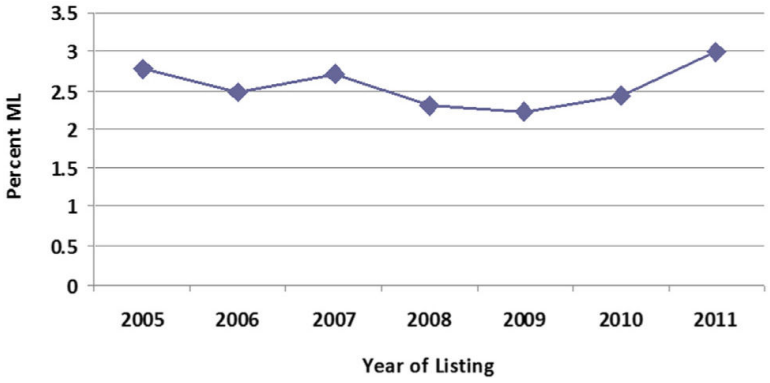

Figure 1.
Percent of multiply listed (ML) candidates per year during the study period (2005–2011).

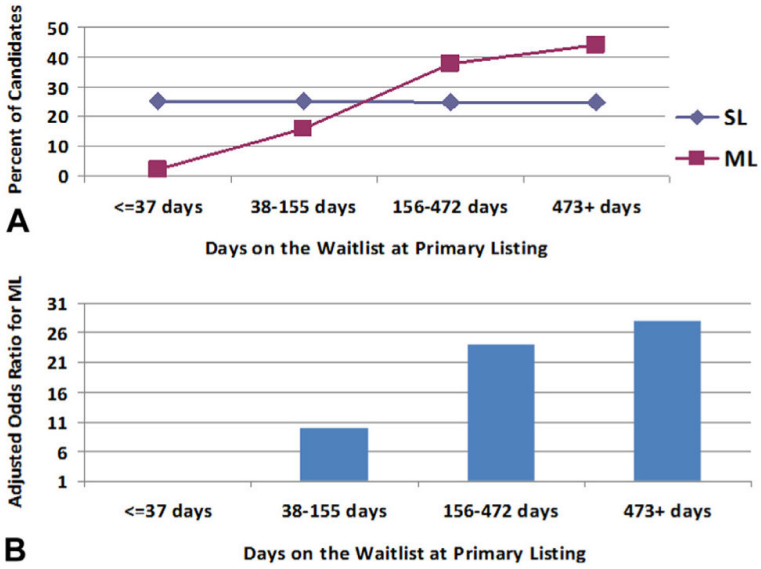

Figure 2.

(A) Comparison of days on the liver transplant waitlist for multiply listed (ML) and singly listed (SL) candidates, with (B) subsequent demonstration of increased odds of pursuing multiple listing as time on the waitlist increased.

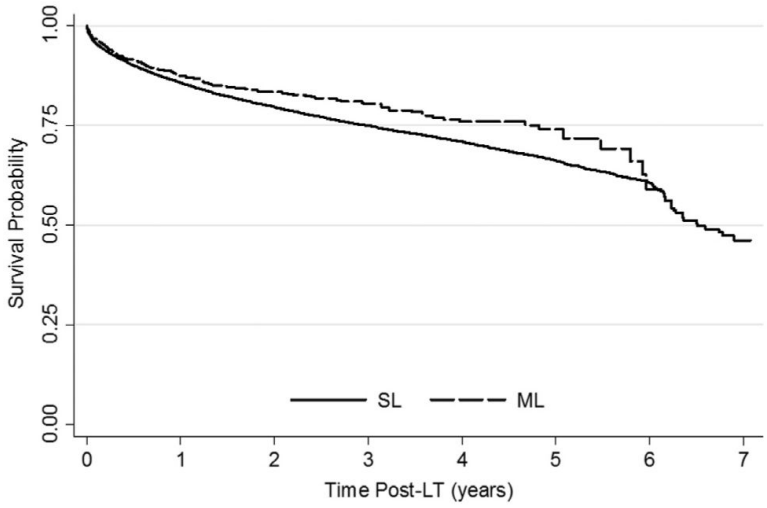

Figure 3.

Graft survival for multiply listed (ML) vs singly listed (SL) recipients of liver transplants. There was no significant difference in post liver transplantation (LT) graft survival between ML and SL recipients.

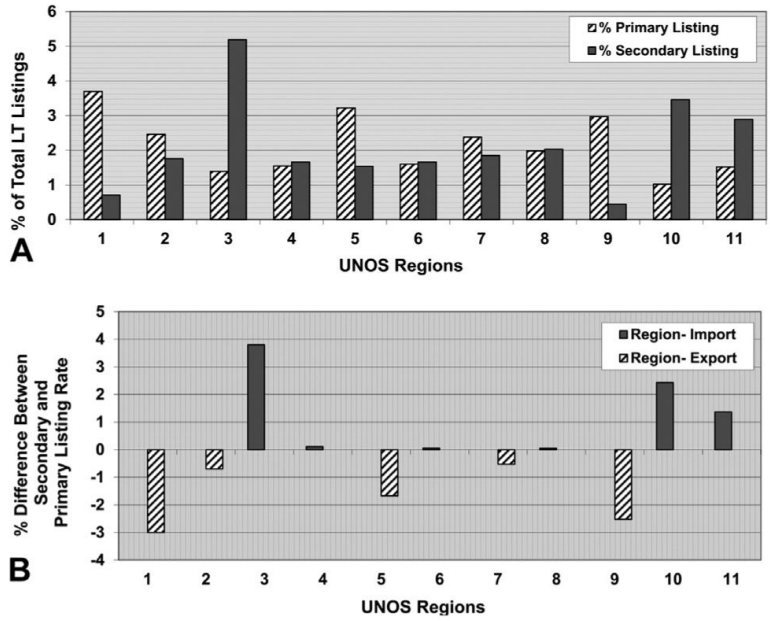

Figure 4.

Regional perspective on the migration of liver transplantation (LT) candidates. (A) Percent of LT candidates who multiple list as either a primary or secondary listing within each region. (B) Classification of regions as “export” of “import” of multiply listed candidates based on percent differences in listing within each region. UNOS, United Network for Organ Sharing.

Table 1

Characteristics of Multiply Listed vs Singly Listed Patients, and Multiply Listed Patients Not Receiving Transplants vs Multiply Listed Patients Receiving Transplants

Characteristic	SL (n = 58,199)	ML (n = 1,358)	p Value	ML-NT (n = 440)	WL-LT (n = 918)	p Value
Male, %	66.2	70.6	0.001	66.4	72.7	0.02
Ethnicity, %						
White	70.9	80.5	<0.001	79.3	81.0	0.45
Black	8.6	4.4	<0.001	5.0	4.1	0.47
Hispanic/Latino	14.8	10.9	<0.001	12.3	10.2	0.26
Asian	4.6	3.3	0.03	2.3	3.8	0.14
Other	1.1	0.9	0.43	1.1	0.8	0.47
Blood type, %						
A	37.6	38.4	0.54	36.6	39.3	0.33
AB	3.9	1.3	<0.001	0.5	1.7	0.05
B	12.3	8.4	<0.001	7.3	8.9	0.3
O	46.1	51.8	<0.001	55.7	50.0	0.0499
HCC exception point, %						
At primary listing	15.1	9.2	<0.001	4.1	11.7	<0.001
At secondary listing	n/a	11.9	n/a	5.7	14.9	<0.001
College educated, %	39.0	55.5	<0.001	50.7	57.8	0.01
Insurance at listing, %						
Medicare	20.3	14.4	<0.001	15.2	13.9	0.53
Medicaid	16.1	4.6	<0.001	*6.6*	3.7	0.02
Private	58.9	75.6	<0.001	72.0	77.3	0.03
Other	4.8	5.4	0.3	6.1	5.0	0.39
Diabetes, %	25.3	19.4	<0.001	19.3	19.5	0.94
ESLD diagnosis, %						
Hepatitis c virus	36.4	35.9	0.71	39.8	34.0	0.04
Alcoholic cirrhosis	16.1	11.9	<0.001	14.5	10.6	0.03
Noncholestatic cirrhosis	10.4	10.5	0.88	10.0	10.8	0.66
Cholestatic/AHN/PBC/PSC, %	9.8	16.0	<0.001	11.1	18.3	<0.001
Hepatitis B virus	2.5	1.8	0.1	2.0	1.6	0.59
Nonalcoholic steatohepatitis	7.3	5.7	0.02	7.7	4.7	0.02
Metabolic/biliary atresia/other	8.2	11.9	<0.001	9.8	13.0	0.09
Malignant neoplasm/hepatoma	9.4	6.4	<0.001	5.0	7.1	0.14
Ascites at listing	74.6	68.9	<0.001	70.9	67.8	0.26
Encephalopathy at listing	59.5	51.8	<0.001	57.7	48.9	0.002
Dialysis twice in wk before listing	5.0	1.6	<0.001	3.0	1.0	0.007
Age at primary listing, y, median (IQR)	55 (49-60)	54 (48-60)	<0.001	54 (47-60)	54 (48-60)	0.94

Characteristic	SL (n = 58,199)	ML (n = 1,358)	p Value	ML-NT (n = 440)	WL-LT (n = 918)	p Value
Match MELD, median (IQR)						
At primary listing	15 (11-21)	14 (11-17)	<0.001	13 (10-17)	14 (11-17)	0.01
At secondary listing	NA	16 (12-21)	NA	14 (11-18)	17 (13-21)	<0.001
At transplant	24 (21-29)	22 (18-26)	<0.001	NA	22 (18-26)	NA
On waitlist, d, median (IQR)						
At primary listing	151 (37-463)	402 (194-835)	<0.001	678 (277-1290)	330 (169-655)	<0.001
At secondary listing	NA	86 (26-246)	NA	259 (93-644)	53 (18-131)	<0.001
Between 1st and 2nd listing						
Days, median (IQR)	NA	243 (106-538)	NA	277 (132-678)	219 (97-506)	<0.001
Distance, mi, median (IQR)	NA	490 (206-1088)	NA	356 (167-1009)	588 (229-1095)	<0.001

AHN, acute hepatic necrosis; ESLD, end-stage liver disease; HCC, hepatocellular carcinoma; LT, liver transplantation; MELD, Model for End-Stage Liver Disease; ML, multiply listed; NA, not applicable; NT, no liver transplantation; PBC, primary biliary cirrhosis; PSC, primary sclerosing cholangitis; SL, singly listed.

Table 2

Multivariate Logistic Regression Model for the Odds of Multiple Listing

Characteristic	Odds ratio	95% CI	p Value
Sex, female vs male	0.76	0.67–0.86	<0.001
Ethnicity, black vs white	0.54	0.42–0.71	<0.001
Ethnicity, Hispanic/Latino vs white	0.74	0.61–0.88	0.001
Ethnicity, Asian vs white	0.61	0.44–0.83	0.002
ABO, A vs O	0.88	0.78–0.99	0.03
ABO, AB vs O	0.39	0.24–0.63	0.001
ABO, B vs O	0.66	0.54–0.80	<0.001
HCC exception points, yes vs no	0.70	0.57–0.85	<0.001
Education, college vs pre-college	1.91	1.67–2.17	<0.001
Insurance, Medicaid vs Medicare	0.37	0.27–0.49	<0.001
Insurance, private vs Medicare	1.38	1.17–1.62	<0.001
Diabetes, yes vs no	0.79	0.69–0.91	0.001
Earlier dialysis, yes vs no	0.53	0.34–0.83	0.006
ESLD, alcoholic cirrhosis vs all other	0.69	0.58–0.82	<0.001
ESLD, cholestatic/AHN/PBC/PSC vs all other	1.41	1.20–1.65	<0.001
ESLD, metabolic/biliary atresia/other vs all other	1.31	1.09–1.58	0.003
Region 1 vs 8	1.81	1.34–2.45	<0.001
Region 2 vs 8	1.22	0.93–1.61	0.15
Region 3 vs 8	1.04	0.77–1.41	0.78
Region 4 vs 8	0.76	0.56–1.05	0.09
Region 5 vs 8	1.64	1.28–2.11	<0.001
Region 6 vs 8	0.72	0.46–1.13	0.15
Region 7 vs 8	1.31	0.98–1.75	0.07
Region 9 vs 8	1.55	1.17–2.05	0.002
Region 10 vs 8	0.66	0.46–0.94	0.02
Region 11 vs 8	0.85	0.62–1.17	0.32
Days on waitlist, 38 to 155 days vs <37 days	10.06	6.59–15.36	<0.001
Days on waitlist, 156 to 472 days vs <37 days	24.24	15.91–36.94	<0.001
Days on waitlist, >472 days vs <37 days	27.95	18.19–42.95	<0.001
Initial age	0.88	0.83–0.93	<0.001
Initial MELD score	1.03	1.01–1.04	<0.001
Initial serum sodium	0.98	0.97–1.00	0.02

AHN, acute hepatic necrosis; ESLD, end-stage liver disease; HCC, hepatocellular carcinoma; MELD, Model for End-Stage Liver Disease; PBC, primary biliary cirrhosis; PSC, primary sclerosing cholangitis.

Table 3

Donor Characteristics of Multiply Listed and Singly Listed Transplant Recipients

Characteristic	SL-LT (n = 30,612)	ML-LT (n = 918)	p Value
Age, %			
39 y or younger	44.8	46.9	<0.001
40 to 49 y	19.9	21.9	<0.001
50 to 59 y	19.6	17.5	0.06
60 to 69 y	11.2	10.0	0.16
70+ y	4.6	3.6	0.97
Male, %	59.8	59.5	0.84
Blood type, %			
A	37.5	38.7	<0.001
AB	3.5	1.0	0.001
B	12.3	8.7	0.38
O	46.7	51.6	<0.001
Ethnicity, %			
White	67.8	69.4	<0.001
Black	16.5	16.1	0.004
Hispanic/Latino	12.2	11.7	0.03
Asian	2.3	1.5	0.55
Other	1.2	1.3	0.22
Share type, %			
Local	75.0	68.7	<0.001
Regional	19.3	26.5	<0.001
National	5.7	4.8	0.57
CIT, %			
<9	75.4	79.4	<0.001
9–11.9	14.4	12.4	0.24
≥12	4.8	4.0	0.6
Missing	5.5	4.1	0.87
Split liver, %	4.7	5.6	0.23
Cause of death, %			
Anoxia	18.6	20.2	<0.001
Other	2.5	2.7	0.09
Stroke	40.0	38.1	<0.001
Head trauma	35.2	34.0	<0.001
Live donor, %	3.6	5.0	0.03
HBV core+, %	5.3	4.8	0.5
HCV+, %	3.1	2.7	0.55

Characteristic	SL-LT (n = 30,612)	ML-LT (n = 918)	p Value
LT primary center, %	100.0	16.4	<0.001
DCD, %	5.2	6.3	0.12
CDC high risk, %	8.9	7.0	0.04
DRI, median (IQR)	1.39 (1.13–1.69)	1.39 (1.14–1.68)	0.83

CIT, cold ischemic time; DCD, donation after cardiac death; DRI, Donor Risk Index; HBV, hepatitis B virus; HCV, hepatitis C virus; IQR, interquartile range; LT, liver transplantation; ML, multiply listed; SL, singly listed.