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Impact of Race and Ethnicity on Outcomes for Children Waitlisted for Pediatric Liver Transplantation

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Abstract

Objective—African Americans and other minorities are known to face barriers to health care influencing their access to organ transplantation but it is not known whether these barriers exist among pediatric liver transplant waitlist candidates. We sought to determine whether outcomes on the waitlist (i.e., mortality, deceased donor liver transplantation (DDLT), and living-donor liver transplantation (LDLT)) varied by race/ethnicity.

Methods—National registry data were studied to estimate the race/ethnicity-specific risk of waitlist mortality, DDLT and LDLT in children (<18 years) waitlisted between March, 2002 and March, 2015.

Results—There was no evidence of racial/ethnic disparities in waitlist mortality. Compared to Caucasians, LDLT varied by race/ethnicity, with only 6.7% African Americans and 10.3% Hispanic children receiving LDLT compared with 12.4% Caucasian, 13.3% Asian, and 9.4% mix/other children. In an adjusted Cox proportional hazards model, African Americans were half as likely as Caucasians to use LDLT (hazard ratio (HR): $_{0.41}0.55_{0.73}$) but had similar use of DDLT (HR: $_{0.98}1.06_{1.16}$). In a model that considered mortality, DDLT, and LDLT as competing risks, African Americans had significantly reduced incidence of LDLT (subhazard ratio (sHR): $_{0.41}0.56_{0.75}$) compared to Caucasians, but increased use of DDLT (sHR: $_{1.06}1.16_{1.26}$).

Conclusion—Compared to Caucasian children, African-American children are less likely to use LDLT but have higher rates of DDLT and similar survival on the waitlist. Additional research is necessary to understand the clinical and socioeconomic factors contributing to lower utilization of LDLT among African-American children awaiting transplantation.

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Disclosure

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Keywords

disparities; living-donor; liver; transplant; pediatric

INTRODUCTION

Since implementation of the Pediatric End-stage Liver Disease (PELD) and Model for End-stage Liver Disease (MELD) system in 2002, liver transplantation has provided life-saving therapy for over 5,000 children in the United States[1]. Outcomes after transplantation in children are excellent, with 1-year and 5-year survival reported to be 95% and 85%, respectively[2]. Furthermore, increasing experience with newer surgical techniques in recent years, such as living-donor liver transplantation (LDLT), may yield outcomes that are superior to whole liver transplantation while allowing for shorter waitlist periods and a reduction in associated pre-transplant morbidity[3,4].

There is strong evidence that health disparities exist between individuals from different racial/ethnic groups that are waitlisted for organ donation, and these disparities are likely to apply to children with end-stage liver disease (ESLD) as well[5,6]. First, African-American adults with ESLD are less likely to be referred for liver transplantation and are more likely to die while awaiting transplantation[5]. Second, use of LDLT is significantly reduced in African-American adults[7]. Third, racial/ethnic disparities exist in access for children with end-stage kidney disease awaiting transplantation, as well as in their use of living donation[8]. Fourth, Hsu *et al.* report that nearly one third of children on the liver transplant waitlist are ultimately transplanted through use of exception points, for which use differs by race/ethnicity[9,10].

Given the evidence that racial/ethnic disparities exist among adults awaiting organ donation and children awaiting kidney donation, we evaluated whether these disparities exist for children awaiting liver transplantation. Specifically, we hypothesize that African-American children have lower rates of living donation for liver transplantation and that the lower rate cannot be explained by geographic consolidation around centers that do not offer LDLT. Furthermore, given the lower use of exception points for African Americans, the possibility exists that this group is disadvantaged with respect to waitlist mortality and access to deceased livers.

METHODS

Data Source

This study used data from the Scientific Registry of Transplant Recipients (SRTR). The SRTR data system includes data on all donors, waitlisted candidates, and transplant recipients in the U.S., submitted by the members of the Organ Procurement and Transplantation Network (OPTN) and has been described elsewhere[11]. The Health Resources and Services Administration (HRSA), U.S. Department of Health and Human Services, provides oversight to the activities of the OPTN and SRTR contractors. 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 U.S. Government.

Study Population

This study included pediatric (age less than 18 years), liver-only transplant candidates who were initially listed between March 1, 2002 (i.e., implementation of PELD/MELD), and October 31, 2014. Data were administratively censored on March 31, 2015. Candidates listed for re-transplantation or listed as Status 1A were excluded from analysis.

Candidate Race/Ethnicity

Candidate race/ethnicity was classified as Caucasian/White (i.e., Caucasian non-Hispanic), African American/Black, Hispanic/Latino (i.e., Caucasian Hispanic), Asian, and mixed/other.

Hazard of Waitlist Outcomes by Candidate Race/Ethnicity Group

Waitlisted candidates were followed until they received a DDLT (either a whole liver transplant or segmental graft from a deceased donor), LDLT, or died. Death was defined by the date that an individual was removed from the waitlist due to death, medical unsuitability or refusal to transplant for declining health, or deteriorating condition, regardless of whether the candidate was active or not on the waitlist. The hazards of DDLT, LDLT, and mortality while on the waitlist were examined individually using Cox proportional hazards regressions to model the cause-specific hazards in unadjusted and adjusted models. In Cox proportional hazard models, individuals are followed from time entry (i.e., listing) to the time that they have an event (e.g., transplant, death), are lost-to-follow-up, or are administratively censored. In considering one of the three specific events, candidates were censored when either of the other two outcomes occurred (for example, in considering mortality, candidates were censored once they received either a DDLT or LDLT). This method allowed us to identify candidate-specific risk factors, including race/ethnicity and other potential biologic associations with waitlist outcomes independent of the effects of organ allocation.

Subhazard of Waitlist Outcomes Accounting for Organ Allocation

In order to evaluate the association between race/ethnicity and outcomes due to the allocation system, DDLT, LDLT, and mortality were considered together in a competing risk regression[12]. In a competing risk regression, instead of censoring candidates when an alternate outcome occurs, the subhazards account for the fact that the candidate is at risk of more than one outcome and that these outcomes compete or preclude each other. For example, if a candidate receives a LDLT, they are no longer at risk of receiving a DDLT.

Sensitivity Analysis of Centers Performing LDLT

To verify that any reduced rate of LDLT among African Americans (or any race/ethnic group) was not due to geographic consolidation away from centers where LDLT was not available, a sensitivity analysis was performed on centers that had performed ≥1 LDLT per year during the study period on pediatric recipients.

Statistical Analysis

Categorical variables were compared using a chi-square test. Comparison of continuous variables was made using Wilcoxon rank-sum test. Cox proportional hazard models were used to compare the hazard ratio (HR) for each outcome, as well as the subhazard ratio (sHR) in a competing risk model. All analyses were adjusted for primary diagnosis (i.e., biliary atresia, inborn error of metabolism, tumor, and other), weight, ABO blood type, status 1B, insurance status, and year. Age was excluded from the multivariable analysis because there was evidence of collinearity with weight (variance inflation factor < 2.5), which would lead to overfitting of the model. Analyses were also adjusted using a patient's calculated or laboratory PELD/MELD score; based on prior research, exception points were considered a mediator between race/ethnicity and outcomes and therefore should not be included from adjustment in a multivariable model[10]. PELD was used for children on the waitlist before they turned 12 years old, and MELD was used for children on the waitlist who were older than 12 years. Because an individual's weight and PELD/MELD score change over time, these variables were treated as time-varying variables, meaning that the specific time that an individual spent at each level contributed separately to the risk of a given outcome. The multivariable model also analyzed the change in the allocation score for every 5 points, meaning that there is no reference value. There were no missing data for any variables in the model. The proportional hazards assumption was checked using complementary log-log curves. Statistical significance was tested using a two-sided α of 0.05. Confidence intervals are reported using the method of Louis and Zeger, as previously reported[13,14]. All analyses were performed using STATA 14.0 (College Station, TX, USA). This study was approved by the Institutional Review Board of Johns Hopkins University School of Medicine.

RESULTS

Waitlist Registrants

We studied 7,355 children on the liver waitlist including 1,184 (16.1%) African American, 3,927 (53.4%) Caucasian, 1,629 (22.1%) Hispanic, 390 (5.3%) Asian, and 225 (3.1%) children of mixed/other race/ethnicity (Table 1). Biliary atresia (BA) was the indication for transplant in 2,398 (32.6%) registrants, whereas 3,869 (52.6%) were listed for reasons other than BA, metabolic disease, or malignancy. The median (interquartile range (IQR)) calculated PELD/MELD score at listing was 15 (6–27). Among waitlisted children, 4,532 (61.6%) ultimately received a DDLT and 558 (7.6%) received a LDLT, whereas 631 (8.6%) children died on the waitlist and 1,634 (22.2%) were still on the waitlist at the end of the study.

Characteristics by Race/Ethnicity

Compared to Caucasians, African Americans had lower median age at listing (14 vs. 20 months; pairwise $P = 0.002$) and at removal (22.2 vs. 31.2 months; $P = 0.01$; Table 2) alongside lower median weight at listing (8.7 vs. 10.9 kg; pairwise $P < 0.001$) and at removal (10.2 vs. 12.0 kg; $P < 0.001$). At the same time, the median allocation score was higher for African Americans compared to Caucasians at listing (15 vs.10; pairwise $P < 0.001$) and at removal (17 vs.14; $P < 0.001$). ABO blood type and disease category also

varied across all races (groupwise $P < 0.001$). African Americans were less likely to be granted exception points compared to Caucasian (30.7% vs 41.3%; pairwise $P < 0.001$), Asian (40%; $P = 0.001$), or Hispanic (35.2%; $P = 0.017$) children on the waitlist. Among those who ultimately received a DDLT, there was no difference in the use of whole liver transplantation compared to split liver transplantation by African-American and Caucasian recipients (split: 75.2 vs. 74.3%; pairwise $P > 0.05$).

Predictors of Outcomes on Waitlist

Compared to Caucasians, African Americans had significantly higher 1-year unadjusted cumulative incidence of DDLT (65.3% vs. 63.8%; competing risk model $P = 0.04$), lower LDLT (4.9% vs. 8.8%; $P < 0.001$) and similar mortality (8.5% vs. 8.3%; $P > 0.05$; Table 3). Hispanics had higher mortality than Caucasian non-Hispanics (10.1% vs 8.3%; $P = 0.02$), lower use of LDLT (7.0 vs 8.8; $P = 0.047$) and similar use of DDLT (64.1% vs 63.8%; $P > 0.05$). In an adjusted Cox proportional hazard model, African Americans were half as likely as Caucasians to receive LDLT (HR: $_{0.41}0.55_{0.73}$) compared with Caucasians (Table 4a), while having similar rate of mortality (HR: $_{0.79}1.00_{1.26}$) and DDLT (HR: $_{0.98}1.06_{1.16}$). In an adjusted model that that considered the competing risk of DDLT, LDLT, and mortality, African Americans continued to show decreased use of LDLT (sHR: $_{0.41}0.56_{0.75}$) compared with Caucasians but had corresponding higher risk of DDLT (sHR: $_{1.06}1.16_{1.26}$; Table 4b). Subhazard of mortality in a competing risk did not vary by race/ethnicity. Analysis of data that excluded inactive person time did not change the findings.

In the competing risk model, for every 5 points higher in allocation score (e.g., 35 vs. 30, 15 vs. 10), there was greater risk of mortality (sHR: $_{1.94}2.03_{2.12}$), LDLT (sHR: $_{1.25}1.31_{1.38}$) and DDLT (sHR: $_{1.23}1.26_{1.28}$). However, compared to an allocation score of 40, status 1B was associated with lower mortality (sHR: $_{0.27}0.35_{0.45}$) and lower use of LDLT (sHR: $_{0.20}0.33_{0.54}$) but greater use of DDLT (sHR: $_{1.33}1.53_{1.77}$). Children ≤10 kg also had higher likelihood of death (sHR: $_{1.72}$ 2.13 $_{2.64}$), DDLT (sHR: $_{1.05}$ 1.14 $_{1.22}$) and LDLT (sHR: $_{1.77}$ 2.23 $_{2.82}$) compared with children weighing 15 kg or more. Individuals with blood type A (sHR: $_{1.24}1.33_{1.42}$) and AB (sHR: $_{.52}1.74_{2.00}$) had greater use of DDLT compared to individuals with blood type O, but did not have higher rate of mortality. Individuals with public insurance had lower use of LDLT (sHR: $_{0.45}0.54_{0.65}$), higher use of DDLT (sHR: $_{1.02}1.08_{1.15}$) and higher mortality (sHR: $_{1.16}1.38_{1.54}$). The probability of dying on the waitlist decreased each year from 2002 onward (sHR: $_{0.94}0.96_{0.99}$), while the probability of getting transplanted using DDLT (sHR: $_{1.02}1.03_{1.04}$) or LDLT (sHR: $_{1.02}1.04_{1.07}$) increased.

Center Impact

Among the 106 centers that performed a pediatric liver transplant over the study period, 89 centers performed at least one LDLT (84%), and 29 (27%) performed ≥1 LDLT per year. For individuals transplanted at centers performing ≥1 LDLT per year, the likelihood of LDLT for African Americans was one quarter that of Caucasians (sHR $_{0.39}0.25_{0.61}$; Table 5).

CONCLUSION

To the best of our knowledge, our study is the first to look at potential disparities for all outcomes (i.e., DDLT, LDLT, and death) for children awaiting liver transplantation since the adoption of the PELD/MELD system, and we demonstrate that disparities do exist for waitlisted children. Specifically, African Americans are half as likely as Caucasians to use LDLT. Furthermore, this observation was independent of insurance status, a factor that is well-known to correlate with, but not thoroughly account for, socioeconomic status (SES). Therefore, other aspects of an individual's SES may provide additional explanation for reduced use of LDLT in African Americans. Our findings also suggest that these variations are not due to consolidation of African Americans around centers that don't offer LDLT. These data also indicate that African Americans correspondingly receive DDLT at increased rates compared with Caucasians, an observation that could not be explained by a lack of availability of LDLT at those centers. Finally, Hispanic children had higher mortality compared to Caucasian non-Hispanic children in an unadjusted analysis, but risk of mortality between these groups was similar after adjustment in the multivariable model.

While the probability of waitlist mortality does not vary across race/ethnic groups, the use of exception points is associated with reduced risk of mortality, and their use has been shown to correlate with race/ethnicity[9,18]. Specifically, a recent publication by Hsu *et al.* noted that, while exception score request were made for 34% of waitlisted children and granted for 90% of these requests, the rate of requests for non-Caucasian children throughout their time on the waitlist was significantly lower than for Caucasian children[10]. Not surprisingly, these exception points were associated with increased likelihood of transplantation. However, the authors found a lower, but not statistically significant, rate of transplantation for non-Whites, whereas we demonstrate a higher rate of DDLT for African Americans. This discordance is likely to be explained in that our analysis separates out living and deceased donors and that the lower use of LDLT among African Americans correlates with the higher use of DDLT in this group. Additionally, the earlier study did not report on racial differences in mortality, whereas our study suggests that the overall mortality is the same between groups.

We found that African Americans, compared to Caucasians, have lower weights at listing and removal from the list (i.e., death or transplant) while simultaneously they have higher allocation scores at listing and removal. It is not clear if these observations are the consequence of some bias on the part of providers, or if the natural history varies by race such that African American children progress more rapidly toward ESLD. Presently, there is little evidence to suggest that the natural history of biliary atresia, the indication for nearly half of all liver transplants, varies by race/ethnicity[19,20]. Similarly, there is no evidence that age at Kasai, an important predictor of outcomes in biliary atresia, is associated with race. At the same time, listing individuals when they have more severe disease, as evidenced by higher PELD/MELD score and lower weight, may make LDLT less feasible and may be associated with worse outcomes after transplantation.

The evaluation of the association between race/ethnicity and outcomes for individuals awaiting liver transplantation has been inconclusive, and research has been largely limited to studies of adult candidates that vary from children with respect to their underlying disorders.

Reid *et al.* looked at outcomes for adult waitlist candidates in the pre-MELD era and found higher rates of mortality and lower rates of transplantation in African-American candidates compared to Caucasians[21]. However, two studies from the post-MELD era found equivalent likelihood of death and transplantation for African Americans and Caucasians[22,23]. Finally, a study of children with BA, the most common pediatric cause of ESLD, did not identify race/ethnicity as a risk factor for waitlist mortality but also did not specifically look at rates of LDLT[19].

Our finding that African-American children waitlisted for transplant are half as likely to use LDLT is new, but not surprising. Several investigators have identified a range of barriers to transplantation experienced by racial/ethnic minorities awaiting transplantation, and have suggested these barriers are multifactorial[5,6]. For example, a study of adult liver transplant patients that collected data on the evaluation of potential living donors noted that African-American patients had less inquiries per patient for LDLT than Caucasian patients[7]. Although this study of waitlisted adult patients did not have additional socioeconomic data of potential living donors or recipients, reports from the kidney transplant literature show a similar decrease in the rates of living donation among African Americans and these have been attributed to financial concerns, reluctance to ask family members, distrust of the medical community, and lack of health literacy or understanding of the process[6,7,24,25]. One limitation from our study is that the only socioeconomic status variable recorded in SRTR is insurance status, which does not fully represent a true surrogate. Consequently, we are not able to explain how varying rates of LDLT by race may be due in part to variations in socioeconomic status such as education and cultural literacy or frequency of single-income household.

Although pre-transplant mortality was comparable for African Americans and Caucasians, lower rates of LDLT in African Americans may have significant effects on both their pre-transplant morbidity as well as their post-transplant morbidity and mortality. Specifically, studies of adult candidates awaiting transplant have demonstrated that patients undergoing LDLT are transplanted at lower MELD scores and consequently have lower pre-transplant length of hospital stay, length of stay in the intensive care unit, and lower hospital costs[26]. Similar discrepancies in pre-transplant morbidity likely occurs among children awaiting transplantation. At the same time, living donation may be associated with improved patient and graft survival compared to deceased donation[3,4,17]. Therefore, lower rates of LDLT among African-American children awaiting transplantation has implications that extend beyond access to treatment for ESLD, but to long-term morbidity and mortality as well.

It is clear that increasing the supply of available organs will positively affect quality of life for children awaiting transplantation, and earlier transplantation would likely have a positive impact on long-term outcomes following transplantation as well. Living donation is one important method of increasing this supply. While our study identifies African-American children as being listed at higher PELD/MELD scores and less likely to use a living donor, our study is limited in its ability to identify the root cause of these disparities. Do physicians advocate for this approach at different rates depending on race/ethnicity? Are the patients' families unaware LDLT is an option? Is the decision to pursue LDLT or DDLT influenced heavily by the family's available resources and ability to interrupt a source of income while

care is being provided to both the sick child and the donor? Or do other variables such as health literacy or differences in culture account for reduced rates of living donation? Depending on the reason for decreased rates of LDLT in African-American children, there may be solutions that would yield higher rates of living donation to the benefit of African Americans and all waitlisted children.

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Abbreviations

DDLT	deceased-donor liver transplant
HR	hazard ratio
LDLT	living-donor liver transplant
sHR	subhazard ratio

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What is Known

- There is evidence that health disparities occur among individuals from different race/ethnic groups waitlisted for organ donation, but little is known regarding whether variations in outcomes occur for children awaiting liver transplantation.
- Reduced use of living-donor liver transplantation has been reported for African-American adults.
- African-American children are less likely to be transplanted using exception points.

What is New

- African-American children are half as likely as Caucasian children to use living-donor liver transplantation, but have higher rates of deceased donation.
- Mortality for children waitlisted for liver transplantation does not vary by race/ethnicity.

Table 1

Characteristics of pediatric waitlist registrants

Characteristic	No. (%)
Age in months (median, IQR)	
at listing	16 (7–101)
at end of follow-up*	25.5 (10.3–114.6)
Weight in kg (median, IQR)	
at listing	9.7 (6.6–24.8)
at end of follow-up	11 (7.3–26.3)
Female	3,726 (50.7)
Race/ethnic group	
African American	1,184 (16.1)
Caucasian	3,927 (53.4)
Hispanic	1,629 (22.1)
Asian	390 (5.3)
mixed/other	225 (3.1)
Blood type	
O	3,648 (49.6)
A	2,467 (33.5)
B	952 (13)
AB	288 (3.9)
Disease	
biliary atresia	2,398 (32.6)
metabolic disease	211 (2.9)
malignancy	877 (11.9)
other	3,869 (52.6)
Outcome	
death	631 (8.6)
living-donor liver transplant	558 (7.6)
deceased donor liver transplant	4,532 (61.6)
whole liver transplant	3,304 (72.9)
split/partial	1,228 (27.1)
censored	1,634 (22.2)
PELD/MELD score (median, IQR)	
at listing	15 (6–27)
at end of follow-up	27 (15–40)
Status 1B	323 (4.4)
Private insurance	3,392 (46.1)

* end of follow-up occurs at transplantation, death, or administrative censoring

Table 2

Patient characteristics by race/ethnicity

	Caucasian	African American	Hispanic	Asian	mixed/other	*P*[*]
Number	3,927	1,184	1,629	390	225	
Age in months (median, IQR)						
at listing	20 (7–121)	14 (7–102.5)	14 (6–70)	13 (7–74)	10 (6–30)	<0.001
at end of follow-up[**]	31.2 (10.7–131)	22.2 (10.9–113.2)	23 (9.9–87.6)	21.3 (9.5–88.7)	15.2 (8.0–39.1)	<0.001
Weight in kg (median, IQR)						
at listing	10.9 (6.7–20.6)	8.7 (6.3–25.5)	9.0 (6.6–19.0)	8.9 (6.8–18.6)	7.8 (6.2–12.5)	<0.001
at end of follow-up[**]	12.0 (7.4–30.3)	10.2 (7.2–27.0)	10.3 (7.4–21.0)	10.3 (7.4–19.6)	9.0 (6.9–13.7)	<0.001
Female (%)	49.6	52	53.3	47.4	48.9	>0.05
Blood type (%)						
O	46.3	47.8	60.4	40.8	53.8	<0.001
A	39.3	25	28.2	25.6	31.1	
B	10.4	21.8	8.8	29.7	11.5	
AB	4	5.4	2.6	3.9	3.6	
Years of follow-up (median, IQR)	0.5 (0.2–1.5)	0.5 (0.2–1.5)	0.4 (0.2–1.3)	0.5 (0.2–1.1)	0.4 (0.2–1.0)	>0.05
PELD/MELD Score (median, IQR)						
at listing	10 (6–18)	15 (7–21)	11 (6–20)	12 (6–20)	15 (6–22)	<0.001
at end of follow-up	14 (6–22)	17 (9–23)	15 (6–23)	13 (6–21)	18 (8–27)	<0.001
Exception points (%)	41.3	30.7	35.2	40	28.9	<0.001
Status 1B (%)	4.3	4	4.8	3.6	6.7	>0.05
Disease (%)						
biliary atresia	29.7	36.5	32.3	46.7	40	<0.001
metabolic	3.6	1.3	3	1.8	0.9	
malignancy	12.8	7.5	12.8	13.1	11.5	
other	53.9	54.7	51.9	38.4	47.6	
Private insurance (%)	59.4	30.9	24.1	58.5	33.3	<0.001

[*] Groupwise *P* values

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** End of follow-up occurs at transplantation, death, or administrative censoring.

Table 3

1-year unadjusted cumulative incidence by race/ethnic group

	Mortality (%)	*P*	DDLT (%)	*P*	LDLT (%)	*P*
Caucasian non-Hispanic	8.3	–	63.8	–	8.8	–
African American	8.5	>0.05	65.3	0.04	4.9	<0.001
Hispanic	10.1	0.02	64.1	>0.05	7	0.047
Asian	7	>0.05	68	>0.05	10.1	>0.05
mixed/other	14.3	0.001	64.9	>0.05	5.7	>0.05

P value from coefficient in competing risk regression

Table 4a

Estimates of Hazard Ratios (HR) by Outcome

	Mortality	DDLT	LDLT
Race/ethnic group			
Caucasian non-Hispanic	–	–	–
African American	$_{0.79}1.00_{1.26}$	$_{0.98}1.06_{1.16}$	$\mathbf{_{0.41}0.55_{0.73}}$
Hispanic	$_{0.94}1.14_{1.39}$	$_{0.92}0.99_{1.08}$	$_{0.73}0.92_{1.15}$
Asian	$_{0.71}1.06_{1.59}$	$_{0.93}1.06_{1.21}$	$_{0.67}0.94_{1.33}$
mixed/other	$_{0.97}1.41_{2.06}$	$_{0.79}0.94_{1.11}$	$_{0.41}0.70_{1.20}$
Allocation score (per 5 points increase)	$\mathbf{_{1.94}2.03_{2.12}}$	$\mathbf{_{1.23}1.26_{1.28}}$	$\mathbf{_{1.25}1.31_{1.38}}$
Status 1B (to PELD/MELD 40)	$\mathbf{_{0.27}0.35_{0.45}}$	$\mathbf{_{1.33}1.53_{1.77}}$	$\mathbf{_{0.20}0.33_{0.54}}$
Diagnosis			
biliary atresia	–	–	–
metabolic disease	$_{0.26}0.70_{1.92}$	$_{1.00}1.18_{1.39}$	$_{0.34}0.62_{1.15}$
malignancy	$_{0.49}0.74_{1.13}$	$\mathbf{_{1.04}1.16_{1.30}}$	$_{0.54}0.78_{1.12}$
other	$\mathbf{_{1.75}2.16_{2.66}}$	$\mathbf{_{0.64}0.69_{0.74}}$	$\mathbf{_{0.35}0.43_{0.52}}$
Weight			
≥15 kg	–	–	–
10–15 kg	$\mathbf{_{1.19}1.57_{2.06}}$	$_{0.85}0.93_{1.02}$	$\mathbf{_{1.14}1.52_{2.03}}$
≤10 kg	$\mathbf{_{1.72}2.13_{2.64}}$	$\mathbf{_{1.05}1.14_{1.22}}$	$\mathbf{_{1.77}2.23_{2.82}}$
Blood type			
O	–	–	–
A	$_{0.93}1.11_{1.33}$	$\mathbf{_{1.24}1.33_{1.42}}$	$_{0.91}1.09_{1.31}$
B	$_{0.96}1.22_{1.54}$	$_{1.00}1.10_{1.21}$	$_{0.81}1.05_{1.36}$
AB	$_{0.39}0.70_{1.25}$	$\mathbf{_{1.52}1.74_{2.00}}$	$_{0.38}0.69_{1.22}$
Insurance			
private	–	–	–
public/other	$\mathbf{_{1.16}1.38_{1.54}}$	$\mathbf{_{1.02}1.08_{1.15}}$	$\mathbf{_{0.45}0.54_{0.65}}$
Year (2002 reference)	$\mathbf{_{0.94}0.96_{0.99}}$	$\mathbf{_{1.02}1.03_{1.04}}$	$\mathbf{_{1.02}1.04_{1.07}}$

Table 4b

Estimates of Subhazard Ratios (sHR) by Outcome

	Mortality	DDLT	LDLT
Race/ethnic group			
Caucasian non-Hispanic	–	–	–
African American	0.74 0.94 1.19	**1.06 1.16 1.26**	**0.41 0.56 0.75**
Hispanic	0.89 1.10 1.36	0.91 0.99 1.07	0.71 0.90 1.13
Asian	0.57 0.87 1.34	0.90 1.04 1.20	0.65 0.91 1.28
mixed/other	0.92 1.37 2.06	0.77 0.93 1.13	0.39 0.66 1.14
Allocation score (per 5 point increase)	**1.60 1.69 1.77**	**1.06 1.08 1.11**	**1.07 1.13 1.19**
Status 1B (to PELD/MELD 40)	**0.23 0.32 0.44**	**1.80 2.12 2.50**	**0.21 0.34 0.54**
Diagnosis			
biliary atresia	–	–	–
metabolic disease	0.27 0.74 2.06	**1.03 1.18 1.36**	0.31 0.57 1.03
malignancy	0.50 0.81 1.33	**1.15 1.29 1.45**	**0.40 0.57 0.81**
other	**2.47 3.09 3.86**	**0.65 0.69 0.75**	**0.38 0.46 0.56**
Weight			
≥15 kg	–	–	–
10–15 kg	**1.09 1.44 1.89**	0.77 0.84 0.92	**1.15 1.52 2.01**
≤10 kg	**1.23 1.53 1.91**	**0.79 0.86 0.93**	**1.45 1.81 2.27**
Blood type			
O	–	–	–
A	0.77 0.93 1.12	**1.16 1.24 1.33**	0.76 0.92 1.11
B	0.91 1.17 1.49	0.94 1.04 1.15	0.73 0.95 1.24
AB	**0.25 0.45 0.82**	**1.57 1.83 2.14**	**0.27 0.48 0.85**
Insurance			
private	–	–	–
public/other	**1.10 1.33 1.53**	**1.04 1.11 1.19**	**0.43 0.52 0.63**
Year (2002 reference)	**0.91 0.93 0.95**	**1.03 1.04 1.05**	1.00 1.03 1.06

Table 5

Estimates of Subhazard Ratio (sHR) for LDLT for Individuals Waitlisted at Centers Performing ≥1 LDLT per year

Race/ethnic group	LDLT
Caucasian non-Hispanic	–
African American	$_{\mathbf{0.39}}\mathbf{0.25}_{\mathbf{0.61}}$
Hispanic	$_{0.81}1.07_{1.41}$
Asian	$_{0.69}1.02_{1.52}$
mixed/other	$_{0.38}0.78_{1.6}$