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Racial and Ethnic Differences in Mortality in Children Awaiting Heart Transplant in the United States

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Abstract

Racial differences in outcomes are well known in children after heart transplant (HT) but not in children awaiting HT. We assessed racial and ethnic differences in wait-list mortality in children < 18 years old listed for primary HT in the United States during 1999–2006 using multivariable Cox models. Of 3299 listed children, 58% were listed as white, 20% as black, 16% as Hispanic, 3% as Asian and 3% were defined as “Other”. Mortality on the wait-list was 14%, 19%, 21%, 17% and 27% for white, black, Hispanic, Asian and Other children, respectively. Black (hazard ratio [HR] 1.6, 95% confidence interval [CI] 1.3, 1.9), Hispanic (HR 1.5, CI 1.2, 1.9), Asian (HR, 2.0, CI 1.3, 3.3) and Other children (HR 2.3, CI 1.5, 3.4) were all at higher risk of wait-list death compared to white children after controlling for age, listing status, cardiac diagnosis, hemodynamic support, renal function, and blood group. After adjusting additionally for medical insurance and area household income, the risk remained higher for all minorities. We conclude that minority children listed for HT have significantly higher wait-list mortality compared to white children. Socioeconomic variables appear to explain a small fraction of this increased risk.

Keywords

Heart transplantation; pediatrics; race; racial and ethnic disparities; waiting list; waiting list mortality

Introduction

Racial disparities in utilization of transplant for end-stage organ dysfunction are well known in adults, particularly in patients with advanced renal disease where whites are more likely to be listed for renal transplant than blacks for otherwise comparable disease.(1–3) These disparities have been explained by clinical differences between racial groups that may make transplant a more appropriate therapy for whites, under use of transplantation among blacks

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and overuse among whites.(4) Racial differences in renal transplant listing have also been reported in children with end stage renal disease.(5)

Racial or ethnic differences in utilization of heart transplant for advanced heart failure are not known in either adults or children. The current guidelines for management of heart failure in children(6) and for indications to list children for heart transplant (7), if followed in practice, would be expected to result in similar outcomes across racial and ethnic groups in children with heart failure of comparable severity. Racial differences in outcomes *after* HT are known in children; black pediatric heart transplant recipients are known to have higher incidence of graft failure.(8) This association has been largely attributed to differences in biologic (genetic and immunologic) factors between racial groups rather than due to social factors or health care disparities.(8–14) We were therefore surprised when we identified nonwhite race/ethnicity as one of the risk factors for wait-list mortality in children listed for heart transplant while analyzing data from the Organ Procurement and Transplantation Network (OPTN).(15) In this study, we sought to further evaluate racial and ethnic differences in mortality in children awaiting heart transplant in the United States (US) and to characterize potential mechanisms underlying these differences.

Materials and Methods

Study Population

All children less than 18 years of age who were listed for their primary heart transplant in the US between January 20, 1999 and December 29, 2006 were identified in the OPTN database. The OPTN data system includes demographic and clinical information data on all waiting list candidates, transplant recipients and donors the in the US, submitted by the members of the network (transplant centers). The Health Resources and Services Administration, US Department of Health and Human Services provides oversight to the activities of the OPTN contractor, the United Network for Organ Sharing.

On January 20, 1999, children previously listed as status 1 were now listed as either status 1A or status 1B based on urgency (1A being sicker patients). The new allocation scheme also attempted to lower the wait-list mortality of blood type O recipients by preferentially directing hearts from blood type O donors to blood type O recipients. We excluded children who were listed for heart re-transplantation or for multi-visceral transplantation. All children were followed from the time of listing for heart transplant until death, transplant, removal from the list or the day of last observation on August 3, 2007.

Study Design and Definitions

We tested the hypothesis that the risk of death while awaiting transplant was higher in minority racial/ethnic groups of children compared to white children listed for heart transplant. Time on the wait-list was defined as the duration from initial listing for heart transplant to the date of removal from the wait-list due to transplant, death, or recovery. Children who died while awaiting transplant were considered to have reached the primary endpoint. All clinical and demographic variables were defined at listing. Subjects were

censored at the time of transplant, recovery (removal from the list) or on August 3, 2007, the last day of the study.

The transplant centers reported patient race/ethnicity at the time of listing (a mandatory variable for listing) as one of the following: white (European descent, Arab or Middle Eastern, North African white, other or not-specified/unknown), black (African American, African, West Indian, Haitian, other or not-specified/unknown), Hispanic/Latino (Mexican, Puerto Rican, Cuban, other or not specified/unknown), Asian (Indian Subcontinent, Chinese, Filipino, Japanese, Korean, Vietnamese, other or not specified/unknown), American Indian/Alaska Native (American Indian, Eskimo, Aleutian, Alaskan Indian, other or not specified/unknown), Native Hawaiian/Pacific Islander, Multiracial, and Other. Due to sample size considerations, we categorized patients into 5 groups: white, black, Hispanic, Asian and Other.

To assess the level of hemodynamic support, a child was defined to be on extra-corporeal membrane oxygenation (ECMO) if supported on ECMO, on ventilator if on a ventilator but not on ECMO and on inotropes, if supported by inotropes but not on a ventilator or ECMO. To assess the socioeconomic position of children listed for HT, we extracted data for the median income of the zip code of patient residence from US census 2000 web site.(8) To assess renal function at the time of listing, we estimated creatinine clearance using serum creatinine and Schwartz formula.(16)

To assess the relationship of racial/ethnic groups to transplant center volume where the patients were listed, we divided transplant centers into low-volume (those with less than 40 children listed for heart transplant over the 8-year study duration, n=74), medium-volume (40–80 children listed, n=18) and high-volume (more than 80 children listed, n=13) centers.

Statistical Analysis

Summary statistics are presented as median values (inter-quartile range (IQR): 25th to 75th percentile) or number (percent). Patient characteristics were compared among racial/ethnic groups using the chi-square test for categorical variables and the Kruskal-Wallis test for continuous variables. Univariate relationships between race/ethnicity and wait-list mortality were assessed using the log-rank test. Multivariable analyses were performed using the Cox proportional hazards models. We first used a forward selection procedure to identify clinical variables associated with wait-list mortality; variables significant at the 0.10 level based on a likelihood ratio test were retained in the model. We then modeled the effect of race/ethnicity controlling for all significant clinical variables identified. To assess whether socioeconomic position contributed to the association of race/ethnicity with wait-list mortality, we then modeled the effect of race/ethnicity controlling for medical insurance and area median household income in addition to adjusting for significant clinical variables. We also performed competing risk analysis so as to model multiple observed outcomes (death, transplant, removal from the wait-list) in the cohort.(17) To examine the relationship between center volume and wait-list mortality using Cox model, we accounted for the lack of independence among patients treated at the same center. Finally, we assessed the association of race/ethnicity with wait-list mortality in pre-specified subgroups to evaluate the consistency of this relationship and to assess the interaction of race/ethnicity with other

variables. All tests were two-sided. The data were analyzed using statistical software SAS version 9.1 (SAS Institute Inc, Cary, NC) and STATA version 10.0 (StataCorp LP, College Station, TX).

The authors had full access to the data and take responsibility for its integrity. All authors have read and agree to the manuscript as written.

Results

Study Population

During the study period, 3617 children were listed in the US for heart transplant. Of these, 308 children were listed for heart re-transplantation and 10 for multi-visceral transplantation. These 318 children were excluded from further analysis. The remaining 3299 children formed the analytic cohort. Of these, 1913 (58%) were listed as white, 657 (20%) as black, 519 (16%) as Hispanic, 109 (3%) as Asian and the remaining 101 (3%) were defined as “Other” for the purpose of this analysis. The OPTN database reports race and ethnicity as two separate variables. For all white, black and Hispanic children in the cohort, race and ethnicity variables in the database were concordant (identical). The baseline characteristics of the study cohort are summarized in Table 1. The distributions of age, gender and weight were significantly different among the 5 racial/ethnic groups. White children were more likely to have congenital heart disease compared to other groups ($P<0.001$). However, the groups were not different with respect to the distribution of listing status, hemodynamic support and sensitized patients (those with pre-formed antibodies $>10\%$). There were differences in area household income and type of medical insurance among the groups ($P<0.001$ for each comparison); black and Hispanic children lived in areas with lower median household income than white children (\$33,352, \$37,516, and \$43,077 respectively) and were more likely to have public (Medicaid) medical insurance compared to white children (58%, 59% and 24% respectively). They were also more likely to have blood group O (54%, 62% and 46% respectively) and less likely to have blood group A (27%, 25% and 41% respectively) compared to white children ($P<0.001$ for blood type). Black children were less likely and Asian children were more likely to be listed at high-volume centers ($P<0.001$ for distribution of patients by center volume, Table 1).

None of the patients had any missing data for the variables race/ethnicity, age, listing status, diagnosis or the level of hemodynamic support. Two patients were missing blood group; these patients did not contribute to further analysis. Creatinine clearance was missing for 690 (21%) children. We created an indicator variable “creatinine clearance missing” to allow these subjects to contribute their other risk factors in the multivariable model.

Racial/Ethnic Differences in Wait-list Mortality

Of 3299 children in the study, 2075 (63%) received a transplant, 551 (17%) died while awaiting transplant, 548 (17%) were removed from the list (261 due to recovery, 147 due to deterioration and 140 due to miscellaneous reasons), and 125 (4%) were still waiting on the last day of the study. Figure 1 illustrates cumulative proportion of children in different racial groups who died on the wait-list pre-transplant. Wait-list mortality was 14% in white, 19%

in black, 21% in Hispanic, 17% in Asian and 27% in other children; time to death awaiting transplant was longest for white children and shortest for those classified as other ($P < 0.001$, log rank test). Death or de-listing due to deterioration occurred in 358 white (18.7%), 161 black (24.5%), 126 Hispanic (24.3%), 23 Asian (21.1%), and 30 other (29.7%) children. A comparison of competing outcomes between white and nonwhite children during the first 12 months after listing is demonstrated in Figure 2. In children who underwent heart transplant, median time to transplant was not significantly different between racial/ethnic groups; however 20% of nonwhite children had died on the wait-list by 12 months (Figure 2, panel B) compared to 14% of white children (Figure 2, panel A).

Table 2 demonstrates the association of race/ethnicity with wait-list mortality adjusted for clinical risk factors. After controlling for age, listing status, cardiac diagnosis, hemodynamic support at listing, creatinine clearance and blood group, black (hazard ratio HR 1.6, 95% confidence interval CI 1.3, 1.9, $P < 0.001$), Hispanic (HR 1.5, CI 1.2, 1.9, $P = 0.001$), Asian (HR, 2.0, CI 1.3, 3.3, $P = 0.003$) and other children (HR 2.3, CI 1.5, 3.4, $P < 0.001$) were all at higher risk for wait-list mortality compared to white children (Table 2, model 1). After adjusting additionally for type of medical insurance and area median household income, the risk of death remained higher for all minority children (HR 1.4 for black, 1.4 for Hispanic, 2.3 for Asian and 2.2 for Other children, $P < 0.01$ for all, Table 2, model 2). Public insurance (Medicaid) was also independently associated with higher wait-list mortality (HR 1.2, $P = 0.03$). Of note, there was no difference in wait-list mortality in low, medium and high volume centers (HR 1.0, $P = 0.99$ for low- versus high-volume centers; HR 1.0, $P = 0.79$ for medium- versus high-volume centers).

Because 4.5% of listed children were removed from the wait-list due to deterioration, we performed a secondary analysis where the outcome variable was a composite of death on the wait-list *or* removal from the list due to deterioration. In this multivariable model, the racial/ethnic groups remained significantly associated with outcome (HR 1.5, CI 1.2, 1.8, $P < 0.001$ for blacks; HR 1.3, CI 1.0, 1.6, $P = 0.03$ for Hispanics; HR 2.3, CI 1.5, 3.6, $P < 0.001$ for Asians, and HR 1.9, CI 1.3, 2.7, $P = 0.001$ for other children) controlling for all clinical and socioeconomic variables in Table 2, model 2.

Figure 3 demonstrates the risk of wait-list mortality in minority (nonwhite) children compared to white children in pre-specified subgroups controlling for all other risk factors identified in Table 3. The increased wait-list mortality in nonwhite children was seen in most subgroups of patients. There was a significant interaction between race and hemodynamic support at the time of listing ($P = 0.01$ for interaction, Figure 3). The increased risk of wait-list mortality for nonwhite children was highest in children supported with a ventilator at the time of listing (HR 2.3, 95% confidence interval CI 1.6, 3.3), was not increased in children on ECMO (HR 1.1, CI 0.7, 1.7), and was intermediate in those on neither ECMO or ventilator (HR 1.4, CI 1.1, 1.8) at the time of listing. The increased risk of wait-list mortality on ventilator support was similar for black and Hispanic compared to white children (HR 2.1 for black and 2.1 for Hispanic children) adjusted for other risk factors..

Discussion

In this study that included all children listed for their first heart transplant in the US over a recent 8-year period, we found that children of minority racial/ethnic groups were more likely to die while awaiting transplant than white children after controlling for patient factors such as underlying heart disease, heart failure severity and blood group. Although the magnitude of the increased risk of wait-list mortality for major racial minorities was not as high in multivariable analysis (hazard ratio 1.6 for black children and 1.5 for Hispanic children) as the risk associated with a diagnosis of congenital heart disease (hazard ratio 2.1), listing status 1A (hazard ratio 2.1) or level of invasive support, it was statistically significant and appears clinically important. While socioeconomic factors appeared to explain part of the increased risk (accounting for a third of increased risk in black children, 20 percent of the increased risk in Hispanic children and none in Asian or other children), race/ethnicity remained an important independent predictor of wait-list mortality. These findings concern us because they may represent racial/ethnic, and to a lesser extent socioeconomic, disparities in the provision of care.

The Institute of Medicine has defined “disparities” in health care as racial or ethnic differences in the quality of health care that are not due to access related factors or clinical needs, preferences or appropriateness of intervention.(18,19) Reduction and elimination of these health disparities are considered national health priorities in the US. To label racial and ethnic differences as disparities requires a careful evaluation of all potential mechanisms leading to these differences.(19–21)). Potential mechanisms of racial/ethnic differences in wait-list mortality include differences in access to care, illness severity at listing, response to therapy, disease progression, size of donor pool (due to differences in blood group or sensitization), patient/parental preferences and racial/ethnic disparities. We found no racial/ethnic differences in level of invasive support at the time of listing or in proportion of sensitized patients. Although blood group distribution favored white children (who were less likely to have blood group O than black or Hispanic children), the increased mortality risk in minorities was present even after controlling for blood group and other clinical variables.

The finding that risk of wait-list mortality was modified by patient hemodynamic support at the time of listing may provide mechanistic insights into outcome differences among groups. The risk of wait-list mortality in nonwhite children supported by a ventilator was strikingly higher compared to white children on a ventilator; however, no racial/ethnic difference in outcomes was seen in those supported by ECMO (Figure 3). This finding may suggest that minority children supported on a ventilator were either sicker at the time of listing or had a more rapid clinical deterioration compared to white children. In clinical practice, worsening of heart failure in a child already supported on a ventilator at the time of listing for transplant usually manifests as impending end-organ dysfunction when more aggressive care consists of support with ECMO or ventricular assist devices. However, a re-direction of care may be guided by physicians or preferred by parents due to clinical severity, end organ dysfunction, cultural factors (patient/parental preferences) and other mechanisms that have been previously proposed to mediate disparities.(18–22) These factors may become particularly important in clinically uncertain situations when the professional consensus about the standard of care or best practice is unclear in clinical practice.(18).

Being a retrospective study, the absence of variables in the OPTN database that would allow further mechanistic insights into our findings was an important limitation of these data. We were not able to assess health care access and compare clinical criteria for transplant listing among racial/ethnic groups. Moreover, although we evaluated all covariates known to be associated with wait-list mortality, we cannot exclude residual confounding related to illness severity. Furthermore, an important risk factor for wait-list mortality, creatinine clearance, was missing in 21% of children and may not have been missing at random. Although we included these patients in the model so that they contributed all their other risk factors, their precise effect on the risk estimates associated with race/ethnicity cannot be ascertained. Finally, cardiac support at the time of death and cause of death were also not available. These data would have provided important insights regarding parental preferences for continuation of care with progression of heart failure. Irrespective of the mechanisms, the racial/ethnic differences in outcomes noted in this study may be amenable to correction.(23)

Racial and socioeconomic differences in access, health care quality and outcomes have been documented in the US across disciplines and are not limited to adults.(19,24–26) These differences have been reported for a variety of health care outcomes in children.(27,28) Some of the racial differences in health may be mediated by socioeconomic and education differences.(26,27,29) Racial differences in graft survival following organ transplant are also well known in both adult and pediatric heart transplant recipients.(8,10) Although these differences are generally attributed to genetic and biological risk factors, low socioeconomic position may contribute to these differences.(30)

Reducing and eliminating disparities is complex because the mechanisms are usually subtle and difficult to understand and quantify. Specific measures that may decrease racial/ethnic differences in wait-list mortality in children listed for heart transplant may include: (1) improved awareness among pediatric heart failure specialists about the existence of these differences, (2) future research that provides mechanistic insights, and (3) practice guidelines that lead to uniformity and decrease uncertainty in care of children with advanced heart failure.

Conclusions

In conclusion, minority children listed for heart transplant have higher wait-list mortality compared to white children after controlling for clinical risk factors. Socioeconomic variables may contribute to this increased risk. Increased awareness of these findings among health care providers taking care of children with heart failure, prospective studies that provide mechanistic insight into these outcome differences and practice guidelines that lead to uniform, high quality care in children listed for heart transplant may help reduce and eliminate these differences.

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Figure 1. Cumulative mortality on the wait-list (proportion of listed children) for white, black, Hispanic, Asian, and 'Other' groups.

Figure 2. Comparison of competing outcomes during the first 12-months postlisting in white (panel A) and nonwhite (panel B) children demonstrating higher wait-list mortality in nonwhite children.

Figure 3.

Risk of wait-list mortality in nonwhite children (compared to white children) in prespecified subgroups expressed as adjusted hazard ratios and 95% confidence intervals (adjusted for all other covariates in multivariable model 2, Table 2).

Table 1

Baseline Characteristics of Children Listed for Heart Transplant by Racial Groups

	White (N=1913)	Black (N=657)	Hispanic (N=519)	Asian (N=109)	Other (N=101)	Total (N=3299)	P-values
Age, yr	2 (0 to 11)	4 (0 to 13)	1 (0 to 10)	4 (1 to 12)	1 (0 to 12)	2 (0 to 12)	<0.001
Age categories (yr)							<0.001
< 1	744 (39%)	199 (30%)	210 (40%)	22 (20%)	37 (37%)	1212 (37%)	
1–5	413 (22%)	160 (24%)	116 (22%)	39 (36%)	24 (24%)	752 (23%)	
6–11	285 (15%)	94 (14%)	82 (16%)	16 (15%)	14 (14%)	491 (15%)	
12–17	471 (25%)	204 (31%)	111 (21%)	32 (29%)	26 (26%)	844 (26%)	
Female Gender	803 (42%)	314 (48%)	218 (42%)	56 (51%)	60 (59%)	1451 (44%)	0.001
Listing status							0.44
1A	1149 (60%)	397 (60%)	317 (61%)	67 (61%)	58 (57%)	1988 (60%)	
1B	249 (13%)	94 (14%)	83 (16%)	19 (17%)	14 (14%)	459 (14%)	
2	515 (27%)	166 (25%)	119 (23%)	23 (21%)	29 (29%)	852 (26%)	
Blood type							<0.001
A	783 (41%)	177 (27%)	129 (25%)	30 (28%)	38 (38%)	1157 (35%)	
AB	79 (4%)	22 (3%)	15 (3%)	13 (12%)	6 (6%)	135 (4%)	
B	173 (9%)	106 (16%)	52 (10%)	23 (21%)	13 (13%)	367 (11%)	
O	876 (46%)	352 (54%)	323 (62%)	43 (39%)	44 (44%)	1638 (50%)	
Congenital Heart Disease	1000 (52%)	269 (41%)	240 (46%)	33 (30%)	45 (45%)	1587 (48%)	<0.001
Prostaglandin							0.008
Yes	133 (7%)	25 (4%)	32 (6%)	1 (1%)	7 (7%)	198 (6%)	
No	1780 (93%)	632 (96%)	487 (94%)	108 (99%)	94 (93%)	3101 (94%)	
Hemodynamic Support (Listing 1A)							0.15
ECMO	238 (21%)	72 (18%)	43 (14%)	8 (12%)	10 (17%)	371 (19%)	
Ventilator	349 (30%)	120 (30%)	97 (31%)	20 (30%)	19 (33%)	605 (30%)	
Other	562 (49%)	205 (52%)	177 (56%)	39 (58%)	29 (50%)	1012 (51%)	
Peak PRA at transplant							0.35
≥10%	113 (6%)	40 (6%)	28 (5%)	10 (9%)	4 (4%)	195 (6%)	
<10%	542 (28%)	134 (20%)	147 (28%)	33 (30%)	21 (21%)	877 (27%)	
Not recorded	1258 (66%)	483 (74%)	344 (66%)	66 (61%)	76 (75%)	2227 (67%)	
Dialysis	35 (2%)	12 (2%)	8 (2%)	2 (2%)	1 (1%)	58 (2%)	0.97
Creatinine clearance							<0.001
<40	227 (12%)	47 (7%)	71 (14%)	6 (6%)	17 (17%)	368 (11%)	
≥40	1263 (66%)	476 (72%)	368 (71%)	72 (66%)	62 (61%)	2241 (68%)	
Not recorded	423 (22%)	134 (20%)	80 (15%)	31 (28%)	22 (22%)	690 (21%)	
Median household income in zip code	43077 (35219 to 55690)	33352 (26544 to 42370)	37516 (30909 to 46175)	42694 (36973 to 55632)	40385 (30363 to 50610)	40392 (32099 to 51788)	<0.001
Median income quartile							<0.001
1	297 (16%)	287 (46%)	154 (31%)	14 (17%)	30 (30%)	782 (25%)	
2	452 (25%)	152 (24%)	147 (29%)	14 (17%)	20 (20%)	785 (25%)	

	White (N=1913)	Black (N=657)	Hispanic (N=519)	Asian (N=109)	Other (N=101)	Total (N=3299)	P-values
3	501 (27%)	111 (18%)	117 (23%)	25 (31%)	28 (28%)	782 (25%)	
4	574 (31%)	79 (13%)	83 (17%)	28 (35%)	21 (21%)	785 (25%)	
Insurance (Medicaid)	457 (24%)	383 (58%)	304 (59%)	20 (18%)	38 (38%)	1202 (36%)	<0.001
Insurance (Other)	1456 (76%)	274 (42%)	215 (41%)	89 (82%)	63 (62%)	2097 (64%)	
Center Volume							<0.001
Low-volume	356 (19%)	141 (21%)	66 (13%)	10 (9%)	20 (20%)	593 (18%)	
Medium-volume	556 (29%)	248 (38%)	200 (38%)	20 (18%)	27 (27%)	1051 (32%)	
High-volume	1001 (52%)	268 (41%)	253 (49%)	79 (73%)	54 (53%)	1655 (50%)	

Data are presented as number (percent) or median (IQR). Yr = year, ECMO = extracorporeal membrane oxygenation, PRA = panel reactive antibodies. Creatinine clearance is expressed as ml/min/1.73 m², Centers divided by total number of patients listed for transplant as low-volume (<40 patients), medium-volume (40–80 patients), and high-volume (>80 patients).

Table 2

Multivariable Models of Waiting List Mortality*

	Model 1 HR (95% CI)	Model 2 HR (95% CI)	P Value (Model 2)
Age (10 year increase)	1.2 (1.0–1.4)	1.2 (1.0–1.4)	0.037
Listing Status 1A	2.1 (1.7–2.7)	2.2 (1.7–2.7)	<0.001
Diagnosis of CHD	2.1 (1.8–2.6)	2.2 (1.8–2.6)	<0.001
Hemodynamic Support			
ECMO [#]	3.2 (2.5–4.1)	3.2 (2.5–4.1)	<0.001
Ventilator [#]	2.0 (1.6–2.5)	2.0 (1.6–2.5)	<0.001
Creatinine Clearance			
<40 ml/min/1.73m ²	1.6 (1.2–2.0)	1.6 (1.2–2.0)	<0.001
Missing	1.5 (1.2–1.8)	1.5 (1.2–1.9)	<0.001
Blood Type			
O	1.2 (1.0–1.4)	1.2 (1.0–1.5)	0.069
B	1.2 (0.9–1.6)	1.2 (0.9–1.6)	0.34
AB	1.3 (0.8–2.0)	1.3 (0.8–2.1)	0.22
Race[†]			
Black	1.6 (1.3–1.9)	1.4 (1.1–1.8)	0.003
Hispanic	1.5 (1.2–1.9)	1.4 (1.1–1.8)	0.007
Asian	2.0 (1.3–3.3)	2.3 (1.4–3.8)	0.001
Other	2.3 (1.5–3.4)	2.2 (1.5–3.3)	<0.001
Medicaid Insurance	-	1.2 (1.0–1.5)	0.034
Area Median Income			
Quartile 1	-	1.2 (0.9–1.5)	0.26
Quartile 2	-	1.1 (0.8–1.5)	0.35
Quartile 3	-	1.4 (1.1–1.8)	0.008

* Model 1 demonstrates the association of race/ethnicity with waiting list mortality adjusted for clinical risk factors. Model 2 adjusts for medical insurance and area median income in addition to all variables from model 1.

[#] Reference group is children listed as 1A but on neither ECMO nor ventilator,

[†] Reference group is white children