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Research Article

Improvement in Racial Disparities in Heart Transplantation following the Heart Allocation Policy Change

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Objectives. Heart transplantation (HT) is a definitive therapy for refractory heart failure, making it the gold-standard treatment for recipients with end-stage disease. Heart allocation policy (HAP) in the United States was changed on October 18th, 2018. The aim of this study was to assess the effect of the new policy on racial disparities in heart transplantation (HT) outcomes. *Methods*. The United Network for Organ Sharing (UNOS) registry was used to identify adult recipients undergoing isolated HT between 2010 and 2021. Recipients were stratified into pre-HAP (January 2010 to September 2018) vs. post-HAP (October 2018 to September 2021). Recipient race was classified as White, Black, Hispanic, or other. The primary outcome was post-HT mortality. Cox proportional hazard models were used for risk-adjustment in evaluating the independent effect of race on post-HT mortality. *Results*. A total of 27,403 recipients underwent HT in 143 centers during study period. The proportion of non-Whites undergoing HT increased in the post-HAP era: (pre-HAP: White 66.0%, Black 21.2%, Hispanic 8.2%, Other 4.6% versus post-HAP: White 62.5%, Black 23.2%, Hispanic 9.5%, Other 4.8%; $p < 0.001$). In risk-adjusted analysis, Black recipients were at higher risk of post-HT mortality in the pre-HAP era (HR 1.31, 95% CI 1.22–1.41; $p < 0.001$) but not in the post-HAP era (HR 1.12, 95% CI 0.03–1.34; $p = 0.222$) compared to White recipients. Other non-White recipients had comparable risk-adjusted post-HT mortality rates compared to White recipients both in the pre-HAP and post-HAP eras. *Conclusions*. Under the new heart allocation system, a higher percentage of recipients are non-White. In addition, racial disparities in HT outcomes have improved with Black recipients no longer having an increased risk-adjusted mortality following HT.

1. Introduction

Heart transplantation (HT) is a definitive therapy for refractory heart failure, making it the gold-standard treatment for recipients with end-stage disease [1–3]. Minority recipients, and specifically black recipients, have historically experienced higher mortality rates post-HT than white recipients [1, 4–10]. Prior research has demonstrated a center effect such that Black recipients are more likely to receive their HT care at worse performing centers, but this is likely not the only contributing factor to the mortality difference [6]. The rates of referral and rates of the undergoing HT are traditionally lower in Black recipients than those in white recipients [5, 11–14] although listing of Black recipients for HT increased after the 2014 implementation of the Affordable Care Act Medicaid expansion [15]. An additional factor that negatively contributes to survival of Black recipients post-HT is that Black HT recipients have the highest rate of HLA antigen mismatch with their donor heart out of all racial groups [16].

The heart allocation policy (HAP) was changed on October 18th, 2018, in an attempt to address several issues with the preexisting policy. Changes enacted by this policy included the introduction of a 6-tier system in which the highest risk patients were prioritized and broader organ sharing for patients with the highest urgency statuses in an effort to reduce waitlist mortality and improve donor organ allocation. The patients at highest risk as determined by this policy

include those on extracorporeal membrane oxygenation (ECMO), those with a surgically implanted biventricular support device who are nondischargeable, and those with a mechanical circulatory support device (MCSD) with a concurrent life-threatening ventricular arrhythmia. Notably, patients with left ventricular assist devices (LVADs) who were able to be discharged were placed in lower risk tiers. The policy also addressed specific circumstances in which expedited wait list times were required. Before this change, candidates were classified by risk based on a 3-tier system in which patients with univentricular assist devices—LVADs or RVADs—and intra-aortic balloon pumps were in the highest risk tier along with the patients on ECMO. The HAP change allows greater prioritization of the highest risk patients by introducing expanded risk stratification [17]. The purpose of this study was to evaluate the impact of the 2018 HAP change on racial disparities in HT outcomes.

2. Materials and Methods

2.1. Study Design. The United Network for Organ Sharing (UNOS) database is a prospectively maintained registry of all solid organ transplantations performed in the United States. The UNOS database was queried for all adult (≥18 years) recipients who underwent isolated HTs between January 2010 and September 2021. Recipients that underwent HT in centers that performed less than 5 transplants per year were excluded. Recipients were stratified by race with categories being White, Black, Hispanic, or Other. After recipients were identified, they were stratified into a pre-HAP group or a post-HAP group using October 18th, 2018, as the cutoff date. This study was deemed exempt from review by the Institutional Review Board at the Medical University of South Carolina.

2.2. Outcomes. The primary outcome in this study assessed all-cause post-HT mortality. Secondary outcomes included the rates of major postoperative complications (stroke, acute renal failure requiring dialysis, acute rejection, need for permanent pacemaker implantation, and post-HT length of hospital stay).

2.3. Statistical Analysis. Chi-square test or Fisher's exact test was utilized for categorical variables. Continuous variables were analyzed with two-sided *t*-test if normally distributed and Mann–Whitney *U* test if non-Gaussian. Categorical variables are represented as number (percentage), and nonparametric continuous variables are represented as median (interquartile range, IQR). Receipt and donor variables that were associated with all-cause mortality on univariable Cox proportional regression ($p < 0.20$) were included in the multivariable regression model. The statistical analyses were performed using R version 4.0.2.

3. Results

3.1. Overall Recipient Cohort and Baseline Characteristics. In the observed study period, 27,403 eligible recipients underwent HT. The proportion of recipients undergoing HT in the pre-HAP era was 66.0% White, 21.2% Black, 8.2% Hispanic, and 4.6% Other. This differed from the post-HAP era where recipients were 62.5% White, 23.2% Black, 9.5% Hispanic, and 4.8% Other ($p < 0.001$). The mean age of the study population pre-HAP was 54.66 ± 12.62 years for White recipients, 50.53 ± 12.64 years for Black recipients, 51.09 ± 13.27 years for Hispanic recipients, and 51.43 ± 13.33 years for Other recipients ($p < 0.001$). Post-HAP, mean age was 54.76 ± 12.77 years for White recipients, 51.12 ± 13.04 years for Black recipients,50.00 ± 13.94 years for Hispanic recipients, and 51.21 ± 13.51 years for Other recipients ($p < 0.001$). Recipients were more likely to be male than female in all groups in the pre-HAP and post-HAP eras (75.3% of White recipients, 66.4% of Black recipients, 74.2% of Hispanic recipients, and 75.0% of Other recipients, ($p < 0.001$); post-HAP 74.0% of White recipients, 66.9% of Black recipients, 74.2% of Hispanic recipients, and 78.0% of Other recipients, ($p < 0.001$). In the pre-HAP period, the percentage of recipients that were on bridging methods prior to transplant among was 52.4% of White recipients, 59.2% of Black recipients, 48.7% of Hispanic recipients, and 47.0% of Other recipients, ($p < 0.001$). Post-HAP, the percentage of recipients that were on bridging methods prior to transplant was 65.1% of White recipients, 72.9% of Black recipients, 62.7% of Hispanic recipients, and 63.7% of Other recipients, ($p < 0.001$). Demographic characteristics for pre-HAP HT recipients stratified by race are summarized in Table 1. Characteristics for post-HAP HT recipients stratified by race are summarized in Table 2.

3.2. Survival following Isolated Heart Transplantation. A multivariable Cox proportional hazards model for pre-HAP era total mortality following isolated HT is shown in Table 3. After risk adjustment, Black race was associated with an increased risk for all-year mortality compared to White race (HR 1.31, 95% CI 1.22–1.41, $p < 0.001$). A multivariable Cox proportional hazards model for post-HAP era all-year mortality following isolated HT is shown in Table 3. After risk adjustment, Black race was not associated with a significant increase in all-year mortality (HR 1.12, 95% CI, 0.93–1.34, $p = 0.222$).

3.3. Secondary Outcomes after Isolated Heart Transplantation. Secondary outcomes after pre-HAP era HT stratified by race are shown in Table 4, and secondary outcomes after post-HAP era HT stratified by race are shown in Table 5. In the pre-HAP era, recipients of Hispanic race had a lower rate of pacemaker requirement post-HT (2.8% White, 2.0% Black, 0.7% Hispanic, and 2.6% Other; $p = 0.004$), and recipients categorized as Other suffered less acute rejection events (21.1% White, 26.0% Black, 22.1% Hispanic, and 13.5% Other; $p < 0.001$). There were no significant differences in pre-HAP rates of acute renal failure requiring dialysis, stroke, or length of stay between racial groups. In the post-HAP era, recipients in the Other group had a higher rate of stroke post-HT (4.0% White, 3.1% Black, 2.8% Hispanic, and 5.5% Other; $p = 0.04$) but a lower rate of acute rejection events (19.8% White, 20.9% Black, 17.1% Hispanic, and

Table 1: Demographic characteristics of pre-HAP HT recipients stratified by race.

	White	Black	Hispanic	Other	p
n	12801	4106	1583	897	
Center					
Center 1-year mortality rate (mean (SD))	10.10 (5.99)	10.56 (6.19)	10.45 (6.68)	10.25 (6.40)	0.001
Center volume (mean (SD))	33.62 (21.88)	32.12 (20.91)	32.82 (21.05)	37.81 (26.80)	<0.001
Recipient					
Age (years) (mean (SD))	54.66 (12.62)	50.53 (12.64)	51.09 (13.27)	51.43 (13.33)	<0.001
Male sex no. (%)	9635 (75.3)	2728 (66.4)	1174 (74.2)	673 (75.0)	<0.001
BMI (kg/m^2) mean (SD))	27.47 (4.81)	28.03 (5.23)	27.07 (4.81)	25.32 (4.97)	<0.001
Creatinine (mg/dL) (mean (SD))	1.23 (0.53)	1.34 (0.57)	1.21 (1.24)	1.19 (0.88)	<0.001
Dialysis prior to transplant no. (%)	294 (2.3)	119 (2.9)	48 (3.0)	27 (3.0)	0.057
Total bilirubin (mg/dL) (mean (SD))	0.96 (1.30)	0.96 (1.56)	1.01 (1.27)	0.98 (1.18)	0.571
Diabetes no. (%)	3377 (26.4)	1178 (28.7)	535 (33.8)	295 (32.9)	<0.001
Heart failure etiology no. (%)					<0.001
Nonischemic cardiomyopathy	6365 (49.7)	3221 (78.4)	947 (59.8)	495 (55.2)	
Ischemic cardiomyopathy	4871 (38.1)	664 (16.2)	480 (30.3)	312 (34.8)	
Congenital heart disease	457 (3.6)	44 (1.1)	40 (2.5)	20 (2.2)	
Valvular heart disease	131 (1.0)	38 (0.9)	21 (1.3)	12 (1.3)	
Hypertrophic cardiomyopathy	363 (2.8)	31 (0.8)	30 (1.9)	22 (2.5)	
Restrictive cardiomyopathy	210 (1.6)	33 (0.8)	13 (0.8)	11 (1.2)	
Failed heart transplantation	317 (2.5)	61 (1.5)	43 (2.7)	18 (2.0)	
Other/unknown	87 (0.7)	14 (0.3)	9 (0.6)	7 (0.8)	
ICU at time of transplant no. (%)	3533 (27.6)	1157 (28.2)	529 (33.4)	277 (30.9)	<0.001
Mechanical ventilation no. (%)	169 (1.3)	41 (1.0)	19 (1.2)	9 (1.0)	0.382
Inotropes no. (%)	4565 (35.7)	1475 (35.9)	647 (40.9)	353 (39.4)	<0.001
Bridging method no. (%)					<0.001
None	6097 (47.6)	1677 (40.8)	812 (51.3)	475 (53.0)	
Intra-aortic balloon pump	803 (6.3)	294 (7.2)	94 (5.9)	61 (6.8)	
Temporary ventricular assist device	139 (1.1)	41 (1.0)	21 (1.3)	16 (1.8)	
Durable ventricular assist device	5693 (44.5)	2080 (50.7)	651 (41.1)	342 (38.1)	
ECMO	69 (0.5)	14 (0.3)	5 (0.3)	3 (0.3)	
Karnofsky index no. (%)					<0.001
80%	1353 (13.1)	395 (11.8)	144 (10.7)	85 (11.0)	
50–70%	2881 (27.8)	961 (28.7)	347 (25.8)	176 (22.8)	
40%	6126 (59.1)	1998 (59.6)	856 (63.5)	510 (66.1)	
Cardiac index (L/min/m^2) (mean (SD))	2.33 (0.67)	2.29 (0.71)	2.26 (0.67)	2.24 (0.66)	<0.001
Mean pulmonary artery pressure (mmHg) (mean (SD))	26.38 (9.74)	28.00 (9.98)	28.22 (10.50)	26.84 (10.18)	<0.001
Calculated panel reactive antigen (mean (SD))	10.42 (22.66)	13.62 (25.24)	10.86 (22.40)	9.18 (20.94)	<0.001
Days on waitlist (mean (SD))	242.12 (380.79)	247.95 (360.65)	219.73 (350.11)	179.89 (299.63)	<0.001
Heart ischemic time (hours) (mean (SD))	3.15 (1.05)	3.08 (1.06)	3.12 (1.07)	3.28 (1.07)	<0.001
Donors					
Age (years) (mean (SD))	32.15 (11.37)	31.85 (10.87)	31.67 (11.38)	31.68 (11.86)	0.174
Male sex no. (%)	9020 (70.5)	2920 (71.1)	1011 (63.9)	556 (62.0)	<0.001
Race no. (%)					<0.001
White	12801 (100.0)	0 (0.0)	0 (0.0)	0 (0.0)	
Black	0 (0.0)	4106 (100.0)	0 (0.0)	0 (0.0)	
Hispanic	0 (0.0)	0 (0.0)	1583 (100.0)	0 (0.0)	
Other	0 (0.0)	0 (0.0)	0 (0.0)	897 (100.0)	
BMI (kg/m^2) (mean (SD))	27.50 (5.97)	27.73 (6.04)	26.71 (5.60)	26.27 (6.05)	<0.001
Mechanism of death no. (%)					0.253
Trauma	6270 (49.0)	2013 (49.0)	755 (47.7)	429 (47.8)	
Cerebrovascular	2661 (20.8)	867 (21.1)	357 (22.6)	195 (21.7)	
Drug overdose	1552 (12.1)	516 (12.6)	179 (11.3)	91 (10.1)	
Other	2310 (18.1)	710 (17.3)	292 (18.4)	182 (20.3)	
Diabetes no. (%)	485 (3.8)	138 (3.4)	67 (4.3)	27 (3.0)	0.26
Recipient-donor matching					
Sex-matched no (%)	9800 (76.6)	3122 (76.0)	1114 (70.4)	616 (68.7)	<0.001
Race-matched no. (%)	12801 (100.0)	4106 (100.0)	1583 (100.0)	0 (0.0)	<0.001
HLA-matched no. (%)	1852 (16.0)	386 (10.1)	204 (13.9)	94 (11.2)	<0.001
ABO-identical no. (%)	11048 (86.3)	3454 (84.1)	1384 (87.4)	726 (80.9)	<0.001
CMV-matched no. (%)	5830 (45.7)	1905 (46.6)	731 (46.4)	432 (48.4)	0.384

Table 2: Demographic characteristics for post-HAP HT recipients stratified by race.

	White	Black	Hispanic	Other	p
n	5009	1857	764	386	
Center					
Center 1-year mortality rate (mean (SD))	9.59 (5.42)	9.60 (5.50)	9.02 (5.68)	9.08 (4.86)	0.039
Center volume (mean (SD))	35.63 (21.81)	34.61 (21.88)	37.97 (23.38)	40.55 (25.69)	<0.001
Recipient					
Age (years) (mean (SD))	54.76 (12.77)	51.12 (13.04)	50.00 (13.94)	51.21 (13.51)	<0.001
Male sex no. (%)	3706 (74.0)	1243 (66.9)	567 (74.2)	301 (78.0)	<0.001
BMI (kg/m^2) mean (SD))	27.85 (4.91)	28.28 (5.36)	27.22 (4.85)	25.71 (4.95)	<0.001
Creatinine (mg/dL) (mean (SD))	1.21 (0.48)	1.29 (0.72)	1.17 (0.65)	1.15 (0.43)	<0.001
Dialysis prior to transplant no. (%)	101 (2.0)	57 (3.1)	14 (1.9)	11 (2.9)	0.047
Total bilirubin (mg/dL) (mean (SD))	0.99 (1.76)	0.96 (1.43)	1.18 (2.45)	1.08 (1.26)	0.029
Diabetes no. (%)	1290 (25.8)	546 (29.4)	236 (30.9)	115 (29.8)	0.001
Heart failure etiology no. (%)					<0.001
Nonischemic cardiomyopathy	2674 (53.4)	1486 (80.1)	478 (62.6)	224 (58.0)	
Ischemic cardiomyopathy	1585 (31.7)	237 (12.8)	186 (24.4)	116 (30.1)	
Congenital heart disease	220 (4.4)	39 (2.1)	32 (4.2)	12 (3.1)	
Valvular heart disease	41 (0.8)	4 (0.2)	12 (1.6)	5 (1.3)	
Hypertrophic cardiomyopathy	213 (4.3)	31 (1.7)	16 (2.1)	7 (1.8)	
Restrictive cardiomyopathy	102 (2.0)	28 (1.5)	9 (1.2)	8 (2.1)	
Failed heart transplantation	110 (2.2)	23 (1.2)	26 (3.4)	7 (1.8)	
Other/unknown	62 (1.2)	8 (0.4)	4 (0.5)	7 (1.8)	
ICU at the time of transplant no. (%)	2529 (50.6)	998 (53.9)	418 (55.6)	226 (59.2)	<0.001
Mechanical ventilation no. (%)	127 (2.5)	38 (2.0)	12 (1.6)	16 (4.1)	0.035
Inotropes no. (%)	1808 (36.1)	777 (41.8)	328 (42.9)	159 (41.2)	<0.001
Bridging method no. (%)					<0.001
None	1748 (34.9)	503 (27.1)	285 (37.3)	140 (36.3)	
Intra-aortic balloon pump	1351 (27.0)	566 (30.5)	223 (29.2)	102 (26.4)	
Temporary ventricular assist device	274 (5.5)	90 (4.8)	47 (6.2)	20 (5.2)	
Durable ventricular assist device	1474 (29.4)	647 (34.8)	187 (24.5)	103 (26.7)	
ECMO	162 (3.2)	51 (2.7)	22 (2.9)	21 (5.4)	
Karnofsky index no. (%)					<0.001
80%	304 (7.2)	95 (6.1)	32 (4.8)	26 (7.6)	
50–70%	895 (21.3)	249 (16.1)	115 (17.3)	49 (14.4)	
40%	3002 (71.5)	1202 (77.7)	519 (77.9)	265 (77.9)	
Cardiac index (L/min/m^2) (mean (SD))	2.24 (0.67)	2.23 (0.70)	2.26 (0.72)	2.24 (0.75)	0.628
Mean pulmonary artery pressure (mmHg) (mean (SD))	26.49 (9.89)	28.03 (10.13)	28.03 (10.51)	26.71 (11.06)	<0.001
Calculated panel reactive antigen (mean (SD))	9.54 (22.29)	14.78 (26.37)	11.13 (23.41)	8.54 (19.76)	<0.001
Days on waitlist (mean (SD))	188.42 (378.96)	204.57 (434.30)	184.14 (400.46)	138.15 (318.82)	0.023
Heart ischemic time (hours) (mean (SD))	3.45 (1.09)	3.49 (1.11)	3.38 (1.01)	3.38 (1.04)	0.067
Donors					
Age (years) (mean (SD))	32.63 (10.54)	32.17 (10.23)	32.26 (10.68)	31.93 (10.96)	0.26
Male sex no. (%)	3607 (72.0)	1344 (72.4)	531 (69.5)	256 (66.3)	0.048
Race no. (%)					<0.001
White	5009 (100.0)	0 (0.0)	0 (0.0)	0 (0.0)	
Black	0 (0.0)	1857 (100.0)	0 (0.0)	0 (0.0)	
Hispanic	0 (0.0)	0 (0.0)	764 (100.0)	0 (0.0)	
Other	0 (0.0)	0 (0.0)	0 (0.0)	386 (100.0)	
BMI (kg/m^2) (mean (SD))	28.00 (6.24)	28.15 (6.15)	27.76 (6.27)	27.06 (6.56)	0.013
Mechanism of death no. (%)					0.255
Trauma	1978 (39.5)	782 (42.1)	306 (40.1)	156 (40.4)	
Cerebrovascular	747 (14.9)	242 (13.0)	119 (15.6)	66 (17.1)	
Drug overdose	1213 (24.2)	458 (24.7)	174 (22.8)	81 (21.0)	
Other	1071 (21.4)	375 (20.2)	165 (21.6)	83 (21.5)	
Diabetes no. (%)	215 (4.3)	53 (2.9)	27 (3.6)	14 (3.7)	0.051
Recipient-donor matching					
Sex-matched no (%)	3958 (79.0)	1486 (80.0)	586 (76.7)	281 (72.8)	0.007
Race-matched no. (%)	5009 (100.0)	1857 (100.0)	764 (100.0)	0 (0.0)	<0.001
HLA-matched no. (%)	754 (16.7)	156 (9.2)	95 (13.5)	34 (9.4)	<0.001
ABO-identical no. (%)	4297 (85.8)	1578 (85.0)	671 (87.8)	306 (79.3)	0.001
CMV-matched no. (%)	1951 (39.1)	672 (36.4)	297 (39.2)	132 (34.3)	0.067

Table 3: Multivariable Cox proportional hazards model for pre- and post-HAP era mortality following isolated HT with race as a categorical variable.

All mortality		Before policy change (univariable)	Before policy change (multivariable)	After policy change (univariable)	After policy change (multivariable)
Race/Ethnicity	White	Reference	Reference	Reference	Reference
	Black	1.20 (1.12–1.29, $p < 0.001$)	1.31 (1.22–1.41, $p < 0.001$)	1.05 (0.88–1.24, $p = 0.592$)	1.12 (0.93–1.34, $p = 0.222$)
	Hispanic	1.02 (0.92–1.13, $p = 0.722$)	1.05 (0.94–1.18, $p = 0.397$)	0.95 (0.74–1.23, $p = 0.714$)	1.16 (0.89–1.51, $p = 0.280$)
	Other	0.89 (0.77–1.03, $p = 0.113$)	0.94 (0.80–1.09, $p = 0.392$)	1.19 (0.87–1.63, $p = 0.286$)	1.37 (0.98–1.92, $p = 0.067$)
Center volume		1.00 (1.00–1.00, $p = 0.217$)	1.00 (1.00–1.00, $p = 0.407$)	1.00 (0.99–1.00, $p = 0.018$)	0.99 (0.99–1.00, $p = 0.002$)
Age	Years	1.01 (1.01–1.01, $p < 0.001$)	1.01 (1.00–1.01, $p < 0.001$)	1.02 (1.01–1.02, $p < 0.001$)	1.02 (1.01–1.02, $p < 0.001$)
Sex	Male	1.03 (0.97–1.10, $p = 0.294$)	—	1.00 (0.86–1.18, $p = 0.955$)	—
BMI	kg/m^2	1.02 (1.02–1.03, $p < 0.001$)	1.02 (1.01–1.02, $p < 0.001$)	1.04 (1.03–1.06, $p < 0.001$)	1.03 (1.02–1.05, $p < 0.001$)
Creatinine	mg/dL	1.10 (1.08–1.12, $p < 0.001$)	1.08 (1.05–1.11, $p < 0.001$)	1.14 (1.08–1.21, $p < 0.001$)	1.10 (1.01–1.19, $p = 0.027$)
Dialysis prior to transplant		1.96 (1.70–2.25, $p < 0.001$)	1.65 (1.41–1.92, $p < 0.001$)	2.92 (2.15–3.96, $p < 0.001$)	2.24 (1.60–3.12, $p < 0.001$)
Total bilirubin	mg/dL	1.06 (1.05–1.07, $p < 0.001$)	1.05 (1.04–1.07, $p < 0.001$)	1.05 (1.04–1.07, $p < 0.001$)	1.06 (1.04–1.07, $p < 0.001$)
Diabetes		1.40 (1.32–1.49, $p < 0.001$)	1.24 (1.16–1.33, $p < 0.001$)	1.39 (1.20–1.62, $p < 0.001$)	1.21 (1.03–1.41, $p = 0.021$)
Heart failure etiology	Nonischemic cardiomyopathy	Reference	Reference	Reference	Reference
	Ischemic cardiomyopathy	1.35 (1.27–1.43, $p < 0.001$)	1.30 (1.22–1.39, $p < 0.001$)	1.51 (1.29–1.77, $p < 0.001$)	1.31 (1.10–1.55, $p = 0.002$)
	Congenital heart disease	1.21 (1.03–1.43, $p = 0.023$)	1.54 (1.26–1.88, $p < 0.001$)	1.70 (1.23–2.35, $p = 0.001$)	2.84 (1.99–4.05, $p < 0.001$)
	Valvular heart disease	0.97 (0.73–1.29, $p = 0.861$)	1.01 (0.74–1.36, $p = 0.966$)	1.42 (0.67–3.01, $p = 0.354$)	1.43 (0.66–3.11, $p = 0.366$)
	Hypertrophic cardiomyopathy	0.65 (0.51–0.83, $p = 0.001$)	0.73 (0.56–0.95, $p = 0.021$)	1.10 (0.72–1.67, $p = 0.660$)	1.34 (0.86–2.08, $p = 0.191$)
	Restrictive cardiomyopathy	1.07 (0.84–1.38, $p = 0.569$)	1.23 (0.95–1.59, $p = 0.121$)	1.57 (0.97–2.56, $p = 0.067$)	1.85 (1.13–3.02, $p = 0.014$)
	Failed heart transplantation	1.59 (1.35–1.88, $p < 0.001$)	1.55 (1.27–1.87, $p < 0.001$)	2.00 (1.34–3.00, $p = 0.001$)	2.19 (1.42–3.36, $p < 0.001$)
	Other/Unknown	0.95 (0.62–1.44, $p = 0.799$)	1.07 (0.67–1.71, $p = 0.767$)	0.48 (0.15–1.49, $p = 0.202$)	0.63 (0.20–1.97, $p = 0.428$)
ICU at the time of transplant		1.10 (1.03–1.17, $p = 0.002$)	1.14 (1.06–1.23, $p = 0.001$)	0.94 (0.81–1.08, $p = 0.386$)	—
Mechanical ventilation		1.96 (1.63–2.37, $p < 0.001$)	1.44 (1.14–1.83, $p = 0.002$)	2.33 (1.68–3.23, $p < 0.001$)	2.08 (1.41–3.07, $p < 0.001$)
Inotropes		0.99 (0.94–1.05, $p = 0.820$)	—	0.85 (0.73–0.98, $p = 0.028$)	0.99 (0.84–1.18, $p = 0.933$)
Bridging	None	Reference	Reference	Reference	Reference
	Intra-aortic balloon pump	1.23 (1.10–1.39, $p < 0.001$)	1.11 (0.98–1.26, $p = 0.106$)	0.93 (0.76–1.13, $p = 0.447$)	0.99 (0.80–1.21, $p = 0.903$)
	Temporary ventricular assist device	1.32 (1.02–1.71, $p = 0.036$)	1.24 (0.93–1.65, $p = 0.144$)	0.80 (0.54–1.18, $p = 0.262$)	0.79 (0.52–1.20, $p = 0.264$)
	Durable ventricular assist device	1.18 (1.12–1.25, $p < 0.001$)	1.21 (1.12–1.29, $p < 0.001$)	1.33 (1.11–1.58, $p = 0.001$)	1.29 (1.06–1.58, $p = 0.012$)
	ECMO	2.56 (1.86–3.51, $p < 0.001$)	1.70 (1.17–2.47, $p = 0.005$)	1.68 (1.18–2.39, $p = 0.004$)	1.07 (0.70–1.63, $p = 0.771$)
Cardiac index	$L/min/m^2$	1.04 (1.00–1.09, $p = 0.058$)	—	0.98 (0.88–1.09, $p = 0.699$)	—
PA pressure	mmHg	1.00 (1.00–1.01, $p = 0.114$)	1.00 (1.00–1.00, $p = 0.892$)	1.00 (1.00–1.01, $p = 0.394$)	—
Time on waitlist	days	1.00 (1.00–1.00, $p = 0.038$)	1.00 (1.00–1.00, $p = 0.359$)	1.00 (1.00–1.00, $p = 0.002$)	1.00 (1.00–1.00, $p = 0.281$)
Heart ischemic time	hours	1.08 (1.05–1.11, $p < 0.001$)	1.07 (1.04–1.10, $p < 0.001$)	1.13 (1.06–1.20, $p < 0.001$)	1.13 (1.06–1.20, $p < 0.001$)
Donor age	years	1.01 (1.01–1.01, $p < 0.001$)	1.01 (1.01–1.01, $p < 0.001$)	1.01 (1.00–1.02, $p = 0.002$)	1.01 (1.00–1.01, $p = 0.031$)
Donor sex	Male	0.95 (0.90–1.01, $p = 0.108$)	0.95 (0.88–1.02, $p = 0.151$)	0.92 (0.79–1.08, $p = 0.311$)	—
Donor race	White	Reference	Reference	Reference	Reference
	Black	1.20 (1.12–1.29, $p < 0.001$)	—	1.05 (0.88–1.24, $p = 0.592$)	—
	Hispanic	1.02 (0.92–1.13, $p = 0.722$)	—	0.95 (0.74–1.23, $p = 0.714$)	—
	Other	0.89 (0.77–1.03, $p = 0.113$)	—	1.19 (0.87–1.63, $p = 0.286$)	—

Table 3: Continued.

All mortality		Before policy change (univariable)	Before policy change (multivariable)	After policy change (univariable)	After policy change (multivariable)
Donor BMI	kg/m^2	1.01 (1.00–1.01, $p < 0.001$)	1.00 (0.99–1.00, $p = 0.180$)	1.01 (0.99–1.02, $p = 0.365$)	—
Mechanism of death	Trauma	Reference	Reference	Reference	Reference
	Cerebrovascular	1.20 (1.12–1.28, $p < 0.001$)	1.07 (0.98–1.15, $p = 0.124$)	1.06 (0.86–1.31, $p = 0.558$)	—
	Drug overdose	0.97 (0.88–1.07, $p = 0.556$)	0.95 (0.86–1.05, $p = 0.327$)	0.92 (0.76–1.12, $p = 0.410$)	—
	Other	1.03 (0.95–1.11, $p = 0.471$)	0.98 (0.90–1.07, $p = 0.723$)	0.98 (0.81–1.18, $p = 0.842$)	—
Donor diabetes		1.07 (0.93–1.24, $p = 0.356$)	—	0.97 (0.67–1.42, $p = 0.890$)	—
Sex-matched		0.95 (0.89–1.01, $p = 0.098$)	0.94 (0.87–1.01, $p = 0.087$)	1.03 (0.87–1.23, $p = 0.712$)	—
Race-matched		1.17 (1.02–1.36, $p = 0.028$)	—	0.85 (0.62–1.16, $p = 0.299$)	—
HLA-matched		1.00 (0.92–1.08, $p = 0.965$)	—	1.00 (0.81–1.24, $p = 0.975$)	—
ABO-identical		0.97 (0.89–1.04, $p = 0.376$)	—	1.09 (0.88–1.35, $p = 0.417$)	—
CMV-matched		0.95 (0.90–1.00, $p = 0.074$)	0.96 (0.90–1.01, $p = 0.141$)	0.94 (0.81–1.09, $p = 0.418$)	—

Table 4: Secondary outcomes after pre-HAP era HT stratified by race.

	White	Black	Hispanic	Other	p
Outcomes					
Acute renal failure dialysis no. (%)	1423 (11.2)	465 (11.4)	201 (12.8)	83 (9.3)	0.063
Stroke no. (%)	356 (2.8)	104 (2.5)	46 (2.9)	26 (2.9)	0.799
Need for pacemaker no. (%)	421 (3.3)	105 (2.6)	31 (2.0)	21 (2.4)	0.003
Acute rejection no. (%)	2429 (19.0)	960 (23.4)	309 (19.5)	127 (14.2)	<0.001
Length of stay (days) (mean (SD))	20.80 (24.44)	21.69 (22.31)	21.26 (24.19)	21.19 (30.88)	0.231

Table 5: Secondary outcomes after post-HAP era HT stratified by race.

	White	Black	Hispanic	Other	p
Outcomes					
Acute renal failure dialysis no. (%)	751 (15.0)	248 (13.4)	89 (11.8)	52 (13.7)	0.062
Stroke—no. (%)	199 (4.0)	57 (3.1)	21 (2.8)	21 (5.5)	0.041
Need for pacemaker—no. (%)	84 (1.7)	33 (1.8)	16 (2.1)	8 (2.1)	0.801
Acute rejection—no. (%)	989 (19.8)	387 (20.9)	129 (17.1)	51 (13.4)	0.002
Length of stay (days) (mean (SD))	22.86 (24.79)	23.81 (24.02)	21.38 (19.98)	22.19 (22.99)	0.121

13.4% Other; $p = 0.002$). There were no significant differences in post-HAP rates of acute renal failure requiring dialysis, pacemaker requirement, or length of stay between racial groups.

4. Discussion

Historically, racial disparities in isolated HT outcomes have been noted for Black recipients [1, 4–10]. Previous literature suggests multiple potential causes of this finding. Foremost, Black recipients are more likely to be treated at centers that have higher than average mortality rates following HT [6]. Second, Black recipients were less likely to be referred for initial evaluation and subsequent transplant, thus potentially making them higher risk at the time of transplant due to later presentation and more advanced heart failure [13]. Breathett et al. assessed incidence of transplant in early and late adopters of the Affordable Care Act (ACA) and found that the rate of HT for Black recipients increased in early-adopting states [15]. It did not, however, narrow the gap in rates when compared to their White counterparts [15]. Last, many social determinants have been cited as potential influences. Some of these factors include access to private health insurance, primary care preventative services, education, and Medicare or Medicaid coverage [12].

One variable to consider when evaluating mortality in a subset of recipients is the center in which their transplant occurred. High-volume centers tend to have lower mortality rates. The centers and their staff are better prepared for complex cases and adverse events [10, 18, 19]. Kim et al. analyzed institutions pre- and post-HAP and found that low volume centers seem to have improved waitlist mortality and deterioration since the policy change, whereas intermediate and high-volume centers have not shown any significant differences in outcomes [20]. Black recipients are more likely than their white counterparts to be transplanted at worse performing centers with higher-than-expected mortality rates. While the center status affects outcomes for minority recipients, controlling for this does not eliminate the disparity completely [6]. The 2018 HAP change was enacted to address several issues in the preexisting US policy that had been in place since 2006. Chouairi et al. studied HT recipients from 2011 to 2020 stratified by race and pre- and post-HAP eras. Their analysis showed that the rates of HT increased for all groups post-HAP, but Black recipients were still less likely than White recipients to receive an HT in the post-HAP era. Trivedi et al. studied HT recipients from 1987–2020 stratified by race and time period of transplant, although not by pre- and post-HAP. Their analysis also showed that Black recipients were less likely to receive HTs than other racial groups, but they posited that post-HT survival in Black recipients has increased and is now comparable to post-HT survival in other racial groups including White recipients.

Limitations of the present study include that data are limited to the UNOS registry. In addition, we cannot capture unmeasured practice differences between programs performing HT, although center volume which is an important center-level predictor was controlled for in multivariable Cox proportional hazards modeling [18, 19]. Additionally, because data are limited to UNOS database, race and ethnicity codification is also limited to information found in the database. Our study used the list of races reported by UNOS that includes White, Black, Hispanic, Asian American Indian/Alaska Native, Native Hawaiian/other Pacific Islander, multiracial, and unknown. Asian American Indian/Alaska Native, Native Hawaiian/other Pacific Islander, and multiracial patients were classified as "Other" in this study, and we did not have any unknowns. Another limitation of this study is that the UNOS registry does not contain information on recipient-specific factors such as perioperative care that could potentially impact survival. We also could not assess for variables that may relate to access to care and earlier referral to the advanced heart failure specialists. Lastly, because the HAP occurred in 2018, it is possible that with longer follow-up in the post-HAP change era, outcomes will change. It is also important to note that the post-HAP period includes the beginning of the COVID-19 pandemic which could potentially affect the mortality in a nonuniform way among racial groups. More research is needed to discern the race-specific impact of COVID-19 among patients awaiting heart transplantation.

This analysis of the UNOS registry determined that while pre-HAP Black recipients showed increased all-year mortality when compared with White recipients, post-HAP Black recipients did not. In addition, a higher proportion of HT recipients were non-White in the post-HAP era. While data should continue to be studied over the next several years, this analysis demonstrates that the 2018 HAP change is associated with a reduction in racial disparities in HT outcomes.

5. Conclusion

While continued observation is necessary, initial results suggest that the 2018 heart allocation policy change was successful in reducing racial disparities in heart transplantation outcomes. Our results show that Black patients do not face any significantly increased mortality as compared to White patients after this policy change.

Data Availability

The data used in this study included all adult recipients of heart transplant between January 2010 and September 2021. These data were collected from the UNOS database and can be accessed here.

Disclosure

This research was performed as part of the employment of the authors at Medical University of South Carolina.

Conflicts of Interest

Dr. Kilic is a speaker and consultant for Abiomed, Abbott, LivaNova, and 3ive.

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