Title

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ORIGINAL RESEARCH

CONGENITAL HEART DISEASE

Racial Health Disparity Associated With Poor Pediatric Cardiac Surgery Outcomes

A Multicentered, Cross-Sectional Study

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ABSTRACT

BACKGROUND Health disparities are known to play a role in pediatric cardiac surgery outcomes.

OBJECTIVES Risk factors associated with poor clinical outcomes were assessed.

METHODS Using Pediatric Health Information System Database, pediatric subjects undergoing cardiac surgery using International Classification of Diseases 10th Revision from October 2015 to December 2020 were evaluated. Subjects were categorized by case complexity using the newly validated Risk Adjustment for Congenital Heart Surgery-2 (RACHS-2). Multivariable regression analyses were conducted to ascertain risk factors.

RESULTS A total of 59,856 subjects, median age 7.4 months (IQR: 1.5-61 months) were included; 38,917 (low), 9,833 (medium), and 11,106 (high) RACHS-2. Overall, hospital mortality was 3% and postoperative length of stay (LOS) was 7 days (IQR: 4-18 days), with significant increases in both mortality and postoperative LOS from low to high RACHS-2 scores by multivariable analysis, Kaplan-Meier, and Cox regression. Mechanical ventilation, extracorporeal membrane oxygenation, infection, and surgical complication were most significantly associated with increased mortality by 1.198 to 10.227 times ($P < 0.008$). After controlling for these significant variables as well as RACHS-2, age at surgery and emergency/urgent admission type, multivariable analysis revealed that non-White race was associated with increased mortality (relative risk: 1.2, 95% CI: 0.729-0.955, $P = 0.008$) and increased postoperative LOS by 1.04 days (95% CI: 0.95-0.97, $P < 0.001$). This significant increase in both clinical outcomes was concordant in non-White neonates (mortality relative risk: 1.3, 95% CI: 1.1-1.6, $P = 0.003$; and postoperative LOS by 2.05 weeks (95% CI: 1.36-3.10, $P < 0.001$).

CONCLUSIONS The influence of racial differences in neonates and children should be further evaluated to mitigate any disparity in those undergoing cardiac surgery. (JACC Adv 2024;3:100987) © 2024 The Authors. Published by Elsevier on behalf of the American College of Cardiology Foundation. This is an open access article under the CC BY-NC-ND license (http://creativecommons.org/licenses/by-nc-nd/4.0/).

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The authors attest they are in compliance with human studies committees and animal welfare regulations of the authors' institutions and Food and Drug Administration guidelines, including patient consent where appropriate. For more information, visit the Author Center.

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ABBREVIATIONS AND ACRONYMS

CHD = congenital heart defect

ECMO = extracorporeal membrane oxygenation

ICD-10 = International Classification of Diseases-10th Revision

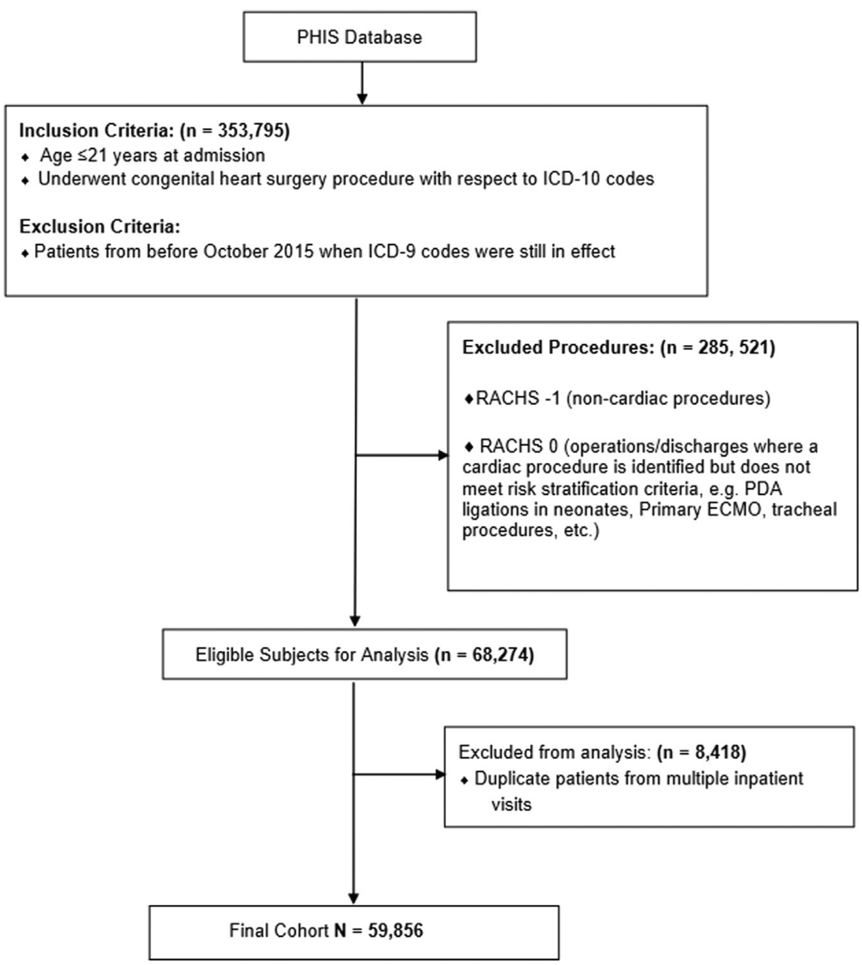
LOS = length of stay

PHIS = Pediatric Health Information System

Past studies utilizing the surgical complexity scoring of the Society of Thoracic Surgeons-European Association for Cardiothoracic Surgery and RACHS-1 (Risk Adjustment for Congenital Heart Surgery-1) in pediatric cardiac surgery reveal that discharge mortality remains around 3% from 2000 to 2012.[1-4] Factors, including race and ethnicity, have been associated with increased mortality and hospital length of stay.[3,5-7] Minority populations, including Blacks and Hispanics residing in U.S. metropolitan cities, face socioeconomic barriers which impact their health care before and after surgery.[7] Studies utilizing national databases (Society of Thoracic Surgeons Congenital Heart Surgery Database and Virtual Pediatric Systems) have reported increased mortality among Blacks and Hispanics and those with Medicaid insurance.[6-10] The health care disparities originating from these racial/ethnic and socioeconomic differences are complex and the specific etiologies are multifactorial as concluded previously by our research group.[11]

The RACHS-2 (Risk Adjustment for Congenital Heart Surgery-2) is a risk adjustment model for mortality and has been validated in 2 separate administrative data sources and compared to clinical registry data (including Pediatric Health Information System [PHIS] and STS-CHS). The RACHS-2 model utilizes objective data similar to the Society of Thoracic

FIGURE 1 Consort Diagram



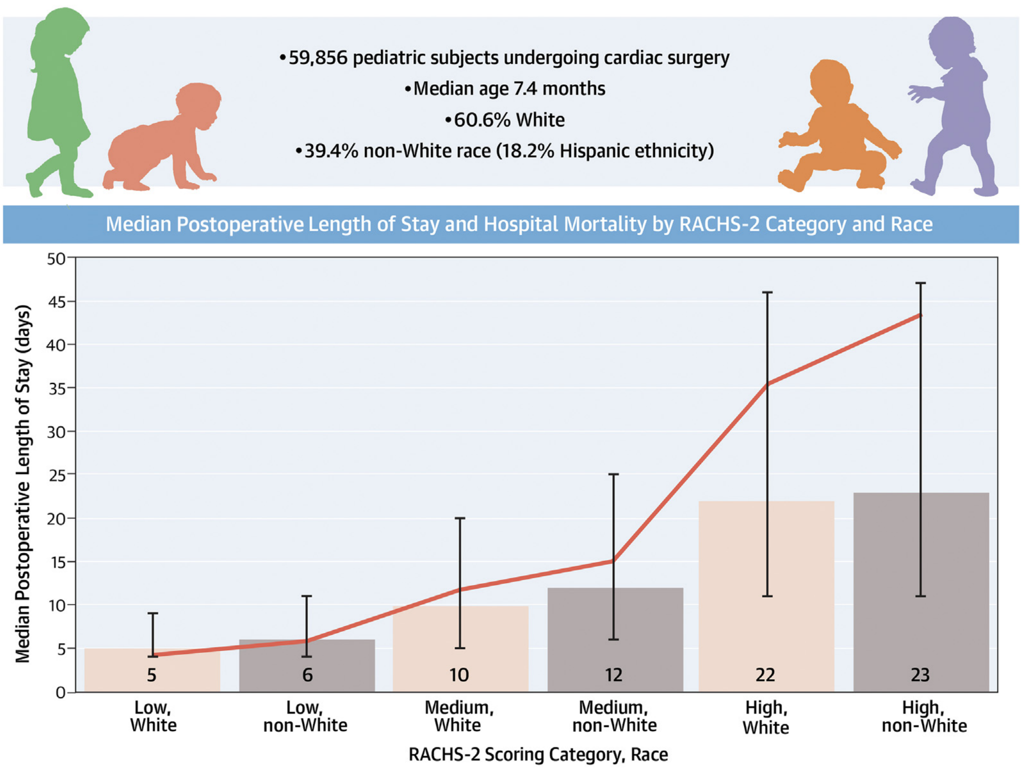
ECMO = extracorporeal membrane oxygenation; ICD = International Classification of Diseases; PHIS = Pediatric Health Information System; RACHS = Risk Adjustment for Congenital Heart Surgery.

TABLE 1 Demographic and Clinical Characteristics by RACHS-2 Categories

	Total (N = 59,856)	Low RACHS-2 [1,2] (n = 38,917)	Medium RACHS-2 [3] (n = 9,833)	High RACHS-2 [4,5] (n = 11,106)	Neonates Only (n = 15,260)
Age at surgery, y	0.613 (0.121-5.079)	1.01 (0.296-5.60)	2.31 (0.244-11.3)	0.0301 (0.0137-0.315)	7 d (4-14)
Age at surgery[a]					
≤30 d	13,536 (22.6)	4,698 (12.1)	1,863 (18.9)	6,975 (62.8)	Not applicable
31-60 d	2,858 (4.8)	1,874 (4.8)	325 (3.3)	659 (5.9)	
61-364 d	16,970 (28.4)	12,846 (33.0)	2,046 (20.8)	2,078 (18.7)	
1-5 y	11,363 (19.0)	8,872 (22.8)	1,702 (17.3)	789 (7.1)	
5+ y	15,114 (25.3)	10,619 (27.3)	3,895 (39.6)	600 (5.4)	
Sex[a]					
Male	32,855 (54.9)	20,947 (53.8)	5,697 (57.9)	6,211 (55.9)	8,928 (59)
Female	26,980 (45.1)	17,960 (46.1)	4,130 (42.0)	4,890 (44.0)	6,317 (41)
Race[b]					
White	36,281 (60.6)	23,360 (60.0)	6,289 (64.0)	6,632 (59.7)	9,257 (61)
Black	8,543 (14.3)	5,779 (14.8)	1,186 (12.1)	1,576 (14.2)	2,100 (14)
Asian	2,392 (4.0)	1,656 (4.3)	382 (3.9)	354 (3.2)	466 (3)
Pacific Islander	578 (1.0)	373 (1.0)	103 (1.0)	102 (0.9)	161 (1)
American Indian	369 (0.6)	246 (0.6)	53 (0.5)	70 (0.6)	77 (0.5)
Other	8,647 (14.4)	5,553 (14.3)	1,428 (14.5)	1,666 (15.0)	2,290 (15)
Ethnicity[c]					
Hispanic or Latino	10,906 (18.2)	7,012 (18.0)	1,731 (17.6)	2,163 (19.5)	2,739 (18)
Not Hispanic or Latino	42,729 (71.4)	27,944 (71.8)	7,141 (72.6)	7,644 (68.8)	10,703 (70)
Insurance type					
Private	26,563 (44.4)	17,465 (44.9)	4,608 (46.9)	4,490 (40.4)	6,660 (44)
Public	30,225 (50.5)	19,521 (50.2)	4,636 (47.1)	6,068 (54.6)	8,196 (54)
Other[d]	3,068 (5.1)	1,931 (5.0)	589 (6.0)	548 (4.9)	404 (2)
Residence area					
Urban/Suburban	48,021 (80.2)	31,487 (80.9)	7,765 (79.0)	8,769 (79.0)	12,198 (80)
Not urban	9,807 (16.4)	6,171 (15.9)	1,687 (17.2)	1,949 (17.5)	2,608 (17)
Unknown	2,028 (3.4)	1,259 (3.2)	381 (3.9)	388 (3.5)	454 (3)
Priority on admission					
Emergency	7,417 (12.4)	3,676 (9.4)	1,536 (15.6)	2,205 (19.9)	3,718 (24)
Urgent	11,676 (19.5)	5,270 (13.5)	2,367 (24.1)	4,039 (36.4)	6,989 (46)
Elective	34,912 (58.3)	27,175 (69.8)	5,108 (51.9)	2,629 (23.7)	868 (6)
Newborn	3,550 (5.9)	1,085 (2.8)	440 (4.5)	2,025 (18.2)	3,545 (23)
Trauma	16 (<0.01)	10 (<0.01)	4 (<0.01)	2 (<0.01)	2 (0)
Unknown	2,285 (3.8)	1,701 (4.4)	378 (3.8)	206 (1.9)	138 (1)
Mechanical ventilation	43,588 (72.8)	24,826 (63.8)	8,245 (83.9)	10,517 (94.7)	14,808 (97)
Extracorporeal membrane oxygenation	3,664 (6.1)	1,218 (3.1)	888 (9.0)	1,558 (14.0)	1,739 (11)
Infection during hospitalization[e]	19,639 (32.8)	10,854 (27.9)	4,101 (41.8)	4,684 (42.2)	5,776 (38)
Medical complication[f]	1,317 (2.2)	599 (1.5)	315 (3.2)	403 (3.6)	545 (4)
Surgical complication[g]	25,320 (42.3)	14,252 (36.6)	5,147 (52.3)	5,921 (53.3)	7,238 (47)
Pediatric Medical Complexity Algorithm Score[h]					
Nonchronic	363 (0.6)	302 (0.8)	24 (0.2)	3 (0.3)	60 (0.4)
Noncomplex chronic	11,392 (19.0)	9,209 (23.7)	1,339 (13.6)	844 (7.6)	2,281 (15)
Complex chronic	48,093 (80.3)	29,398 (75.5)	8,470 (86.1)	10,225 (92.1)	12,919 (84)
Unknown	8 (<0.01)	8 (<0.01)	0 (<0.01)	0 (<0.01)	0
Postoperative length of stay, d	7 (4-18)	5 (4-10)	10 (6-22)	23 (11-47)	22 (12-50)
Mortality	1,787 (3.0)	451 (1.2)	306 (3.1)	1,030 (9.3)	1,236 (8.1)
Transplant	1,929 (3.2)	19 (0.04)	1,617 (16.4)	293 (2.6)	213 (1.4)

Values are median (IQR) or n (%). [a]N/A or missing values were not included in the analysis. [b]Patients could fall under more than 1 category. [c]Total percentage not 100% due to missing data. [d]Other corresponds to self-payment, charity, other payer, the hospital choosing not to bill for this encounter, or missing data. [e]Infection was defined as infection following a procedure, bloodstream infection due to central venous catheter, infection and inflammatory reaction due to other cardiac and vascular devices/implants/grafts, pneumonia due to *Pseudomonas*, pneumonia due to methicillin-susceptible/resistant *Staphylococcus aureus* etc. [f]Medical complication was defined by the ICD-CM codes that included other complications following infusion/transfusion/therapeutic injection, failed/difficult intubation, extravasation of other vesicant agent, adverse effect of unspecified drugs, medicaments and biological substances, and adverse effect of other drugs, medicaments and biological substances etc. [g]Surgical complication was defined by the ICD-CM codes that included acute postprocedural respiratory failure, postprocedural heart failure following cardiac surgery, postprocedural pneumothorax, stenosis of cardiac prosthetic devices, implants and grafts, initial encounter, postprocedural cardiac arrest following cardiac surgery etc. [h]Uses the least conservative version of the Pediatric Medical Complexity Algorithm to assign the category. See reference[14] for more details.

CENTRAL ILLUSTRATION Racial Health Disparity Associated With Poor Pediatric Cardiac Surgery Outcomes



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RACHS-2 = Risk Adjustment for Congenital Heart Surgery-2.

Surgeons-European Association for Cardiothoracic Surgery Mortality Scores and Categories, which stratifies mortality risk of congenital heart operations based on a variety of factors including the complexity of the procedure performed as well as the patient's preoperative condition.[12] The RACHS-2 can more accurately predict mortality associated with pediatric cardiac surgery than the RACHS-1 model as it captures 99.6% of cases with 1.0% false positives.[13] As such, the objective of this study was to evaluate the impact of health disparities on major outcomes (ie, hospital discharge mortality and postoperative length of stay [LOS]) in infants and children with cardiac surgeries using RACHS-2 categories in an extensive administrative database.

METHODS

DATA EXTRACTION. We conducted a retrospective, multicentered, cross-sectional cohort study using data from the PHIS Database. PHIS integrates clinical and resource utilization data for inpatients from at least 49 children's hospital across the United States. Member hospitals contribute data on demographics, diagnoses, procedures, interventions, and outcomes for all inpatient encounters.[14] Our study included all subjects ≤21 years of age who underwent cardiac procedures based on the International Classification of Diseases-10th Revision (ICD-10) codes from October 1, 2015, to December 31, 2020 (Supplemental Table 1). Variables missing more than 5.5% of the cohort's values were excluded.

Since the implementation of the ICD-10 in 2015, the RACHS-1 has been updated to RACHS-2 to transition from ICD-9 to ICD-10. As such, subjects were categorized by case complexity using the validated RACHS-2 model based on ICD-10: RACHS-2 scores of 1 and 2 were considered low, 3 as medium, and 4 and 5 as high-risk groups (Supplemental Table 2). Noncardiac procedures and cardiac procedures that did not meet risk stratification (ie, neonates with patent ductus arteriosus as the sole procedure) were excluded.

DATA ANALYSIS. After the data were extracted, R Statistical Software (Version 4.1.2, R Foundation for Statistical Computing) was used for analysis. Patient demographics and clinical characteristics were described using summary statistics, including frequencies and percentages for categorical data and median (IQR) for continuous data, stratified by RACHS-2 score. A logistic multivariable regression model was built to assess the factors associated with in-hospital mortality. Subjects were categorized using PHIS category of White vs non-White race. Variables (White race, categorical RACHS-2 groups, age at surgery in years, median household income, admission type, urban/suburban vs rural, extended mechanical ventilation, extracorporeal membrane oxygenation [ECMO], infection, and surgical complications) were originally all included in the multivariable model but were subsequently eliminated if they were found to be insignificant ($P > 0.05$). Extended period of mechanical ventilation was defined as >96 consecutive hours of ventilation. Surgical complication was defined by the ICD-10 codes that included acute postprocedural respiratory failure, postprocedural heart failure following cardiac surgery, postprocedural pneumothorax, stenosis of cardiac prosthetic devices, implants and grafts, initial encounter, postprocedural cardiac arrest following cardiac surgery, etc (Supplemental Table 1). A linear regression model was constructed to assess the variables associated with postoperative LOS. The postoperative LOS was logarithmically transformed and used in building the model since the distribution was nonnormal. Variables were included in the multivariable linear model if the univariate model was found to be significant ($P < 0.05$). However, median household income was eliminated from the multivariable analysis due to inaccuracies associated with PHIS reporting median household income using solely zip codes.

Stratified linear and logistic regression analyses were performed on non-White and neonatal patients to evaluate for potential health disparities. The non-White stratum was created by eliminating those of White race as noted in PHIS. Neonatal patients were defined as any patient 30 days old or younger while non-neonatal patients were defined as any patient older than 30 days.

Stratified Kaplan-Meier analysis was used to examine survival during the hospitalization related to surgery. A log rank test was performed on the Kaplan-Meier to assess the statistical significance of hospital mortality during postoperative LOS in relation to the stratified RACHS-2 groups. A Cox proportional hazards model was used to incorporate the same variables that were found significant in the univariate analysis as covariates.

TABLE 2 Multivariate Regression Models for Factors Associated With Hospital Mortality and Postoperative Length of Stay for Entire Study Cohort[a]

	Relative Risk	95% CI	*P* Value
Hospital mortality			
RACHS-2 group			
Low [1,2]	(Ref)[b]	(Ref)[b]	(Ref)[b]
Medium [3]	0.815	0.665-0.998	0.0491
High [4,5]	1.850	1.579-2.166	<0.001
Age at surgery (y)[c]	0.98	0.99-1.038	0.062
Race			
White	(Ref)[b]	(Ref)[b]	(Ref)[b]
Non-White	1.198	0.729-0.955	0.008
Postoperative length of stay (d)			
RACHS-2 group			
Low [1,2]	(Ref)[b]	(Ref)[b]	(Ref)[b]
Medium [3]	1.300	1.27-1.320	<0.001
High [4,5]	1.630	1.60-1.660	<0.001
Age at surgery (y)[c]	0.980	0.98-0.990	<0.001
Race			
White	(Ref)[b]	(Ref)[b]	(Ref)[b]
Non-White	1.040	0.947-0.972	<0.001

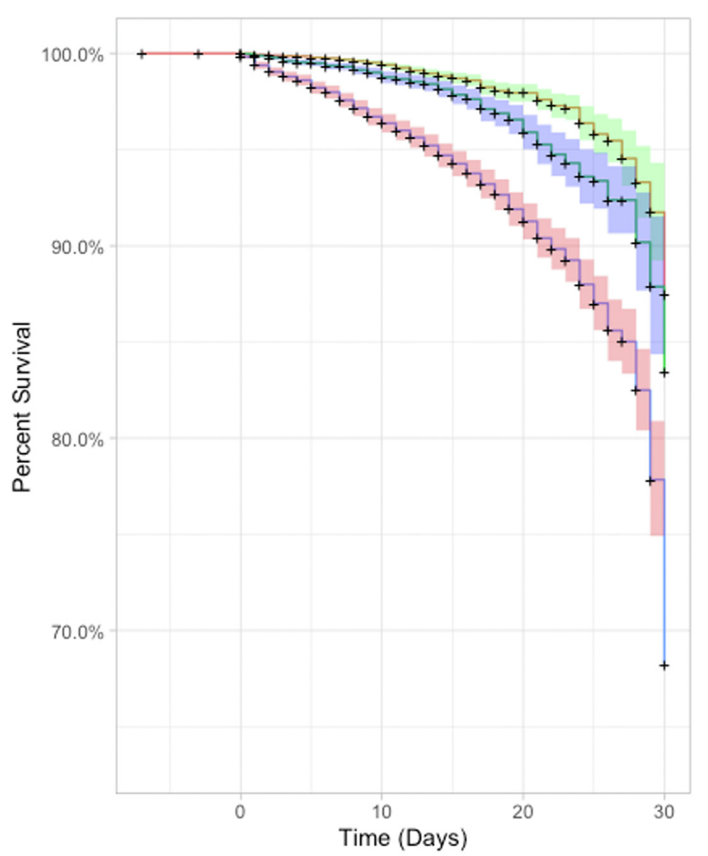
[a]Factors controlled for were infection, surgical complication, type of admission, extended mechanical ventilation (defined as >96 hours of consecutive ventilation after surgery), and extracorporeal membrane oxygenation. [b]Ref = reference group, which is the group chosen to be the reference so that all relative risks will be a comparison to the reference group. [c]Increased risk for mortality with younger age.

RESULTS

A total of 293,939 subjects were excluded from the study. The remaining 59,856 subjects with a median age of 7.4 months (IQR: 1.5-61 months) were included (**Figure 1**). Subjects were classified into low (38,917), medium (9,833), and high (11,106) risk according to assigned RACHS-2 scores for their procedures. Within the cohort, 54.9% of subjects were male, 39.4% non-White race, and 18.2% Hispanic (**Table 1**). Approximately 58.3% of patients had elective heart surgeries, 72.8% of patients required postoperative mechanical ventilation, and 32.8% of subjects experienced an infection sometime during their hospital stay. Overall, in-hospital mortality was 3% and total LOS was 8 days (IQR: 4-24 days). Notably, 3.2% of the patients had cardiac transplants. The data showed significant increases in both hospital mortality and postoperative LOS from low to high RACHS-2 categories (**Central Illustration**).

In addition to RACHS-2 category, extended mechanical ventilation, ECMO, infection, and surgical

FIGURE 2 **Kaplan-Meier Curve by RACHS-2 Categories**



Low RACHS-2 = red; Medium RACHS-2 = blue; High RACHS-2 = green. Cox regression analysis showed that the risk of hospital mortality was increased with high RACHS-2 relative to low RACHS-2 categories (HR: 1.56, 95% CI: 1.37-1.77, $P < 0.001$); but no difference was observed between low and medium RACHS-2 (HR: 0.90, 95% CI: 0.65-1.21, $P < 0.46$) and medium RACHS-2 and high RACHS-2 categories ($P < 0.001$). RACHS-2 = Risk Adjustment for Congenital Heart Surgery-2.

complication were most significantly associated with increased mortality by 1.198 to 10.227 times ($P < 0.008$). After controlling for these important factors, multivariable analyses revealed that non-White race was significantly associated with both increased mortality (relative risk: 1.198, 95% CI: 0.729-0.955, $P = 0.008$) and increased postoperative LOS by 1.04 day (95% CI: 0.947-0.972, $P < 0.001$) (**Table 2**). Ethnicity was not associated with these poor clinical outcomes.

Using Kaplan-Meier analysis with a log rank test, a significant difference was detected in mortality ($P < 0.001$) based on RACHS-2 categories (**Figure 2**). Cox regression analysis demonstrated RACHS-2 group (HR: 1.56, 95% CI: 1.37-1.77, $P < 0.001$), age at surgery (HR: 1.02, 95% CI: 1.01-1.04, $P < 0.001$), ECMO (HR: 7.68, 95% CI: 6.95-8.60, $P < 0.001$), mechanical ventilation use (HR: 8.99, 95% CI: 4.23-19.09, $P < 0.001$), and infection (HR: 0.75, 95% CI: 0.67-0.85, $P < 0.001$) were found to be significant. The concordance of this model was 0.84.

STRATIFIED ANALYSIS. Race. To further evaluate racial differences, subgroup analyses were performed by race, separating the overall cohort into 36,281 White and 23,575 non-White children (Supplemental Table 3). Demographic and clinical characteristics were provided for different non-White races in **Table 3**. Comparable to the entire cohort, multivariable regression analyses revealed that RACHS-2 categories, admission type, mechanical ventilation, ECMO, infection, and surgical complication were significantly associated with mortality and postoperative LOS when the non-White and White subgroups were analyzed separately. For mortality, the median age at surgery for non-White and White subgroups who died was 15 (IQR: 4-210) days and 18 (IQR: 5-133) days, respectively.

Neonates. The total number of neonates within our cohort who were <30 days old was 15,260. The race, ethnicity, and residence area were similar between neonates and non-neonates (Supplemental Table 4). However, compared to the non-neonates, neonates had more in the following parameters: high RACHS-2 score, emergent/urgent status on admission, mechanical ventilation, and ECMO. After controlling for factors known to contribute to poor clinical outcomes (including RACHS-2, mechanical ventilation, ECMO, infection, and surgical complication), a multivariable logistic analysis of only neonates revealed that non-White race was significantly associated with increased risk in mortality (**Table 3**) (relative risk: 1.305, 95% CI: 1.097-1.553, $P = 0.003$). In addition, a multivariable linear model demonstrated that non-White race was associated with a significant increase in the postoperative LOS by 2.053 weeks (95% CI: 1.358-3.103, $P < 0.001$).

DISCUSSION

Our study reports an overall cohort in-hospital mortality rate of 3%, which parallels a 2016 study conducted on The Society of Thoracic Surgeons Congenital Heart Surgery Database by Jacobs et al Similar in-hospital mortality rates and postoperative LOS were found in previous studies and noted higher mortality rates for non-White patients.[6-8] The median total LOS for the cohort was 8 (IQR: 4-24) days, which is consistent with the LOS reported by other groups.[6,11] Racial variation in mortality is also observed in ECMO patients where Blacks (OR: 1.22, 95% CI: 1.05-1.42) and non-Whites (OR: 1.36, 95% CI: 1.17-1.58) are at increased odds of mortality compared to Whites.[9] The past literature substantiates our results, which incorporate recent data up to 2020. It reveals that there have been no major improvements with regard to race and health disparities with congenital heart defect (CHD) care.

RACHS-2, a newly developed, externally validated ICD-10-based scoring system, was identified as a potentially strong predictor of both in-hospital mortality and postoperative LOS for our cohort, supporting its use as a risk categorization tool. Since the transition from ICD-9 to ICD-10 in 2015, there has been a lack of risk adjustment methods in pediatric cardiac procedures for administrative data. To meet this need, RACHS-2 was developed in 4 centers with PHIS and STS-CHS clinical registry data and externally validated in 11 centers using NY Medicaid/Society of Thoracic Surgeons- Congenital Heart Surgery data from The NY State CHS-COLOUR (Congenital Heart Surgery Collaborative for Longitudinal Outcomes and Utilization of Resources.[13] As the complexity rises in the RACHS-2 scoring, as expected, so do the in-hospital mortality rates and postoperative LOS (**Figure 2**).

Within this cohort, White and non-White neonates underwent surgery at the median age of 7 days. Based on their worse outcomes, non-White infants with CHD may not have been diagnosed initially, including the prenatal period, presented in a worse clinical status. Infants with critical CHD and unknown ductal dependent lesions could present in extremis, portending to worse outcomes. It is known that pulse oximeter screening CHD program may not work as well in infants who are non-White. The accuracy of the pulse oximeter measurements in patients with dark-skin tones is known to be problematic.[15]

The racial effect on physiology is one that has not been elucidated well; is there a physiological reason why some patients experience more myocardial dysfunction and do not fare well as others? The inherent ability of Black patients to have the compensatory ability to rebound from a major cardiac surgery is an important question. Tahhan and colleagues have found that Black adults had lower levels of these circulating progenitor cells, partly explained by having decreased metallopeptidase-9 levels to thereby increased cardiac risk.[16] While in adults, comorbidities such as obesity or hypertension can increase cardiovascular risk; this would not inherently be the case in neonates. Studies in these children are needed to evaluate any racial physiological differences. Maternal and infant mortality in Blacks remains higher than non-Hispanic Whites.[17] Black American infants have a death rate of 10.8 deaths per 1,000 live births which is close to double that of the national average (ie, 5.7 deaths per 1,000 live births).[18]

TABLE 3 Multivariate Logistic Regression Model for Factors Associated With Hospital Mortality in Neonates[a]

	Relative Risk	95% CI	*P* Value
Hospital mortality			
RACHS-2 group			
Low [1,2]	(Ref)[b]	(Ref)[b]	(Ref)[b]
Medium [3]	0.900	0.653-1.213	0.461
High [4,5]	1.690	1.370-2.084	<0.001
Race			
White	(Ref)[b]	(Ref)[b]	(Ref)[b]
Non-White	1.305	1.097-1.553	0.003
Postoperative length of stay (wk)			
RACHS-2 group			
Low [1,2]	(Ref)[b]	(Ref)[b]	(Ref)[b]
Medium [3]	0.1597	0.085-0.302	<0.001
High [4,5]	0.395	0.102-0.251	<0.001
Age at surgery (y)	0.547	0.038-7.817	<0.001
Race			
White	(Ref)[b]	(Ref)[b]	(Ref)[b]
Non-White	2.053	1.358-3.103	<0.001

[a]Factors controlled for were infection, surgical complication, type of admission, extended mechanical ventilation (defined as >96 hours of consecutive ventilation after surgery), and extracorporeal membrane oxygenation. [b]Ref = reference group, which is the group chosen to be the reference so that all relative risks will be a comparison to the reference group.

While there exists a higher complexity of cases in younger patients, the increased time of mechanical ventilation and postoperative ECMO can potentially lead to poor outcomes, necessitating the need to evaluate racial disparities. The RACHS-2 risk scoring in line with new ICD-10 scoring opens a wealth of administrative data which can help with future studies as was used in this one. Administrative databases have limitations but also very high sample sizes in which a wealth of data can be garnered. The data in which we need to make these assessments are crucial, including known databases such as PHIS and STS to garner the best data and when possible, linking them together to augment the validity of the data. Clinical and administrative databases linked together can support future research studies to improve our understanding of other clinical and social issues.

The true issue of health care disparities within this cohort spans multiple societal factors that contribute to many individual roadblocks. Known societal factors such as language differences, lack of transportation, and access to care can be impediments to care and require further inquiry.[18-21]

Within our cohort, 15,260 of the patients were classified as neonates and a multivariable regression of mortality yielded results showing that race was significant. The critical cardiac surgical care performed in these complex neonatal patients is known to have higher risk than others, but the role of race must be elucidated. Although difficult, forming a propensity-matched prospective study may be what is necessary to study each step of the care algorithm from prenatal care, intraop pathology, to postoperative care. It is only then that we can breakdown and improve upon a very complex clinical and social interplay that will better the lives of future congenital heart surgery patients.

LIMITATIONS/AREAS OF FURTHER INTEREST. While the administrative structure of the PHIS database provided informative results, the granularity of the data remain limited, lacking details of patient demographics, surgical diagnosis, postoperative clinical course, and other clinical parameters that may alter care and impact clinical outcomes. In particular, the PHIS database did not provide the true economic status or income for each patient, outside of one income assumed for each patient's zip code that was reported upon admission. In addition, our study was aimed to encompass all applicable pediatric cardiac surgeries (excluding neonatal Patent Ductus Arteriosus) and the heterogeneity of the population might limit extrapolation to specific patient populations or surgery type. More in-depth studies of special populations, especially neonates, and surgeries should be conducted to improve clinical outcomes and mitigate racial disparities in patient care.

CONCLUSIONS

The use of RACHS-2 score supported the identification of children potentially at increased risk for mortality and postoperative LOS within this PHIS administrative database. Non-White race was associated with a significant increased risk in mortality and longer postoperative LOS in both neonates and children. Other significant factors contributing to increased mortality were ECMO, mechanical ventilation, urgent/emergent admission, infection, and surgical complication. Racial, along with ethnic and socioeconomic, factors should be further evaluated to mitigate any disparity among infants and children undergoing cardiac surgery.

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PERSPECTIVES

COMPETENCY IN MEDICAL KNOWLEDGE: The role of race continues to be a significant factor in the outcomes of pediatric cardiac surgery, when compared with other risk factors.

TRANSLATIONAL OUTLOOK: Racial, ethnic, and socioeconomic factors should be further investigated to mitigate any disparity among infants and children undergoing cardiac surgery.

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KEY WORDS extracorporeal membrane oxygenation, heart surgery, morbidity, mortality, neonates, RACHS-2

APPENDIX For supplemental tables, please see the online version of this paper.