# Racial variations in extracorporeal membrane oxygenation use following congenital heart surgery

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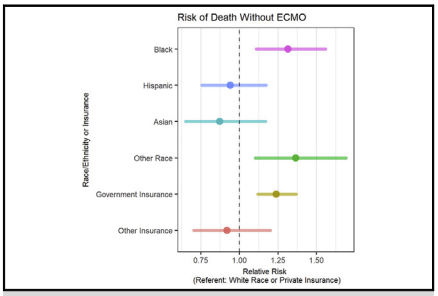
## ABSTRACT

**Objectives:** Previous studies demonstrate racial and ethnic disparities among children undergoing congenital heart surgery. Extracorporeal membrane oxygenation (ECMO) is used to support critically ill children after congenital heart surgery and improve survival. Thus, racial or ethnic variations in postoperative ECMO use following congenital heart surgery may be associated with racial/ethnic disparities in hospital survival.

**Methods:** All children in the Pediatric Health Information Systems dataset undergoing congenital heart surgery from 2004 to 2015 were examined. Multivariable, multinomial regression models examining hospital survival without ECMO use, survival after ECMO, death after ECMO, and death without ECMO support were constructed.

**Results:** Of 130,860 congenital cardiac surgery patients, 95.4% survived to hospital discharge without requiring ECMO support, whereas 1.3% survived after ECMO support, 1.3% died after ECMO support, and 1.9% died without receiving ECMO support. After adjustment for other covariates, black patients (odds ratio, 1.22; 95% confidence interval [CI], 1.05-1.42) and patients of other race (odds ratio, 1.36; 95% CI, 1.17-1.58) were at increased odds of mortality compared with white patients. In multivariable multinomial models, black patients had increased risk of death without ECMO support (relative risk, 1.31; 95% CI, 1.11-1.56). Patients of other race (relative risk, 1.37; 95% CI, 1.10-1.69) and governmental insurance (relative risk, 1.24; 95% CI, 1.12-1.37) were also at increased risk of death without ECMO.

**Conclusions:** Black children and children of other race are at increased odds of mortality after congenital heart surgery. These disparities can be traced to variations in ECMO utilization across racial/ethnic groups. (J Thorac Cardiovasc Surg 2018;■:1-10)




Black race and other nonwhite race as well as government insurance are risk factors for death without ECMO.

**Central Message**

Nonwhite and publicly insured children are more likely to die without receiving ECMO after cardiac surgery. This variation in ECMO use contributes to postsurgical mortality.

**Perspective**

Nonwhite children and children with government insurance have higher rates of mortality after congenital heart surgery. We demonstrate that race and insurance are risk factors for death without ECMO and may be the driver of postsurgical disparities. Changing how ECMO is discussed and offered to patients' families may be the first step in improving differences in surgical mortality.

See Editorial Commentary page XXX.

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Nonwhite children are at increased risk of mortality following cardiac surgery.[1-4] The etiology behind postsurgical survival disparities in this population is unclear. Previous studies show that nonwhite patients are at increased risk of experiencing a complication[3] and failure-to-rescue[5] (mortality after experiencing a

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**Abbreviations and Acronyms**

CCC = complex chronic conditions
CPR = cardiopulmonary resuscitation
CTC = clinical transaction code
ECMO = extracorporeal membrane oxygenation
ICD-9-CM = International Classification of Diseases, Ninth Revision, Clinical Modification
IVH = intraventricular hemorrhage
PHIS = Pediatric Health Information System
RACHS = Risk Adjustment for Congenital Heart Surgery

complication). However, previous studies of failure-to-rescue included extracorporeal membrane oxygenation (ECMO) as a postoperative complication and not as a support modality.

Although requiring ECMO is an undesired outcome, ECMO is used to improve survival of cardiac surgical patients who would have otherwise likely died.[6] Thus, variations in ECMO use across populations may result in differences in overall postsurgical survival. If ECMO use varies across race or ethnicity, this may contribute to racial or ethnic disparities in hospital mortality. For these reasons, we examined an administrative database of children's hospitals, to assess variations in ECMO use across racial or ethnic groups in children undergoing congenital heart surgery. Furthermore, we also evaluated the influence of ECMO use on overall hospital survival.

## PATIENTS AND METHODS

This was a retrospective, cross-sectional study using the Pediatric Health Information System (PHIS) database, an administrative dataset maintained by the Children's Hospital Association. PHIS includes administrative and billing data from 49 tertiary care children's hospitals. Participating hospitals provide information on demographic characteristics, outcomes, diagnoses, procedures, and charge codes. The majority of hospitals also submit data for pharmacy, medical imaging, laboratory, supply, nursing, and therapy services using clinical transaction classification (CTC) codes for billed services. Use of de-identified administrative data qualified for exemption from human subjects review by the University of Utah Institutional Review Board.

We included all patients aged $\leq$ 18 years discharged from a participating children's hospital from January 1, 2004, to September 30, 2015, with a cardiac surgical procedure. PHIS uses International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) procedure and diagnostic codes to assign Risk Adjustment for Congenital Heart Surgery (RACHS) categories to all qualifying patients.[7] All patients with either a RACHS category or procedure codes consistent with a cardiac surgical procedure (eg, cardiopulmonary bypass, hypothermia related to cardiac surgery, cardioplegia, intraoperative pacemaker, or shunts that may be performed off bypass) were included for analysis. Postoperative ECMO was identified using ICD-9-CM and CTC codes. ICD-9-CM diagnosis codes are recorded for the entire hospital stay, whereas CTC and procedure codes are reported with a date of service, enabling investigators to establish a chronology of procedures but not diagnoses.

Because this study focused on variations in postoperative ECMO use, patients who underwent ECMO before cardiac surgery (n = 628) or those in which the timing of surgery could not be established (n = 5669 with 45 cases also undergoing ECMO support) were excluded. Patients were grouped into 4 mutually exclusive discharge outcomes: survival without ECMO, survival after ECMO support, death after or during ECMO support, and death without ECMO support. Overall or hospital mortality includes patients who died after ECMO and those who died without ECMO support.

The independent variable of interest was race and ethnicity. Over the study period, PHIS used 2 different systems of classifying race and ethnicity. The first system (used until 2009) classified race as 1 of 6 mutually exclusive categories (white, black, Asian, American Indian, other, and missing race) and ethnicity as either Hispanic or not Hispanic/unknown. The second system (used 2007 onward) classified each racial group (white, black, Asian, Pacific Islander, American Indian, and other) as a dichotomous variable such that patients could have multiple race categories. Ethnicity was classified as Hispanic, not Hispanic, or unknown. For this analysis, patients were categorized as non-Hispanic white (hereafter referred to as white), non-Hispanic black (hereafter referred to as black), Hispanic ethnicity (including all patients with Hispanic ethnicity, regardless of race), Asian/Pacific Islander (hereafter referred to as Asian), and other race (including multirace). Patients with unknown ethnicity were categorized as non-Hispanic. Primary payer was categorized as private insurance, government payer, and other payer.

Age at the time of surgical procedure was categorized as < 29 days, 1 month to 1 year, 1 to 4 years, 5 to 12 years, and older than age 12 years. Surgical complexity was grouped into low (RACHS 1 and 2), medium (RACHS 3 and 4), and high complexity (RACHS 5 and 6) procedures or no RACHS category. Using ICD-9-CM diagnosis codes, we examined other covariates that may influence outcomes and decisions to utilize ECMO for postsurgical cardiac support. Complex chronic conditions (CCCs) as defined by Feudtner and colleagues[8] were analyzed for each noncardiac organ system. The total number of noncardiac organ system CCCs were totaled and categorized as 0, 1, or $\geq$ 2 organ systems as a measure of underlying patient complexity. Patients born at < 37 weeks' gestational age were categorized as born prematurely. Using CTC codes, presurgical mechanical ventilation and preoperative medications were used as a marker of severity of illness. Preoperative administration of vasoactive medication infusions, antiarrhythmic agents, beta-receptor antagonists (ie, beta-blockers), and pulmonary vasodilators before surgery were included as dichotomous variables. Performance of cardiopulmonary resuscitation (CPR) before and after surgical intervention was assessed. Because billing data (CTC codes) were used to identify therapies used during surgical admissions, hospitals without any billing data were excluded from the analysis.

Patient characteristics are presented as percentages for categorical variables. We examined baseline characteristics by race or ethnicity and performed a univariate analysis of predictors of outcome. Differences in predictors of outcome were analyzed using the $\chi^2$ test and variables found to be statistically significant ($P < .05$) were considered for inclusion into the multivariable analysis. We constructed multiple multivariable regression models that adjusted for sex, age, payer group, surgical complexity, surgical era, hospital surgical volume, prematurity, number of CCCs, presurgical mechanical ventilation, preoperative administration of vasoactive infusions, antiarrhythmic agents, beta-blockers, pulmonary vasodilators, preoperative CPR, and postoperative CPR to examine the relationship between race or ethnicity and outcomes after cardiac surgery. Given the relatively short duration of postoperative hospitalizations, the lack of granularity in regard to time measurement in PHIS and the conditional nature of some of the outcomes, logistic and multinomial regression models were used to analyze these outcomes. First, we performed a logistic

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