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Racial and Ethnic Disparities in Postoperative Mortality Following Congenital Heart Surgery

By

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Degree: Master of Public Health

Epidemiology

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B.S., Vanderbilt University, 1999

M.D., University of Pennsylvania, 2004

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An abstract of

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Abstract

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Study Design: We used the Pediatric Health Information System database to perform a retrospective cohort study of 44,017 patients with 49,833 CHD surgery encounters in 2004-2008 at 41 children's hospitals. We used chi-square analysis to compare unadjusted mortality rates by race/ethnicity (non-Hispanic white, non-Hispanic black, Hispanic) and constructed Poisson regression models to determine adjusted mortality risk ratios (RRs) and 95% confidence intervals (CIs).

Results: In-hospital postoperative mortality rate was 3.4%; non-Hispanic whites had the lowest mortality rate (2.8%), followed by non-Hispanic blacks (3.6%) and Hispanics (3.9%) ($p<0.0001$). After adjusting for age, sex, genetic syndrome, and surgery risk category, the RR of death was 1.32 for non-Hispanic blacks (CI 1.14-1.52) and 1.21 for Hispanics (CI 1.07-1.37), both compared with non-Hispanic whites. After adjusting for access to care (insurance type and hospital of surgery), these estimates did not appreciably change (non-Hispanic blacks: RR=1.27, CI 1.09-1.47; Hispanics: RR=1.22, CI 1.05-1.41).

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Racial and Ethnic Disparities in Postoperative Mortality Following Congenital Heart Surgery

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Running Title: Racial Disparities in Congenital Heart Surgery Outcomes

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Abbreviations:

CHD: Congenital Heart Disease
PHIS: Pediatric Health Information System
CHCA: Child Health Corporation of America
RACHS: Risk Adjustment of Congenital Heart Surgery
RR: Risk Ratio
CI: Confidence Interval

Other keywords not in title: outcomes, pediatric cardiology, race, ethnicity, insurance

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Conclusion: There are notable racial/ethnic disparities in postoperative mortality following CHD surgery that do not appear to be explained by differences in access to care.

Background

Despite various advances in healthcare over the last half century, racial and ethnic disparities have persisted in numerous key outcome measures for children (1). In the case of congenital heart disease (CHD), this trend is easily seen in the mortality rates for blacks and whites. While infant mortality from CHD for blacks improved from 99.87 deaths/100,000 infants in 1979-1981 to 68.43 deaths/100,000 infants in 1995-1997, black infants in 1997 had a mortality rate that was 19% higher than their white counterparts, a gap that did not appear to be closing (2). Similarly, in a recent analysis of neonatal mortality due to CHD from 2003-2006, the Centers for Disease Control and Prevention found that term black infants had 20% higher mortality than term white infants (3).

These disparities in outcomes in CHD have been confirmed in numerous other studies in the last decade, but the reasons for the disparities remain unclear (4-8). One proposed rationale is the finding that patients with public insurance (in which black and Hispanic children are more likely to be enrolled) (9) are more likely to receive CHD care in hospitals with higher mortality (6). Similarly, type of insurance and hospital location have been found to be important factors in explaining differences in resource allocation in care for children with CHD (10-13). Thus, access to care, particularly inpatient surgical care, may play a key role in explaining racial and ethnic disparities in CHD outcomes. Prior studies evaluating disparities in mortality following surgery for CHD have not adequately addressed the role that access to care may play in explaining such disparities.

By including insurance type and hospital of surgery in analyses of in-hospital mortality and postoperative length of stay, it is possible to adjust for variations in access to quality care when examining differences in outcomes for non-Hispanic whites, non-Hispanic blacks, other non-Hispanics, and Hispanics. We hypothesized that racial and ethnic disparities in mortality and postoperative length of stay following pediatric congenital heart surgery persist after accounting for differences in access to care.

Methods

Data Source and Patient Population

We conducted a retrospective cohort study using data from the Pediatric Health Information System (PHIS) database, a large, multi-center administrative database. Data are collected from pediatric tertiary care hospitals that are members of the Child Health Corporation of America (CHCA). Member hospitals contribute data on demographics, diagnoses, procedures, interventions, and outcomes for all inpatient encounters. We included in our analyses all children (aged 0-18 years) who underwent congenital heart surgery from January 1, 2004, to December 31, 2008 at participating institutions which had at least 100 eligible encounters during the study period. For the analysis of postoperative length of stay, we included only those children who survived to discharge.

Study Variables

The primary outcome variable was in-hospital death following congenital heart surgery, and our secondary outcome was postoperative length of stay. Our main predictor of interest for both analyses was race/ethnicity. In the PHIS database, race is reported as white, black, Asian, American Indian, other, or missing; ethnicity is reported as Hispanic or Latino, or unknown. For our analyses, we coded race/ethnicity as Hispanic, non-Hispanic white, non-Hispanic black, or other non-Hispanic (Asian, American Indian, or other race). Patients with missing race were not included. Our primary covariates of interest were age (<30 days, 30 days-1 year, >1 year), sex, presence of a genetic syndrome, surgery risk category, insurance type (government, private, other), and hospital of surgery. For each hospital encounter, we used *International Classification of Diseases, Ninth Revision* (ICD-9) codes to determine the highest surgery risk category for that encounter using the Risk Adjustment for Congenital Heart Surgery Method (RACHS-1) (14). We excluded from our analyses encounters in which a RACHS-1 category could not be assigned. Due to small case counts for RACHS-1 category 5, we combined this group with RACHS-1 category 6 in our regression models.

Statistical Analysis

For the analysis of postoperative mortality, we first compared overall unadjusted mortality rates for each race/ethnicity using chi-square analysis. We then estimated in-hospital mortality for patients undergoing congenital heart surgery during January 2004-December 2008 by constructing generalized estimating equation Poisson regression models with race/ethnicity as an independent predictor and age, sex, genetic syndrome, and surgery risk category (using RACHS-1 method) as potential confounders. Finally, we then built a model adjusting for access to care by adding insurance type and hospital of surgery to the initial model. Because several children had more than one surgical encounter, we used robust variance estimation in all of our regression models to account for the lack of independence (15). From the regression models we calculated adjusted risk ratios (RRs) and 95% confidence intervals (CIs).

In the analysis of postoperative length of stay, we first compared overall unadjusted length of stay for each race/ethnicity using ANOVA. In a similar manner as above, we then used multiple linear regression with least square means to compute baseline adjusted values (with all covariates except hospital of surgery and insurance type) and fully adjusted values (with all covariates) for postoperative length of stay by race/ethnicity. All analyses were performed using SAS Version 9.2 (SAS Institute, Cary, NC).

Results

For the period of January 1, 2004 to December 31, 2008, the PHIS database included 44,017 eligible patients with 49,833 congenital heart surgery hospital encounters at 41 children's hospitals. There were 1791 patients who were not included due to missing race and 28 patients (from 2 hospitals) not included due to having surgery at a hospital with fewer than 100 congenital heart surgery encounters during the study period. Patient characteristics are summarized in Table 1.

The overall in-hospital mortality rate following congenital heart surgery in 2004-2008 was 3.4%. Unadjusted mortality rate was lowest for non-Hispanic whites (2.8%), followed by non-Hispanic blacks, Hispanics, and other non-Hispanics (3.6%, 3.9%, 4.6%, respectively; $p<0.0001$) (Figure).

In the Poisson regression model adjusted for age, sex, and surgery risk category, all minority groups had an increased risk as compared to whites. Of the minority groups, Hispanics had the lowest relative risk (RR=1.21, CI 1.07-1.37), followed by non-Hispanic blacks (RR=1.32, CI 1.14-1.52) and other non-Hispanics (RR=1.41, CI 1.25-1.60).

To evaluate whether race/ethnicity differences in mortality persisted after accounting for access to care, we then added insurance type and hospital of surgery to the model. The results from this analysis were similar to those above, with the minority groups having increased risk of in-hospital mortality as compared to whites (Hispanics: RR=1.22, CI 1.05-1.41; non-Hispanic blac0ks: RR=1.27, CI 1.09-1.47; other non-Hispanics: RR=1.56, CI 1.37-1.78) (Table 2).

For overall postoperative length of stay, the median was 6 days and the mean was 12.5 days. Non-Hispanic whites had the shortest unadjusted length of stay (mean 11.5 days), followed by other Non-Hispanics, Hispanics, and non-Hispanic blacks (12.9, 13.7, and 14.1 days, respectively; $p<0.0001$). In both the baseline and fully adjusted models, there was no difference in postoperative length of stay between non-Hispanic whites and other non-Hispanics. However, compared to whites, non-Hispanic blacks and Hispanics had significantly longer postoperative lengths of stay in both models (Table 3).

Discussion

In this large, retrospective cohort study, Hispanics, non-Hispanic blacks, and other non-Hispanics were at increased risk of in-hospital mortality following congenital heart surgery as compared to non-Hispanic whites. These differences were seen in both unadjusted rates and in a model adjusting for age, sex, and surgery type. After adjusting for access to care by including insurance type and hospital of surgery in our model, the three minority groups were still at increased risk for in-hospital mortality; in fact, the adjusted risk for Asians, American Indians, and “Other” may be even greater. Thus, differences in mortality by race/ethnicity may not be explained by differences in access to care.

For postoperative length of stay, non-Hispanic blacks and Hispanics had longer lengths of stay than non-Hispanic whites, even after adjusting for access to care. Surprisingly, other non-Hispanics, the racial/ethnic group that had the highest relative risk for post-operative mortality, did not have a different length of stay as compared to non-Hispanic whites in either the baseline or fully adjusted models.

While multiple studies in adult populations have found similar differences in racial/ethnic disparities in in-hospital mortality following cardiac procedures (16-18), prior studies in pediatric populations have found mixed results for racial/ethnic differences in risk-adjusted in-hospital mortality following congenital heart surgery. Compared to whites, Benavidez and colleagues reported a significantly increased odds for blacks (odds ratio 1.65, p=0.003) but not for Hispanics or other non-Hispanics in an analysis of a national sample of CHD cases (4). Conversely, when Gonzalez et al. studied CHD cases in four states, they did not find a significantly increased odds for blacks but did for Hispanics (odds ratio 1.71, p=0.008) and Asians (odds ratio 1.73, p=0.04) (7). Interestingly, this group also found stark racial/ethnic differences based on state: minorities had significantly increased odds of in-hospital death in some states but decreased in others. This finding led Gonzalez and colleagues to postulate that racial/ethnic differences in mortality after congenital heart surgery may be due to unequal access to care and not be due to factors such as biology.

In our study we sought to address the possibility of access to care as a rationale for racial/ethnic disparities in outcomes following CHD surgery. We and others have shown that there are significant differences in surgical mortality among centers that persist over time (19, 20). If certain racial or ethnic groups are more likely to undergo surgery at lowperforming centers, then access may be the major factor explaining poorer outcome. To address this issue we constructed a multivariate model that included both insurance type and hospital of surgery, thereby allowing us to control for access to *quality* care. Controlling for insurance addresses issues relating to higher in-hospital mortality for pediatric patients with public insurance following CHD surgery (6) as well as for adult populations with public insurance following myocardial infarction (18). Including hospital of surgery in the model addresses concerns regarding differential referral of minority or public insurance patients to underperforming hospitals (6). This approach is similar to that of a study which found that hospital volume did not account for racial/ethnic disparities in outcomes following cardiovascular procedures in adults (21). As racial/ethnic disparities in mortality following CHD surgery persisted after adjusting for insurance type and hospital of surgery in our study, we believe that these differences are likely due to factors other than access to care.

If racial/ethnic disparities in outcomes following CHD surgery are not explained by differences in access to care, what then might be contributing factors? Many possible determinants have been proposed, but none have been well substantiated. One potential rationale is that there is differential referral for CHD based on race/ethnicity. Milazzo et al. did find that blacks were more likely to have their Fontan surgeries later than whites, although whether this differential referral leads to disparities in outcomes in uncertain (22). On the other hand, in a study performed before the widespread use of prenatal echocardiography, Fixler *et al*. found that timing of referral for pediatric cardiac care did not vary by race or ethnicity (23). A second possibility is that race/ethnicity of the provider may play a key role in determining outcomes. This has not been well-studied in pediatric populations, but in an adult population Chen et al. found that controlling for race of the provider did not account for racial differences in catheterization rates following a myocardial infarction (24). Another potential explanation is that there may be important unmeasured differential prenatal exposures that have an important effect on subsequent outcomes (25). Unfortunately, we did not have prenatal data available to analyze in our study population, and most studies to date on prenatal exposures have evaluated only development of CHD, not outcomes of children with CHD. A fourth postulate is that there may be important biologic differences between racial/ethnic groups that contribute to outcomes. Recent data from the heart transplant field have demonstrated significant racial/ethnic differences in outcomes that appear to be due at least in part to variable immune and inflammatory responses (26, 27). These same factors may influence the outcome following CHD surgery. There is certainly a need for further research into the mechanisms leading to racial/ethnic disparities; it is likely that there are important biologic, genetic, societal, or cultural factors that are as of yet unable to be appropriately measured.

This study, which is the largest study to date to evaluate racial/ethnic disparities in in-hospital mortality following CHD surgery, has important limitations. First, the use of ICD-9 codes from administrative data has been shown to be valid in identifying cases of congenital heart disease, but it has also been shown to have some false positives (28, 29). Since our study included not only diagnosis but also procedure code, we would expect that this false positive rate would have been decreased. Second, prematurity has been shown to be associated with poorer outcomes following CHD surgery, and we did not have sufficient data in the administrative database to appropriately control for this. What confounding effect prematurity would have on the association of race/ethnicity with outcomes after CHD surgery is unclear. Blacks with CHD are more likely than whites with CHD to have preterm birth (30), yet preterm blacks have been shown to have lower neonatal mortality from CHD than preterm whites (3). Third, since our primary outcome was death vs. not death, children with failing hearts who required heart transplant shortly after CHD surgery would not be counted in mortality estimates. As there have been shown to be differences in mortality for blacks vs. whites while awaiting heart transplant, estimates of the effect of race on outcomes in this population may be inaccurate (31, 32). Finally, for the analysis of postoperative length of stay, we excluded patients who died in the hospital following CHD surgery. This exclusion may lead to a biased estimate and may explain the paradoxical findings for the "Other non-Hispanic" group, i.e., that this group had the highest risk of mortality but had a similar length of stay as compared to white non-Hispanics. Further analyses may be indicated, such as the use of survival analysis techniques for length of stay.

Conclusion

There are notable racial/ethnic disparities in postoperative mortality following surgery for congenital heart disease, with Hispanics, non-Hispanic blacks, and other non-Hispanics (Asian, American Indian, or other) having worse outcomes than non-Hispanic whites. These disparities do not seem to be adequately explained by differences in access to care. Further research is warranted to determine factors contributing to racial/ethnic disparities in outcomes following congenital heart surgery and to explore effective strategies to reduce these disparities.

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Table 1. Characteristics of Inpatient Congenital Heart Surgery Encounters, 2004-2008

	No. (%)	% Mortality
Race/Ethnicity		
Non-Hispanic White	26,287 (55.0)	2.8
Non-Hispanic Black	6,142 (12.9)	3.6
Other Non-Hispanic	6,691 (14.0)	4.6
Hispanic	8,686 (18.2)	3.9
Age		
0-30 days	12,736 (25.6)	9.5
31 days-1 year	17,908 (35.9)	1.9
>1 year	19,189 (38.5)	0.9
Sex		
Male	27,751 (55.7)	3.4
Female	22,082 (44.3)	3.5
Genetic Syndrome		
Yes	7,104 (14.3)	3.9
No	42, 686 (85.7)	3.4
RACHS-1 Category		
1	5,933 (11.9)	1.0
2	17,054 (34.2)	1.4
3	18,432 (37.0)	3.3
4	6,026 (12.1)	7.3
5 or 6	2,388 (4.8)	15.9
Insurance type		
Public	21,556 (43.2)	4.4
Private	17,460 (35.0)	2.8
Other	10,817 (21.7)	2.6

Table 2. Adjusted In-Hospital Mortality Risk Ratio (RR) and Confidence Intervals (CI) Following Congenital Heart Surgery, 2004-2008

	*Baseline Adjustment**			*Full Adjustment†*		
Race/Ethncity	**RR**	**95% CI**	**p**	**RR**	**95% CI**	**p**
Non-Hispanic White		referent			referent	
Non-Hispanic Black	1.32	1.14-1.52	0.0002	1.27	1.09-1.47	0.0021
Other Non-Hispanic	1.41	1.25-1.60	<.0001	1.56	1.37-1.78	<0.0001
Hispanic	1.21	1.07-1.37	0.0028	1.22	1.05-1.41	0.0073

*Adjusted for age, sex, genetic syndrome, and surgery risk category

†Adjusted for age, sex, genetic syndrome, surgery risk category, and access to care (insurance type and hospital of surgery)

Table 3. Adjusted Least Squares Means (LSM) Differences in Postoperative Length of Stay (Days) and Confidence Intervals (CI) Following Congenital Heart Surgery, 2004-2008

	*Baseline Adjustment**			*Full Adjustment†*		
Race/Ethncity	**LSM Difference**	**95% CI**	**p**	**LSM Difference**	**95% CI**	**p**
Non-Hispanic White		referent			referent	
Non-Hispanic Black	3.00	2.44-3.56	<.0001	2.63	2.05-3.22	<.0001
Other Non-Hispanic	0.54	-0.01-1.08	0.0536	0.42	-0.15-0.99	0.1531
Hispanic	1.46	0.97-1.95	<.0001	1.28	0.71-1.85	<.0001

*Adjusted for age, sex, genetic syndrome, and surgery risk category

†Adjusted for age, sex, genetic syndrome, surgery risk category, and access to care (insurance type and hospital of surgery)

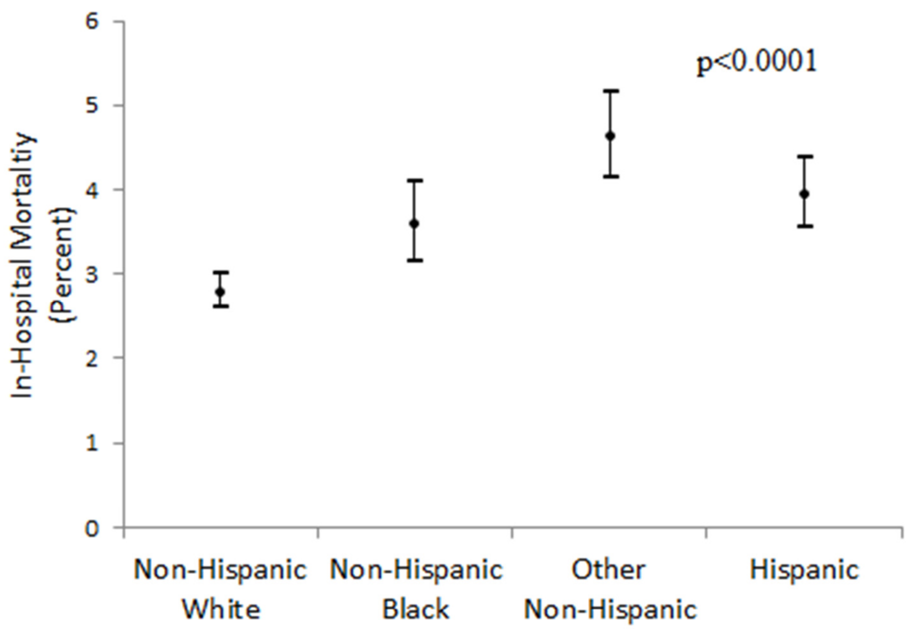

Figure. Unadjusted In-Hospital Mortality Rate Following Congenital Heart Surgery by Race/Ethnicity, 2004-2008