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The Effect of Race and Gender on Pediatric Surgical Outcomes within the United States

Matthew L. Stone, MD¹, Damien J. LaPar, MD, MSc¹, Bartholomew J. Kane, MD, PhD², Sara K. Rasmussen, MD, PhD², Eugene D. McGahren, MD², and Bradley M. Rodgers, MD²

¹Department of Surgery, The University of Virginia, Charlottesville, Virginia, USA

²Division of Pediatric Surgery, The University of Virginia, Charlottesville, Virginia, USA

Abstract

Purpose—The purpose of this study was to examine risk-adjusted associations between race and gender on postoperative morbidity, mortality, and resource utilization in pediatric surgical patients within the United States.

Methods—91,891 pediatric surgical patients were evaluated using the U.S. national KID Inpatient Database (2003 and 2006): appendectomy (81.2%), pyloromyotomy (9.8%), intussusception (6.2%), decortication (1.9%), congenital diaphragmatic hernia repair (0.7%), and colonic resection for Hirschsprung's disease (0.2%). Patients were stratified according to gender (male: 62.6%, n=57,557) and race: white (n=52,334), Hispanic (n=25,697), black (n=6,951), Asian (n=1,855), Native American (n=470), and other (n=4,584). Multivariable logistic regression modeling was utilized to evaluate risk-adjusted associations between race, gender, and outcomes.

Results—After risk-adjustment, race was independently associated with in-hospital death ($p=0.02$), with an increased risk for black children. Gender was not associated with mortality ($p=0.77$). Post-operative morbidity was significantly associated with gender ($p<0.001$) and race ($p=0.008$). Gender ($p=0.003$) and race ($p<0.001$) were further associated with increased hospital length of stay. Importantly, these results were dependent on operation type.

Conclusion—Race and gender significantly affect post-operative outcomes following pediatric surgery. Black patients are at disproportionate risk for post-operative mortality, while black and Hispanic patients have increased morbidity and hospital resource utilization. While gender does not affect mortality, gender is a determinant of both post-operative morbidity and increased resource utilization.

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Corresponding Author: Matthew L. Stone, MD, P.O. Box 800679, Charlottesville, VA 22908, mstone@virginia.edu, Phone: (434) 924-2158.

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Keywords

pediatric surgery outcomes; race; gender

Introduction

Race and gender are principle demographic variables utilized in the standardization and description of pediatric surgical patient populations. Despite inclusion of these data near-universally in pediatric surgical literature, dedicated population-based analyses regarding the effect of race and gender on surgical outcomes remain under-represented.

Racial inequalities in surgical outcomes are established in pediatric patients undergoing congenital heart surgery, with black children demonstrating the highest odds of referral to high-mortality hospitals[1]. In addition, racial disparities have been established in pediatric kidney transplantation, with minority races being less likely to receive a transplant compared to children of white race[2]. While these racial comparisons merit inclusion of race in disease-specific risk-stratification algorithms and in healthcare allocation policies, dedicated analyses to establish the association of race and disparate pediatric surgical outcomes to our knowledge have yet to be performed. In addition, the effect of gender on post-operative morbidity and mortality remains unknown. Thus, the purpose of this study was to evaluate the effect of race and gender on pediatric surgical outcomes within the United States.

The present study utilizes a risk-adjusted model to independently evaluate race and gender influences within a nationwide administrative database. This approach allowed the examination of both racial and gender disparities within pediatric surgery across the United States. An understanding of such potential disparities is critical to reducing inequalities in pediatric surgery, enabling the advancement of care and improvement of outcomes.

Methods

Data Source

Data were obtained from the Kids' Inpatient Database 2003 and 2006 (KID) of the Healthcare Cost and Utilization Project (HCUP), Agency for Healthcare Research and Quality. KID represents the only current administrative national dataset established for healthcare systems dedicated to newborns, children, and adolescents. KID incorporates data from all participating community hospitals every three years within the United States. Presented data represent pediatric discharges for patients with an age of 20 years or less at admission, and include patients of all ages and each race[3].

The presented study was exempt from formal review by the University of Virginia Institutional Review Board (IRB), as it did not meet the definition of human subject research due to the absence of controlled patient identifiers and given that these data were not collected solely for research purposes.

Patients and Hospitals

A total of 91,891 children were identified by the following International Classification of Diseases, Ninth Revision, Clinical Modifications (ICD-9-CM) diagnoses: intestinal intussusception (560.0), acute appendicitis (540.0, 540.1, 540.9), empyema (510.0, 510.9), pyloric stenosis (750.5), congenital diaphragmatic hernia (756.6), and Hirschsprung's disease (751.3)[4]. Procedural codes as classified by the ICD-9 procedure coding system were matched to diagnoses and included: small bowel resection, air contrast enema, appendectomy, decortication, pyloromyotomy, diaphragm repair, and colonic resection[5]. The selected operations modeled prior analyses on primary payer status and were chosen to achieve a representative spectrum of morbidity and mortality for both infant and childhood illness [6]. Patients were stratified according to gender and race for comparison: white, black, Hispanic, Asian or Pacific Islander, Native American, and other. Co-morbid disease was evaluated utilizing the available Agency for Health Research and Quality co-morbidity categories according to the Elixhauser method [7, 8]. The Elixhauser method has been demonstrated to be superior to the Charlson/Deyo method for effective risk adjustment among surgical populations, and is the approved method by the Agency for Healthcare Research and Quality for comorbid disease stratification within KID[8, 9]. Median household income nation quartile for the patient Zone Improvement Plan (ZIP) code provided a surrogate marker for socioeconomic status (I: <\$24,999; II: \$25,000–34,999; III: \$35,000– 44,999; IV: >\$45,000). Bedsize, urban versus rural location, geographic region, and teaching status of included hospitals were determined through the linkage of the American Hospital Association identification numbers and corresponding hospital reports from the Association of American Medical College's Graduate Medical Education tracking system[10].

Measured Outcomes

Measured outcomes were established *a priori* with the primary outcome being the effect of race and gender on post-operative morbidity and mortality. Incidences of in-hospital complications were determined utilizing previously described methods with an established classification system to include: wound (mechanical), infection, urinary, pulmonary, gastrointestinal, cardiovascular, systemic, and procedural [11, 12]. Secondary outcomes were similarly evaluated as a function of both race and gender and included hospital lengths of stay and total charges.

Statistical Analyses

Statistical methodology was designed to test the null hypothesis that risk-adjusted outcomes after pediatric surgical operations in the United States are not significantly different as a function of race or gender. Statistical significance was defined by a *p* value of less than 0.05. All data analyses were performed using SPSS software version 17 (SPSS, Inc.).

Descriptive and inferential statistics were applied to compare the differences in the incidence of post-operative mortality and morbidity as a function of race and gender. Adjustments for contributing covariates were performed as a function of in-hospital death and in-hospital complication. Logistic regression models were applied with the inclusion of variance adjustments for the estimated weighted study population[13]. The statistical

significance of the association between race or gender and post-operative mortality and morbidity was determined by the Wald χ^2 test. The area under the receiver-operating curve (AUC) was used to assess the discrimination of this model, with the values of 1.0 indicating perfect discrimination and values of 0.5 indicating equal probability between groups. In addition, the Hosmer-Lemeshow test was applied to evaluate the significance of differences in the model's calibration across deciles for observed and predicted risk as previously described[12].

Validation of the model discrimination was achieved with the performance of sensitivity analyses. The most statistically significant covariate as determined by the Wald statistic was removed from the analysis to allow re-estimation and determination of the potential presence of spurious results[14]. The absence of attenuation in the observed effect was established by the persistence of statistical significance following removal of this covariate, validating the sensitivity of the original model.

Normal distribution continuous variables are presented as means \pm standard deviation and non-normally distributed data are reported as median (interquartile range). The Student's *t* test or Mann-Whitney *U* test were used as appropriate to evaluate continuous variables and the Pearson's χ^2 or Fisher's exact test were applied in the comparison of categorical variables.

Results

Patient, Operative, and Hospital Characteristics

A weighted total of 91,891 infants and children underwent the designated pediatric surgical operations from 2003 and 2006. Demographic data and descriptive statistics for select model covariates are presented in Table 1. At the time of operation, children were a median age of 12.0 [7,16] years. Females comprised 36.9% of the sample population. The composite incidences of post-operative mortality and morbidity were 0.6% and 6.1%, respectively. Non-elective operative status comprised the majority of all operations (92.4%). Regarding racial demographics, white Americans received the majority of operations (58.1%) followed by Hispanic (25.8%), black (9.0%), Asian or Pacific Islander (1.6%), Native American (0.5%), and other (5.0%) Americans. Patient-related economic factors demonstrated that the highest percentage of operations was performed in children within the lowest quartile of household income status (29.2%), with private insurance (57.7%) and Medicaid (32.6%) payer statuses comprising the most common payer statuses. Appendectomy accounted for the largest percentage of cases (81.2%) and operations were most commonly performed at teaching hospitals (53.6%) within an urban location (89.9%).

Adjusted Effect of Race and Gender on Post-operative Mortality and Morbidity

The adjusted odds ratios for the effects of race and gender on post-operative mortality and morbidity are presented in Table 2. Black race was associated with a significant increase in post-operative mortality in comparison to white patients (AOR = 1.74, $p = 0.02$), with absolute incidences of 1.9% and 0.4%, respectively. In addition, black and Hispanic patient populations demonstrated 24% and 12% increased incidences of post-operative morbidity,

respectively, in comparison to white patients ($p = 0.01$). Female gender was associated with a 13% reduction in post-operative morbidity in comparison to male patients; however, no gender associations were demonstrated within the mortality model. The effect of race and gender on post-operative morbidity and mortality were both dependent on the operation type.

Adjusted Effect of Race and Gender on Post-operative Length of Stay and Total Charges

Risk-adjusted hospital lengths of stay and total charges as a function of patient race and gender are presented in Table 3. Black race was predictive of increased length of hospital stay in comparison to white patients ($p < 0.001$). Additionally, black, Hispanic, and other races were associated with increased total charges in comparison to white patients. Male gender conferred a favorable effect with shorter lengths of stay ($p = 0.003$) and decreased total charges ($p < 0.001$) in comparison to female patients. In accordance with the presented mortality and morbidity findings, race and gender effects on post-operative lengths of stay and total charges were dependent on operation type.

Discussion

This study importantly identifies race as an independently significant predictor of post-operative morbidity and mortality for children undergoing selected pediatric surgical operations within the United States. A risk-adjusted model was applied to the only current nationwide administrative dataset established for the healthcare of newborns, children, and adolescents, accounting for accepted available measures of co-morbidity [15]. With this approach, black race was associated with a significant increase in post-operative mortality in comparison to white patients. In addition, black and Hispanic children demonstrated increased composite post-operative morbidity in comparison to children of white race. The effect of race on surgical outcomes extended to hospital lengths of stay, with black children demonstrating a greater than two-fold increase compared to white children. Furthermore, race was associated with total hospital charges, with black and Hispanic American races conferring significant increases in total hospital charges in comparison to children of white race. To our knowledge, these data provide the most comprehensive analysis of the effect of both race and gender on pediatric surgical outcomes, importantly implicating these demographic variables as areas of current disparity within the United States. Thus, the presented conclusions support inclusion of both race and gender in the further advancement of healthcare reform and risk stratification within pediatric surgery.

Racial disparities are recognized within the care of children. In addition to increased rates of renal allograft failure in black compared to white children, risk-adjustment models have demonstrated that black children are 12% less likely to be activated on the transplantation waiting list following the diagnosis of end-stage renal disease, identifying potential racial influences and provider bias in the allocation and access to surgical care within minority patient populations[16, 17]. Pediatric quality indicators (PDI) provide a metric designed to assess the quality of healthcare delivered to children and represent defined preventable complications in hospitalized children[18]. Recent demographic data utilized in the evaluation of pediatric quality indicators have demonstrated an increased incidence of

preventable adverse events among both black and Hispanic patients[19]. While these studies support the consideration of race in pediatric healthcare algorithms, implications within pediatric surgery remain less well-defined. Prior models within congenital heart surgery have suggested that sociodemographic factors are related to post-operative mortality secondary to the underlying linkage to measures of access to care, location of care, and type of institution administering care[20]. While these are important considerations, the present study indicates that racial influences on post-operative outcomes in pediatric surgery confounding variables remain after controlling for established patient- and hospital-related factors. Similar risk-adjusted models have since demonstrated that non-white race is an independent predictor for increased post-operative mortality following congenital heart disease operations[1]. Recent adult surgical literature has also implicated race as a predictor of post-operative morbidity, mortality, and increased length of stay[10, 21–23]. Collectively, these data support consideration of race in both risk stratification and healthcare reform aimed at the elimination of disparity within the care of children.

This study also importantly implicates gender as an independent predictor of post-operative morbidity, length of stay, and total hospital charges. Female gender conferred a favorable effect on post-operative morbidity, while no gender disparities were identified with the post-operative mortality model. Analyses of pediatric illness and healthcare outcomes have demonstrated divergent predictive associations as a function of gender. Within congenital heart surgery, female gender conferred an 18% higher in-hospital and 30-day post-discharge mortality compared to male gender children[24]. Recent study within the Healthcare Cost and Utilization Project identified male gender as an independent predictor of increased resource utilization in patients with acute sinusitis[25]. It is also recognized within preterm neonatal care that male gender confers a higher mortality and poorer long-term neurologic outcome prior to 27 weeks gestational age[26]. While these prior data demonstrate the potential for gender-related and disease-specific effects, the present study importantly implicates female gender as an independent predictor of decreased post-operative morbidity yet increased length of stay and total hospital charges. Thus, gender should be considered in pre-operative risk stratification algorithms and risk-adjustment research models within pediatric surgery.

The findings of the present study suggest that complex and multi-factorial factors are involved in the explanation of gender and racial disparities within pediatric surgery. Prior study has identified patient ethnicity, physician-patient communication, provider bias, resource allocation, and access to specialized care as important factors influencing surgical outcomes[27–29]. Within pediatric surgery, study of appendicitis outcomes in children has identified increased incidences of perforation in black and Hispanic children compared to children of white race, a difference not explained by measurable factors within the Healthcare Cost and Utilization Project database[30]. While it has been suggested that equal access to care eliminates disparities in outcomes for patients with appendicitis, this and other studies suggest multi-factorial influences within race-related healthcare disparities[1, 31]. In addition to access limitations, developmental genetics and environmental influences have been suggested as potential factors involved in race-related disparities in the analysis of surgical site infections and each merit consideration in the assessment of race and healthcare outcomes[32]. The present study demonstrates that after accounting for current modifiable

social, health system, and economic factors, racial disparities within pediatric surgery remain. Thus, further examination of risk stratification criteria, adverse event monitoring, and healthcare allocation reform are needed to eliminate racial inequalities within pediatric surgery.

Select limitations are inherent to the results of this study. First, selection bias should be considered given the retrospective study design. Second, within all analyses of administrative databases such as KID, it is critical to recognize the potential effect of miscoding within the presented diagnostic and procedural coding system. Paired with this consideration is the potential presence of a confounding influence and the acknowledgement that outcomes may be heavily influenced by co-morbidity profiles not related to surgical disease or intervention as noted in a recent study[29]. While this is a valid consideration, the absence of such a confounder in the present study is supported by our sensitivity analysis. Third, the present study provides an association between race and gender to the primary outcomes of mortality and morbidity in addition to hospital length of stay and total charge and does not support conclusive causality within these relationships. Fourth, this study does not directly examine the effect of payer status on risk-adjusted outcomes as this has recently been demonstrated within pediatric surgery[6]. Fifth, interinstitutional transfers cannot be tracked through patient identifiers, introducing the potential confounding effect of multiple entries for a single patient. Importantly, this and other studies suggest limitations introduced into the assessment of pediatric patients with the translation of adult co-morbid disease and adverse event definitions to children, supporting further definition of pediatric specific criteria[33].

Conclusions

The results of this study demonstrate an independent association for both race and gender in post-operative mortality and morbidity in pediatric surgical patients within the United States. Similarly, race and gender effects are present in the outcomes of length of stay and total charges. These data most strongly implicate black race as a factor for increased post-operative mortality. In addition, black and Hispanic patient populations demonstrated increased post-operative morbidity. Length of stay was greater in black patients and total charges were higher in black and Hispanic American patient populations in comparison to children of white race. Male gender was associated with increased post-operative morbidity yet decreased length of stay and total charges. These data support consideration of both race and gender in pediatric surgical patient risk stratification, outcomes research, and most importantly healthcare reform efforts seeking to optimize modifiable patient risk factors and eliminate disparities in the surgical care of children.

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Table 1

Descriptive Statistics and Risk Factors Entered as Model Covariates

Variable	Weighted Frequency	Percent of Total Sample
	n = 91,891	
Age ^a	91891	12.0 [7,16]
Female gender	37300	36.90%
Mortality	571	0.60%
Any complication	6194	6.10%
Elective operation	7028	7.60%
Select Elixhauser Co-morbidities^b		
Chronic pulmonary disease	5093	5.00%
Fluid and electrolyte disorders	8689	8.60%
Obesity	1222	1.20%
Weight loss	421	0.40%
Race		
White	58711	58.1%
Black	9103	9.0%
Hispanic	26118	25.80%
Asian or Pacific Islander	1582	1.60%
Native American	474	0.50%
Other	5096	5.00%
Median Household Income for ZIP code		
1: < \$39,000	29548	29.20%
2: \$39,000–47,999	24208	23.90%
3: \$48,000–62,999	22975	22.70%
4: >\$63,000	24352	24.10%
Primary Payer Status		
Private	58360	57.70%
Medicare	133	0.10%
Medicaid	32981	32.60%
Uninsured	9609	9.50%
Operation Type		
Appendectomy	82098	81.20%
Pyloromyotomy	9901	9.80%
Intussusception	6235	6.20%
Decortication	1919	1.90%
CDH repair	711	0.70%
Hirschsprung's colonic resection	218	0.20%
Hospital Descriptors		

Variable	Weighted Frequency	Percent of Total Sample
Teaching hospital	54178	53.60%
Urban location	90894	89.90%

^a presented as Median [25th,75th quartile range]

^b Elixhauser co-morbidity data descriptors available at: <http://www.hcup-us.ahrq.gov/db/nation/nis/nisdde.jsp>

Table 2

Hierarchical Logistic Regression Models for the Effect of Race and Gender on Post-operative Mortality and Morbidity

Variable	Mortality Model ^a		Morbidity Model ^b	
	Odds Ratio	<i>p</i>	Odds Ratio	<i>p</i>
	[95% C.I.]		(95% C.I.)	
Race				
Black	1.74 [1.26,2.40]	0.02	1.24 [1.11,1.41]	0.01
Hispanic	1.03 [0.71,1.50]		1.12 [1.02,1.24]	
Asian or Pacific Islander	0.90 [0.36,2.28]		1.14 [0.87,1.50]	
Native American	0.66 [0.08,5.82]		1.10 [0.69,1.75]	
Other	1.25 [0.74,2.10]		1.10 [0.93,1.30]	
White (ref.)	1		1	
Gender				
Female	1.04 [0.83,1.31]	0.77	0.87 [0.81,0.94]	<0.001
Male (ref.)	1		1	

C.I. = Confidence Interval;

^a Model Performance: Area Under Receiver Operating Characteristics Curve (AUC) = 0.98, Nagelkerke Pseudo R^2 = 0.50 with 64 degrees of freedom;

^b Model Performance: Area Under Receiver Operating Characteristics Curve (AUC) = 0.68, Nagelkerke Pseudo R^2 = 0.07 with 52 degrees of freedom. Model adjustment for patient characteristics (age, sex, race, income, primary payer status, 29 co-morbid disease categories) operative characteristics (operation type, operative year, elective vs. non-elective status) and hospital characteristics (size, region, teaching status, rural location).

Table 3

Hierarchical Logistic Regression Models for the Effect of Race and Gender on Length of Stay (LOS) and Total Charges

Variable	LOS ^a		Total Charges (\$) ^b	
	β	<i>p</i>	β	<i>p</i>
	[95% C.I.]		[95% C.I.]	
Race				
Black	2.13 [1.52,2.73]	<0.001	7690.39 [5071.28, 10309.51]	<0.001
Hispanic	-0.09 [-0.36,0.18]		1993.32 [712.17, 3274.46]	
Asian or Pacific Islander	-0.09 [-1.15,0.96]		466.89 [-4409.27,5343.06]	
Native American	-0.65 [-1.64,0.35]		405.62 [-5939.04,6750.28]	
Other	0.45 [-0.21,1.11]		3452.75 [516.26,6389.24]	
White (ref.)	1		1	
Gender				
Male	-0.34 [-0.57, -0.11]	0.003	-1752.91 [-2727.71, -778.12]	<0.001
Female (ref.)	1		1	

C.I. = Confidence Interval;

^aModel Performance: R^2 0.31 with 52 degrees of freedom;

^bModel Performance: R^2 0.30 with 52 degrees of freedom. Model adjustment for patient characteristics (age, sex, race, income, primary payer status, 29 co-morbid disease categories) operative characteristics (operation type, operative year, elective vs. non-elective status) and hospital characteristics (size, region, teaching status, rural location).