Association Between Race, Gender, and Pediatric Postoperative Outcomes: An Updated Retrospective Review

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A B S T R A C T
Introduction: There has not been a recent evaluation of the association between racial and gender and surgical outcomes in children. We aimed to evaluate improvements in race and gender-related pediatric postoperative outcomes since a report utilizing the Kids' Inpatient Database data from 2003 to 2006.

Methods: Using Kids’ Inpatient Database (2009, 2012, 2016), we identified 245,976 pediatric patients who underwent appendectomy for acute appendicitis (93.6%), pyloromyotomy for pyloric stenosis (2.7%), empyema decortication (1.6%), congenital diaphragmatic hernia repair (0.7%), small bowel resection for intussusception (0.5%), or colonic resection for Hirschsprung disease (0.2%). The primary outcome was the development of postoperative complications. Multivariable logistic regression was used to evaluate risk-adjusted associations among race, gender, income, and postoperative complications.

Results: Most patients were male (61.5%) and 45.7% were White. Postoperative complications were significantly associated with male gender (P < 0.0001) and race (P < 0.0001). After adjustment, Black patients were more likely to experience any complication than White patients (adjusted odds ratio 1.3, confidence interval 1.2-1.4), and males were more likely than females (adjusted odds ratio 1.3, confidence interval 1.2-1.4).

Conclusions: No clear progress has been made in eliminating race- or gender-based disparities in pediatric postoperative outcomes. New strategies are needed to better understand and address these disparities.

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Introduction

Although disparities in health and healthcare have been explored and evaluated in the adult population, there has been less evaluation of these disparities in pediatrics. Furthermore, the 2020 SARS-CoV-2 pandemic and overlapping national reckoning on racial injustice have again highlighted long-standing systemic health and social inequities in the United States.11-15

There is an always evolving effort to improve surgical outcomes and decrease the incidence of postoperative morbidity and mortality; however, despite these efforts racial disparities remain.16,17 In the United States, an average of 450,000 pediatric inpatient surgical admissions occur each year; therefore, pediatric surgical outcomes are important to evaluate as there is a sizable population of children undergoing operations annually. In pediatric surgery, race has been shown to affect postoperative outcomes with Black patients having higher rates of morbidity and mortality when compared to White patients.19,20 Although this typically was thought to be secondary to higher rates of comorbid conditions, one database study also showed this to be the case even among healthy pediatric patients.20,21 It has also been reported that racial disparities exist for a variety of pediatric conditions including congenital heart disease, inflammatory bowel disease, traumatic brain injury, pediatric kidney transplantation, and trauma care.27 A study utilizing 2003 and 2006 data from the Kids’ Inpatient Database (KID) demonstrated that postoperative morbidity was significantly associated with gender and race.16 Since this report, however, there has not been an updated evaluation of any associations between race and gender and surgical outcomes in children utilizing more recent data. All of this, therefore, highlights the need for further studies to understand these racial differences in postoperative outcomes.

This study aimed to evaluate whether there has been any change in postoperative outcomes associated with race and gender for pediatric surgical patients in the last 2 decades. By using a risk-adjusted model, we aimed to evaluate race and gender outcomes independently within the pediatric surgery population from 2009, 2012, and 2016. We hypothesized that racial and gender-based disparities would be improved compared to prior analyses 2 decades prior.

Methods

Study design and data source

Cases were extracted from the KID, a database from the Healthcare Cost and Utilization Project (HCUP). This database was used because hospital discharges are sampled primarily from pediatric populations, capturing more patients under the age of 21 compared to other HCUP databases. In addition, KID is the only administrative national database dedicated to newborns, children, and adolescents. The discharge data from KID are made available every 3 y, except for the 2016 database, which was released after a 4 y gap to account for the change from International Classifications of Diseases, Ninth Revision (ICD-9) to Tenth Revision (ICD-10) coding. These data are reported through a network of participating hospitals from numerous states. Hospital participation has increased over the years, from 2784 hospitals in 27 states as of 2000, to 4200 hospitals in 47 states as of 2016. For this study, data from 2009, 2012, and 2016 were utilized intentionally to compare to a previous study evaluating KID data from 2003 to 2006.16 This study did not require institutional review board approval, as it was deemed exempt from review due to its retrospective and deidentified nature.

Patient selection and exposure

Our cohort consisted of children and young adults aged 20 and under at admission who had been diagnosed with an ICD-9 or ICD-10 code of intussusception, appendicitis, empyema, pyloric stenosis, congenital diaphragmatic hernia (CDH), or Hirschsprung disease as well as the corresponding surgery associated with the repair of these conditions between January 1, 2009, and December 31, 2016. These procedures (small bowel resection [SBR] or air contrast enema for intussusception, empyema decortication, CDH repair, or colonic resection [CR] for Hirschsprung disease, appendectomy for appendicitis) were captured according to ICD-9 and ICD-10 diagnosis and procedure codes. The specific codes listed for these diagnoses and procedures are described in Supplementary Table 1.

Patient and hospital characteristics

The age of individuals was defined as age at admission, measured in years. Race was defined according to White, Black, Hispanic, Asian/Pacific Islander, Native American, or other which included those unspecified. Median household income was placed into four categories: <$39,000, $39,000-$47,999, $48,000-$62,999, and $63,000. Insurance was categorized as private, Medicare, Medicaid, or other. The “other” category corresponds to self-pay, no charge, and other unspecified types of insurance. Elixhauser comorbidities were identified based on publicly available Statistical Analysis System (SAS) code on the HCUP website. More specifically, we used Version 3.7 of the Elixhauser Comorbidity Software for identifying these comorbidities based on the ICD-9 diagnostic codes while Version 2020.1 was used for the identification of these comorbidities based on the ICD-10 diagnostic codes. The Elixhauser method was used secondary to its superior method of risk adjustment for surgical populations; furthermore, it is the approved method for comorbidity disease stratification for data from KID by the Agency for Healthcare Research and Quality.28,29 Data on selected comorbid conditions were also collected: (1) chronic pulmonary disease, (2) fluid and electrolyte disorders, (3) obesity, (4) weight loss, (5) diabetes, and (6) hypertension. These specific comorbid conditions were chosen intentionally again to compare to a previous study evaluating a similar patient population from KID data from 2003 to 2006.16 Hospital characteristics collected included children’s hospital status, teaching status, and urban versus rural location.

Discharge weights are numerical values calculated by HCUP based on six characteristics from the American Hospital Association. These are hospital ownership, teaching status,
bed size, urban/rural status, US Census Region, and children’s hospital status. These numerical weights were then incorporated into our analyses through the SAS SURVEY procedures to produce national estimates of our analytical results. More information about the mathematical calculation of these weights can be found in the Agency for Healthcare Research and Quality HCUP website.\textsuperscript{30}

### Outcomes

Primary outcomes were the length of hospital stay (days), total charges, and complications. Complications were those that occurred either intraoperatively or postoperatively and included mechanical wound complications, infections, urinary complications, pulmonary complications, gastrointestinal complications, cardiovascular complications, systemic complications, and intraoperative complications (Supplementary Table 2). The length of stay (LOS) parameter represents the exponentiated beta estimate of the log-transformed LOS and represents the percentage change of the average LOS in one group compared to the reference group. The total charges parameter represents the exponentiated beta estimate of the log-transformed total charges and represents the percentage change in the average total charges in one group compared to the reference group. These outcomes were compared to the reported outcomes from the previous study evaluating KID data from 2003 to 2006.\textsuperscript{16}

### Statistical analysis

Univariate and bivariate analyses were used to describe gender- and race-specific associations with outcomes. For continuous outcomes, bivariate associations were examined using the Wilcoxon-Mann-Whitney test. For categorical variables, bivariate associations were conducted using chi-square or Fisher’s exact tests needed. Multivariable logistic regression analysis was conducted to investigate the association of gender and race on four different binary outcomes, the occurrence of specific complications: infection, pulmonary, gastrointestinal; the occurrence of an overall complication was examined in a separate model and assumes the presence of any of the individual complications denoted. Multivariable linear regression models were used to fit continuous outcomes (log-transformed LOS total cost). For each outcome variable (model applied), we used a combined approach to determine the inclusion of independent variables (potential confounders) that included clinical relevance and the Akaike Information Criterion to compare the efficiency accounted for the information in the data. Adjusted odds ratio (AOR) and 95% confidence intervals (CIs) were provided. Analyses were performed using SAS version 9.4 (SAS Institute, Cary, NC).

### Results

#### Patient characteristics

A total of 245,976 pediatric patients were identified, with demographic data and descriptive statistics available in Table 1. The overall median age at the time of operation was 12 y [interquartile range (IQR) 8-16] and 39.2% were female. With regards to race, 45.7% were White, 5.9% Black, 29.5% Hispanic, 2.6% Asian/Pacific Islander, 1.0% Native American, and 5.3% reported as Other. About 49.5% had private insurance with the next most common insurance type being Medicaid in 40.2% of patients. With regards to median household income, the highest proportion of children (27.4%) were in the lowest reported income range of <$39,000.

| Variable | All patients (n = 245,976) |
|----------|--------------------------|
| Age (y)  | Mean (SD) 11.97 (0.01) |
| Median [interquartile range] | 12 [8-16] |
| Female, n (%) | 94,616 (39.2) |
| Race, n (%) | |
| White | 112,376 (45.7) |
| Black | 14,592 (5.9) |
| Hispanic | 72,650 (29.5) |
| Asian/Pacific Islander | 5687 (2.6) |
| Native American | 2241 (1.0) |
| Other* | 11,571 (5.3) |
| Not reported | 26,859 (10.9) |
| Median household income, n (%) | |
| <$39,000 | 67,327 (27.4) |
| $39,000-$47,999 | 59,581 (24.2) |
| $48,000-$62,999 | 58,525 (23.8) |
| >$63,000 | 55,824 (22.7) |
| Not reported | 4719 (1.9) |
| Primary payer, n (%) | |
| Private | 121,680 (49.5) |
| Medicare | 466 (0.2) |
| Medicaid | 98,893 (40.2) |
| Other\textsuperscript{y} | 24,525 (10.0) |
| Not reported | 412 (0.2) |
| Comorbidities, n (%) | |
| Chronic pulmonary disease | 17,481 (7.1) |
| Fluid and electrolyte disorders | 17,937 (7.3) |
| Obesity | 6613 (2.7) |
| Weight loss | 1182 (0.5) |
| Diabetes | 1143 (0.5) |
| Hypertension | 1059 (0.4) |
| Elective operation | 12,780 (5.2) |
| Hospital characteristics, n (%) | |
| Children’s hospital | 43,998 (17.9) |
| Non–children’s hospital | 201,979 (82.1) |
| Teaching | 137,720 (57.5) |
| Nonteaching\textsuperscript{z} | 101,780 (42.5) |
| Urban | 215,839 (90.1) |
| Rural | 23,662 (9.9) |

SD = standard deviation.

\textsuperscript{1}Includes multiracial and unspecified.

\textsuperscript{2}Self-pay, no charge, and other unspecified.

\textsuperscript{3}Teaching status not assessed for rural hospitals.
The overwhelming majority (93.6%) of patients underwent appendectomy for acute appendicitis. In total, 2.7% of patients underwent pyloromyotomy for pyloric stenosis, 0.5% underwent SBR for intussusception, 1.6% underwent decortication for empyema, 0.7% underwent diaphragm repair for CDH, and 0.2% underwent CR for Hirschsprung disease. The most common operation therefore for both genders and for all races was appendectomy (Table 2). Males were more likely to undergo pyloromyotomy, SBR, and CRs. Females were more likely to require an appendectomy and decortication. With regards to race, Black patients were proportionally more likely to undergo air contrast enema, pyloromyotomy, SBR, decortication, and CR. Operations were most commonly performed at urban hospitals (90.1%), 57.5% at teaching hospitals, and only 17.9% at children’s hospitals. About 5.2% of operations were classified as elective.

With regards to overall outcomes, the median total hospital LOS was 1.4 d [IQR 0.6-3.1] and the median total hospital charges were $26,249 [IQR $17,639-$39,577]. The overall rate of postoperative morbidity was 4.4%.

**Association between race and postoperative morbidity**

Postoperative morbidity, defined as having any of our surgical complications of interest, was significantly associated with race ($P < 0.0001$), with Black patients having the highest rate of postoperative morbidity (6.1%) compared to White patients with the lowest (4.2%). More specifically, race was significantly associated with infectious, pulmonary, gastrointestinal, cardiovascular, and systemic complications, with Black patients having the highest rate of all of these complications except for systemic complications, of which Hispanics had the highest rate (Table 3).

After adjusting for age, Elixhauser comorbidity index, insurance status, and operation type in a multivariate analysis model, the risk of any postoperative morbidity for Black patients was 1.3 times that of White patients (AOR 1.27, 95% CI 1.16-1.40). Patients of all other race categories, including other, were not significantly different when compared to White patients. Specifically, when compared to White patients, Black patients had a 30% increased risk of infectious complications (AOR 1.30, 95% CI 1.03-1.64), an 78% increased risk of pulmonary complications (AOR 1.78, 95% CI 1.43-2.21), and a 26% increased risk of gastrointestinal complications (AOR 1.26, 95% CI 1.11-1.43) (Table 4).

**Association between gender and postoperative morbidity**

Males were significantly more likely to have any postoperative morbidity when compared to females (4.8% versus 3.8%, $P < 0.0001$). More specifically, males were significantly more likely to experience infectious complications, urinary complications, pulmonary complications, and gastrointestinal complications. There was no difference with regards to mechanical wound, cardiovascular, systemic, or intraoperative complications (Table 5).

After adjusting for age, Elixhauser comorbidity index, insurance status, and operation type in a multivariate analysis model, the risk of any postoperative morbidity or

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**Table 2** — Distribution of surgical procedures by gender and race.

| Procedure             | All cases (n = 245,596) | Male (n = 146,797) | Female (n = 94,616) | White (n = 112,376) | Black (n = 14,592) | Hispanic (n = 72,650) | Asian/Pacific Islander (n = 5687) | Native American (n = 2241) | Other (n = 19,500) |
|-----------------------|-------------------------|---------------------|---------------------|--------------------|---------------------|-------------------------------|-------------------------------|------------------------|------------------|
| Appendectomy          | 230,313 (93.5%)         | 135,705 (92.4%)     | 94,885 (90.5%)      | 114,926 (99.6%)    | 13,092 (89.7%)      | 69,077 (95.1%)               | 5299 (92.5%)                 | 2106 (94.0%)          | 10,663 (92.2%)   |
| Air contrast enema    | 6615 (2.6%)             | 1195 (0.8%)         | 702 (0.7%)          | 1092 (0.9%)        | 241 (1.6%)           | 488 (4.2%)                   | 50 (0.9%)                   | 25 (0.2%)              | 82 (4.3%)        |
| Pyloromyotomy         | 1131 (0.4%)             | 758 (0.6%)          | 374 (0.4%)          | 3393 (3.0%)        | 488 (3.3%)           | 155 (1.9%)                   | 15 (1.9%)                   | 6 (0.3%)               | 10 (0.5%)        |
| Small bowel resection | 659 (0.3%)              | 374 (0.3%)          | 155 (0.2%)          | 155 (0.2%)         | 15 (0.1%)            | 168 (2.1%)                   | 10 (0.2%)                   | 10 (0.5%)              | 11 (0.6%)        |
| Diaphragm repair      | 469 (0.2%)              | 341 (0.2%)          | 128 (0.1%)          | 372 (0.4%)         | 8 (0.1%)             | 157 (2.0%)                   | 11 (0.2%)                   | 3 (0.2%)               | 14 (0.7%)        |
| Decortication         | 1774 (0.7%)             | 1032 (0.7%)         | 739 (0.8%)          | 1821 (1.6%)        | 439 (3.0%)           | 135 (1.9%)                   | 10 (0.2%)                   | 10 (0.5%)              | 8 (0.4%)         |
| Colonic resection     | 469 (0.2%)              | 341 (0.2%)          | 128 (0.1%)          | 372 (0.4%)         | 8 (0.1%)             | 157 (2.0%)                   | 11 (0.2%)                   | 3 (0.2%)               | 14 (0.7%)        |

*Jackson et al. / C15 race, gender and pediatric outcomes*
Table 3 — Distribution of outcomes by race.

| Outcome                      | White       | Black       | Hispanic    | Asian/Pacific Islander | Native American | Other       | P-value |
|------------------------------|-------------|-------------|-------------|-------------------------|-----------------|-------------|---------|
| LOS (d)                      |             |             |             |                         |                 |             |         |
| Mean (SE)                    | 2.96 (0.02) | 4.25 (0.10) | 3.34 (0.03) | 3.34 (0.09)             | 3.39 (0.23)     | 3.52 (0.09) | <0.0001 |
| Median [IQR]                 | 1.23 [0.51-2.69] | 1.65 [0.70-3.91] | 1.60 [0.66-3.58] | 1.37 [0.55-3.33]     | 1.53 [0.63-3.23] | 1.43 [0.59-3.24] | <0.0001 |
| Total charges ($)            |             |             |             |                         |                 |             |         |
| Mean (SE)                    | 33,992 (286) | 44,588 (1007) | 42,381 (349) | 42,750 (1109)           | 31,958 (1211)   | 40,912 (1051) | <0.0001 |
| Median [IQR]                 | 23,644 [16,334-35329] | 27,765 [18,883-42927] | 32,144 [22,175-46684] | 29,056 [18,647-46284] | 23,328 [15,838-34,617] | 26,984 [17,665-41482] | <0.0001 |
| Postoperative complications, n (%) |             |             |             |                         |                 |             |         |
| Mechanical wound             | 224 (0.20)  | 46 (0.31)   | 174 (0.24)  | 13 (0.22)               | 6 (0.25)        | 29 (0.25)   | 0.2349  |
| Infections                   | 659 (0.59)  | 136 (0.93)  | 558 (0.77)  | 40 (0.70)               | 14 (0.64)       | 98 (0.85)   | <0.0001 |
| Urinary                      | 159 (0.14)  | 26 (0.18)   | 83 (0.11)   | 5 (0.08)                | 5 (0.23)        | 83 (0.72)   | 0.3728  |
| Pulmonary                    | 656 (0.58)  | 203 (1.39)  | 359 (0.49)  | 49 (0.86)               | 15 (0.68)       | 276 (2.38)  | <0.0001 |
| Gastrointestinal             | 2613 (2.33) | 457 (3.13)  | 1795 (2.47) | 114 (2.01)              | 70 (3.11)       | 21 (0.18)   | <0.0001 |
| Cardiovascular               | 153 (0.14)  | 36 (0.25)   | 64 (0.09)   | 6 (0.10)                | 0 (0)           | 21 (0.18)   | N/A     |
| Systemic                     | 305 (0.27)  | 45 (0.31)   | 302 (0.42)  | 23 (0.41)               | 3 (0.12)        | 37 (0.32)   | 0.0003  |
| Intraoperative               | 444 (0.39)  | 76 (0.52)   | 253 (0.35)  | 23 (0.41)               | 11 (0.50)       | 48 (0.41)   | 0.1959  |
| Any of the above             | 4698 (4.18) | 886 (6.07)  | 3218 (4.43) | 244 (4.30)              | 110 (4.91)      | 550 (4.75)  | <0.0001 |

IQR = interquartile range; N/A = not applicable.
### Table 4 – Multivariable regression analysis for outcomes by gender and race.

#### Gender (reference: female)

| Outcome               | Male                           |
|-----------------------|-------------------------------|
| Length of stay (d)*   | 0.99 (0.98-1.00); P = 0.0055 |
| Total charges*        | 0.98 (0.97-0.99); P < 0.0001  |
| Complications³        |                               |
| Infections            |                               |
| Pulmonary             | 1.43 (1.25-1.64)              |
| Gastrointestinal      | 1.38 (1.28-1.48)              |
| Any complication      | 1.31 (1.24-1.38)              |

#### Race (reference: White)

| Outcome               | Black                              | Hispanic                          | Asian/Pacific Islander | Native American | Other               |
|-----------------------|------------------------------------|-----------------------------------|------------------------|----------------|---------------------|
| Length of stay (d)*   | 1.13 (1.11-1.15); P < 0.0001       | 1.07 (1.05-1.08); P < 0.0001      | 1.07 (1.04-1.09); P < 0.0001 | 1.02 (0.97-1.06); P = 0.4410 | 1.03 (1.00-1.05); P = 0.0179 |
| Total charges*        | 1.16 (1.13-1.18); P < 0.0001       | 1.33 (1.30-1.37); P < 0.0001      | 1.20 (1.15-1.25); P < 0.0001 | 0.96 (0.90-1.03); P = 0.2968 | 1.11 (1.07-1.16); P < 0.0001 |
| Complications³        |                                    |                                   |                        |                 |                     |
| Infections            | 1.30 (1.03-1.64)                   | 1.16 (0.99-1.35)                  | 1.18 (0.80-1.75)       | 1.01 (0.54-1.91) | 1.29 (0.99-1.68)    |
| Pulmonary             | 1.78 (1.43-2.21)                   | 0.94 (0.79-1.12)                  | 1.41 (0.97-2.04)       | 1.17 (0.61-2.25) | 1.09 (0.82-1.46)    |
| Gastrointestinal      | 1.26 (1.11-1.43)                   | 0.93 (0.86-1.01)                  | 0.88 (0.70-1.10)       | 1.15 (0.84-1.57) | 0.95 (0.82-1.11)    |
| Any complication      | 1.27 (1.16-1.40)                   | 0.98 (0.92-1.04)                  | 1.04 (0.88-1.22)       | 1.02 (0.80-1.31) | 1.04 (0.93-1.17)    |

#### Income (reference: <$39,000)

| Outcome               | $39,000-$47,999 | $48,000-$62,999 | >$63,000 |
|-----------------------|-----------------|-----------------|----------|
| Length of stay (d)*   | 0.96 (0.95-0.98); P < 0.0001 | 0.95 (0.94-0.97); P < 0.0001 | 0.90 (0.89-0.92); P < 0.0001 |
| Total charges*        | 0.99 (0.97-1.01); P = 0.5738 | 1.07 (1.04-1.10); P < 0.0001 | 1.09 (1.06-1.13); P < 0.0001 |
| Complications³        |                  |                  |          |
| Infections            | 1.00 (0.84-1.17) | 0.93 (0.78-1.10) | 0.84 (0.69-1.02) |
| Pulmonary             | 0.91 (0.76-1.09) | 0.79 (0.65-0.96) | 0.73 (0.59-0.89) |
| Gastrointestinal      | 1.09 (1.00-1.19) | 1.01 (0.92-1.10) | 0.89 (0.80-0.99) |
| Any complication      | 1.02 (0.95-1.09) | 0.92 (0.86-0.99) | 0.85 (0.78-0.92) |

* Adjusted for age, income quartile, Elixhauser comorbidity index, insurance status, operation type, and complication.

* Represent percent (%) change relative to the reference group.

* Adjusted for age, income quartile, Elixhauser comorbidity index, insurance status, and type of surgery.
complication for males was 1.31 times that of females (95% CI 1.24-1.38). Males had a 43% greater odds of infectious complications (AOR 1.43, 95% CI 1.25-1.64), 32% greater odds of pulmonary complications (AOR 1.32, 95% CI 1.14-1.52), and a 38% greater odds of gastrointestinal complications (AOR 1.38, CI 1.28-1.48) when compared to females (Table 4).

Association between household income and postoperative morbidity

After adjusting for age, Elixhauser comorbidity index, insurance status, and operation type in a multivariate analysis model, the risk of any postoperative morbidity was less likely for patients in the highest income bracket (AOR 0.85, 95% CI 0.78-0.92). The only individual complication that was significantly different between patients in different income brackets was pulmonary complications, which were less likely to occur for those in the top two income brackets when compared to those in the lowest (Table 4).

Associations among gender, race, and income and length of stay and hospital charges

Using the multivariate analysis model, the median LOS for males was 0.01% lower than that of females ($\beta = 0.99$, 95% CI 0.98-1.00). Black patients had a 13% longer LOS when compared to White patients ($\beta = 1.13$, 95% CI 1.11-1.15), Hispanic patients a 7% longer LOS ($\beta = 1.07$, 95% CI 1.05-1.08), and Asian/Pacific Islander patients a 7% longer LOS ($\beta = 1.07$, 95% CI 1.04-1.09). Patients in the lowest income bracket had a significantly longer LOS when compared to all the other income brackets (Table 4).

The median total hospital charges differed significantly by gender ($P < 0.0001$) and race ($P < 0.0001$). After adjusting for age, Elixhauser comorbidity index, insurance status, operation type, and complications, Black patients had 16% higher charges, Hispanic patients had 33% higher charges, Asian/Pacific Islander 20% higher charges all when compared to White patients (Table 4). With regards to gender, males had 0.02% lower charges when compared to females.

Discussion

In this study using KID from 2009, 2012, and 2016, we identified that, in a cohort of 245,976 patients who underwent common pediatric surgical procedures, race and gender are independent predictors of postoperative morbidity, defined as any operative or postoperative complication. Using a risk-adjusted model, taking into account comorbidities, insurance status, income, and age, Black patients were more likely to experience any complication when compared to White patients, more likely to have a longer LOS, and have higher hospital charges accrued. With regards to gender, males were more likely to experience complications. These data provide the most current evaluation of race and gender disparities in pediatric surgery and shows that these disparities unfortunately remain.

Health inequities repeatedly plague our healthcare system and racial disparities continually impact the care of children. It has been reported that children from minority populations are at higher risk for postoperative morbidity and complications compared to their White peers. The effects of health inequities are widespread across surgical specialties. For example, increased complications and mortality rates were found among congenital heart surgery, kidney transplant, heart transplant, urologic surgery, neurological surgery, neurooncological surgery, otolaryngology, and plastic surgery.

| Outcome | All patients | Male | Female | P-value |
|---------|--------------|------|--------|---------|
| LOS (d) |              |      |        |         |
| Mean (SE) | 3.21 (0.02) | 3.24 (0.02) | 3.23 (0.03) | 0.9489 |
| Median [IQR] | 1.39 [0.57-3.05] | 1.39 [0.57-3.09] | 1.41 [0.58-3.07] | 0.2049 |
| Total charges ($) |              |      |        |         |
| Mean (SE) | 37,364 (196) | 37,260 (256) | 37,643 (319) | 0.3504 |
| Median [IQR] | 26,249 [17,639-39,577] | 25,880 [17,386-39,313] | 26,588 [17,853-39,830] | <0.0001 |
| Postoperative complications, n (%) |              |      |        |         |
| Mechanical wound | 559 (0.23) | 378 (0.26) | 180 (0.19) | 0.0055 |
| Infections | 1657 (0.67) | 1123 (0.77) | 529 (0.56) | <0.0001 |
| Urinary | 331 (0.13) | 265 (0.18) | 67 (0.07) | <0.0001 |
| Pulmonary | 1550 (0.63) | 1029 (0.70) | 517 (0.55) | 0.0001 |
| Gastrointestinal | 5844 (2.38) | 3927 (2.68) | 1917 (2.03) | <0.0001 |
| Cardiovascular | 303 (0.12) | 193 (0.13) | 109 (0.12) | 0.3592 |
| Systemic | 766 (0.31) | 474 (0.32) | 293 (0.31) | 0.6257 |
| Intraoperative | 944 (0.38) | 584 (0.40) | 355 (0.38) | 0.4635 |
| Any of the above | 10,731 (4.36) | 7100 (4.84) | 3617 (3.82) | <0.0001 |

SE = standard error.
Each of these was correlated with poorer postoperative outcomes and increased risk of complications for minority children. More specifically, with regards to appendicitis, it has been reported that Hispanic and Asian children were at increased risk of perforated appendicitis compared to White children. Black and low-income children have also been found to have increased odds of perforated appendicitis, intensive care unit admissions, longer LOSs, and lower rates of imaging. The compounding effects of race and socioeconomic status resulted in heightened rates of perforated appendicitis, hospitalizations, and time to surgery, therefore making it difficult to tease out which effect may be causing these higher rates. Our study uniquely included income status in our multivariate model. This analysis revealed that children of lower income had higher rates of complications and that regardless of income or insurance status, Black children had worse postoperative outcomes than White children. Furthermore, our data showed that Black patients had a 30% higher risk of all complications with significantly increased risks of infectious, pulmonary, and gastrointestinal complications. In addition, race was a significant predictor for LOS and hospital charges with all minority patients having longer LOS and higher charges than White patients. The present study adds to the literature that complications in pediatric surgery remain elevated for patients of color and have not appeared to improve over time. Therefore, a deeper level of consideration, research, and healthcare reform will be needed to ensure equitable pediatric surgical outcomes.

Barriers to obtaining healthcare are complex, multifactorial, and tangibly impact pediatric surgical outcomes for minority patients. For example, studies have reported that Black children have higher rates of perforated appendicitis related to delays in treatment. However, with equal access to care, perforated appendicitis rates are equal among different racial groups confirming that inadequate access contributes to the disproportionate rates of complications seen in minority populations. The specific barriers which contribute to delays in treatment may include insurance status or language limitations, both of which have been shown to contribute to worse pediatric surgical outcomes for minority populations. Although many studies have evaluated associations between race and gender with outcomes after pediatric surgery, they have not been able to support the conclusive causality within these relationships. Our study shows that Black children were still more likely to experience any complication, have longer LOSs, and have higher hospital charges despite adjusting for type of surgery, insurance status, income, gender, race, and comorbidity presence. When compared to the report by Stone et al., using KID data from 2003 to 2006, we have demonstrated that over time these disparities have not dissipated, therefore highlighting the need for new strategies to better understand and address these disparities.

Gender has also previously been recognized as an independent predictor of postoperative morbidity; however, a consensus with regards to which gender conferred poor outcomes has been conflicting in the literature. After pediatric scoliosis surgery, it was reported that male gender was associated with a higher occurrence of postoperative complications. Outcomes after pull-through surgery for Hirschsprung disease found that males had a higher frequency of hospitalizations in postoperative year 1 when compared with females. Stone et al. found that being female had a favorable effect on postoperative complications, LOS, and total hospital charges. In contrast, a study evaluating predictors of poor outcomes postoperatively for pediatric surgical patients in Ghana described higher in-hospital mortality in female patients. Similarly, females have higher in-hospital and postdischarge mortality after congenital heart surgery when compared to males. Although there has not been consistent reporting on the associations between gender and outcomes, our study is the most comprehensive database evaluation to date regarding complications in pediatric surgery. Our data showed that males were more likely to have any postoperative morbidity; however, when evaluating the LOS and hospital charges males had a shorter LOS and lower charges when compared to females. Despite the conflicting data within our study, the outcome of complications still emphasizes the importance of considering gender in risk stratification preoperatively and that novel strategies to decrease this difference are needed.

This study has several limitations. As this is a retrospective study utilizing a single database, it is possible that there was information misrepresented in the data we were able to obtain from the database. This may include the miscoding of race or not appropriately classifying patients who are multiracial, for example, therefore making the proportion of patients who are classified as other for race approach 8%. In addition, information pulled from the database may not have been complete including comorbidities, which may have influenced our model. Operative procedures may have been miscoded or inaccurately represented by codes chosen, which could also influence our data, and also potentially have missed patients who would have been included if their procedure or diagnosis was miscoded. There is the potential for a single patient to have multiple entries which would be difficult to discern from the data we receive from the database. Finally, as this is a database study, while hopefully a good representative population, it may not be representative of the general population, specifically with regards to the racial makeup of the cohort. Furthermore, the database may not be truly representative of the geographic location of sites where children receive surgery, and with a high proportion of operations occurring outside of children’s hospitals may lead to nonrepresentative observations, for example, less experience with care of the neonatal diagnoses may lead to greater complications skewing the data.

Conclusions

In 2009, 2012, and 2016, the independent associations of race and gender both remain regarding pediatric surgery complications in the United States. In addition to Black patients having a higher likelihood of any complication when compared to White patients, they also had longer hospital LOSs and higher hospital charges. Hispanic patients and those classified as other also had longer hospital LOSs and higher hospital charges. Male gender was associated with a higher risk of any complication, but interestingly had a shorter LOS.
and lower hospital charges. Overall, this study provides the most up-to-date evaluation of race and gender disparities in pediatric surgery, and shows that these disparities, unfortunately, remain, highlighting the need for improvement and informed strategies to better understand, address, and mitigate these disparities.

Level of Evidence

IV.

Supplementary Materials

Supplementary data related to this article can be found at https://doi.org/10.1016/j.jas.2022.08.027.

Author Contributions

Drs Saadai, Nuño, Coakley, and Jackson developed the study design and concept. Mr Rajasekar and Drs Jackson and Nuño acquired and analyzed the data. Dr Jackson, Ms Vukcevich, and Mr Rajasekar drafted the manuscript. All authors provided critical revisions.

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