Surgical Disparities in Pediatric Urology

Jennifer Ahn

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Committee:

Michelle Garrison

Margarett Shnorhavorian

Adam Goldin

Program Authorized to Offer Degree:

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University of Washington

Abstract

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Jennifer Ahn

Chair of the Supervisory Committee:
Michelle Garrison
Department of Health Services

Health disparities exist in surgical care and outcomes, but have not been investigated thoroughly in pediatric urology. Our aim was to investigate the association of race and ethnicity with timing of surgery and 30 day complications after orchiopexy, hypospadias repair, and urinary continence surgery. We performed a retrospective cohort study of individuals <18 years of age as captured in the NSQIPP PUF from 2012-2016. Primary outcomes of interest were age at time of surgery, proportion undergoing surgery by recommended age, likelihood of CKD at time of bladder augmentation, and 30 day complications. Logistic regression and generalized linear models were created. We found that non-Hispanic white race/ethnicity was associated with younger age at time of orchiopexy and hypospadias repair, several months earlier compared to Hispanic and non-Hispanic black individuals. Race/ethnicity was not associated with age at time of continence surgery or CKD at time of bladder augmentation. Non-Hispanic black race/ethnicity was associated with greater odds of complication after hypospadias repair. There are unexplained delays in surgery for racial and ethnic minorities with cryptorchidism and hypospadias. Further investigation is warranted to determine the factors contributing to these disparities.

Introduction

Health disparities exist across the continuum of care in the United States, and there is a growing body of evidence suggesting inequities in surgical care, particularly with respect to race and ethnicity. These inequities can arise preoperatively with variable access to care, comorbidities, or patient characteristics[1]. In the perioperative setting, hospital quality, surgeon volume, and provider bias are potential contributing factors. Postoperatively, differences exist in readmissions, morbidity, mortality, and access to rehabilitation facilities. The bulk of the surgical disparities literature has focused on the adult population, in which differences are seen in the delivery of care and outcomes for conditions that require urgent intervention such as trauma or cancer[2]. In contrast, the goal of surgery in pediatric urology is often to improve quality of life, or to maximize long-term organ function, through elective procedures. To date, little work has been done to investigate the presence or extent of surgical disparities in pediatric urology, especially in regards to race and ethnicity.

Timing of surgery is important in conditions like cryptorchidism, where earlier surgery (before 18 months of age) is recommended to promote testicular growth and development and to reduce malignancy risk[3,4]. Hypospadias, a congenital penile anomaly, can affect sexual health, fertility, and micturition if not surgically treated. Current guidelines state that surgery should be performed between 6 and 18 months, as earlier surgery is thought to reduce the psychological effects of genital surgery[5]. Children with chronic conditions like spina bifida and neuropathic bladder may require surgical intervention to achieve urinary continence. And while incontinence is not typically detrimental to health, it is associated with decreased health related quality of life (HRQoL) in this population, particularly after the age of 10 years[6]. Neuropathic bladder can also lead to kidney damage if untreated, with an estimated 12% prevalence of chronic kidney disease

at a mean age of 26 years in a cohort of US individuals with spina bifida[7]. While medical management is the mainstay of preserving kidney function, surgery such as bladder augmentation or urinary diversion may be needed in refractory cases, ideally before chronic kidney disease progresses.

The objective of this study was to investigate the presence of disparities in pediatric urology surgical care. Specifically, we evaluated the association of race and ethnicity with age at surgery for cryptorchidism, hypospadias, and urinary incontinence. We also assessed the association of race and ethnicity with the prevalence of chronic kidney disease at time of surgery for urinary incontinence, as well as with the frequency of continence surgery. Lastly, we examined the association of race and ethnicity with 30-day complications after each of these procedures. We hypothesized that African American and Hispanic children 1) undergo surgery at older ages 2) have a greater prevalence of chronic kidney disease at time of surgery 3) undergo continence procedures less frequently and 4) have a higher incidence of 30-day complications.

Methods

Data Source

The National Surgical Quality Improvement Program Pediatric (NSQIPP) was created by the American College of Surgeons (ACS) and American Pediatric Surgical Association (APSA) to provide high-quality surgical outcomes data with the goal of quality improvement across pediatric surgical specialties. Surgical cases for patients aged 0-17 years from participating institutions are systematically sampled on an 8-day cycle by select CPT (Current Procedural Terminology) codes, weighted towards procedures with greater morbidity. A surgical clinical reviewer collects and verifies 120 pre-specified and defined variables including baseline patient

characteristics, perioperative details, and 30-day post-operative outcomes[8,9]. De-identified data from participating institutions are compiled into a Participant Use Data File (PUF), which has been released yearly since 2012. In 2016, 101 participating institutions were included in the PUF, after ensuring data quality. Site, surgeon, and patient identifying data elements are not included, nor is patient insurance or socioeconomic status.

Study Population

Using the PUF from 2012 to 2016, all individuals undergoing the procedures of interest were included. For orchiopexy, individuals with CPT codes 54640, 54650, and 54692 were included. Laparoscopic orchiopexy (54692) is a primary CPT targeted by NSQIP, while open orchiopexy (54640, 54650) is not. As a result, all individuals undergoing open orchiopexy had concurrent procedures performed. Those undergoing procedures with more work relative value units (RVU) than open orchiopexy were excluded from analysis, so as not to confound post-operative complications with more complex procedures. Hypospadias repair is a procedure routinely tracked by NSQIPP, and thus the hypospadias cohort was identified by CPT code and categorized into distal (54322, 54324, 54326, 54328) and proximal (54332, 54336) hypospadias repair. All second stage repairs and redo repairs were excluded. Continence procedures included bladder neck reconstruction (51820, 51800, 51840, 51845, 51990, 51992), catheterizable channel (50845), continent diversion (50825), and bladder augmentation (51960). Individuals with malignancy were excluded from analysis for all three sub-populations, as presence of cancer could influence timing of surgery.

Variables

All variables from the PUF were extracted. Race and ethnicity were categorized as non-Hispanic White, non-Hispanic Black, Hispanic, American Indian or Alaska Native, Asian, Native Hawaiian or Pacific Islander, and other/unknown. Body mass index (BMI) was calculated for individuals ≥2 years of age, and overweight was defined as BMI ≥85th percentile for age and sex, as per CDC and AAP recommendations. Those with BMI ≥95th percentile for age and sex were categorized as obese. Surgical risk score was used as an estimate of co-morbidities, as defined and validated by Rhee and colleagues[10]. Diagnosis of spina bifida was recorded if an ICD9 diagnosis code of 741, 741.03, 741.9, or 741.93 or ICD10 diagnosis code of Q05, Q05.x, or Q76.0 was listed. Chronic kidney disease was defined by estimated glomerular filtration rate (eGFR) as calculated by the bedside Schwartz formula[11]. Complications, readmissions, and reoperations were extracted from the PUF, as defined by NSQIPP.

Analyses

To evaluate the association of race/ethnicity and age at time of orchiopexy, a generalized linear model (GLM) was created with age as the outcome of interest and race/ethnicity as the exposure of interest. Co-variates were determined *a priori* and included surgical risk score and developmental delay. Modified Park test, link test, and modified Hosmer-Lemeshow test were performed to determine appropriate family and link. A logistic regression model was used to estimate the outcome of orchiopexy performed by the age of 18 months, using the same co-variates and exposure of interest. Similar models were created for the outcome of age at time of hypospadias repair and surgery by the age of 18 months.

For the outcome of age at time of continence surgery, a GLM was similarly used, but additional co-variates of sex, spina bifida, and obesity/overweight were included. To evaluate the likelihood of CKD at time of bladder augmentation, a logistic regression model was created with

race/ethnicity as the exposure of interest and presence of CKD stage ≥2 at time of augmentation. Co-variates of sex, developmental delay, spina bifida diagnosis, obesity/overweight, and surgical risk score were included. Logistic regression models were created to estimate the odds of 30-day complications for each sub-group. Covariates of obesity/overweight, surgical risk score, age, sex (when applicable), and developmental delay. All analyses were performed using Stata 14 (StatCorp LLC, College Station, TX).

Results:

The 2012-2016 PUF was comprised of 369,176 cases, with 12% undergoing urologic procedures (Table 1). The majority of patients had a surgical risk score of zero, while 14% had a score of two or greater. Serum creatinine levels were not available for 70% of the overall cohort.

Orchiopexy

A total of 4,230 individuals underwent orchiopexy in our cohort (Table 2). Mean age at orchiopexy was 3.0 years (SD 3.4), and 2,178 (51%) had orchiopexy by 18 months of age. Non-Hispanic whites were most likely to have timely orchiopexy at 56% compared with 44% for non-Hispanic blacks ($p<0.001$). Year of surgery was not associated with likelihood of timely surgery, with 52% undergoing orchiopexy by 18 months from 2012-2014, and 51% in 2015-2016. In our logistic regression model, compared to non-Hispanic whites, non-Hispanic blacks (OR 0.6, 95% CI:0.5, 0.7, $p < 0.001$), Hispanics (OR 0.7, 95% CI: 0.6, 0.9, $p < 0.001$), and American Indian and Alaska Natives (0.3, 0.1, 0.8, $p = 0.018$) had decreased odds of having orchiopexy by 18 months, as did those with developmental delay (OR 0.3, 95% CI: 0.3, 0.4, $p < 0.001$), while adjusting for surgical risk score (Table 5). Examining age at time of orchiopexy with a GLM, the mean estimated age for non-Hispanic whites was 2.8 years, while adjusting for surgical risk

score and developmental delay (Table 6). Non-Hispanic blacks underwent orchiopexy an estimated 0.6 years later (95% CI: 0.2, 0.9, $p < 0.001$), and Hispanics 0.4 years later (95% CI 0.1, 0.7, $p = 0.007$). Developmental delay was also associated with a delay in orchiopexy by 1.0 years (95% CI: 0.7, 1.3, $p < 0.001$).

A total of 156 (4%) patients had a 30-day complication. Surgical site infection (1%), wound dehiscence (1%), and bleeding (1%) were the most commonly seen complications in this cohort. However, a portion of those complications were likely related to other concurrent procedures for the open orchiopexy group, as only 2% (51/2319) of the laparoscopic orchiopexy group had a 30-day complication. In our logistic regression model, Asian race was associated with an increased odds of having a complication (OR 3.3, 95% CI: 1.1, 9.7, $p = 0.027$) compared with non-Hispanic whites, as was surgical risk score (OR 2.5, 95% CI: 1.1, 5.4, $p = 0.021$) and developmental delay (OR 3.4, 95% CI: 1.7, 6.6, $p < 0.001$).

Hypospadias

Primary hypospadias repair was listed for 10,954 individuals with 10% categorized as proximal and 90% as distal (Table 3). Mean age at hypospadias repair was 1.4 years (SD 2.1), and 82% (8,934/10,954) underwent repair by 18 months. On bivariate analysis, non-Hispanic whites were most likely to have timely repair (86%) with American Indian and Alaska Natives the least likely at 68% (26/38), $p <0.001$. With logistic regression modeling, all groups had lower odds of undergoing timely repair as compared to non-Hispanic whites, while adjusting for risk score and developmental delay (Table 5). In our GLM, estimated age at hypospadias repair for non-Hispanic whites was 1.2 years, with non-Hispanic blacks undergoing repair at an estimated 0.5 years later (95% CI: 0.3, 0.6, $p < 0.001$), and Hispanic patients at an estimated 0.4 years later (95% CI: 0.3, 0.6, $p < 0.001$) (Table 6). Asian race was associated with the greatest

delay at 0.9 years (95% CI: 0.5, 1.2 $p < 0.001$). Developmental delay was also associated with an estimated delay of 0.9 years (95% CI: 0.7, 1.2, $p < 0.001$).

Three percent (290/10,954) of primary hypospadias patients had a 30-day complication, with 76 readmitted for related reasons. Wound dehiscence (n=187) was the most common complication, followed by bleeding (n=51) and urinary tract infection (n=39). Only 55/10,954 (0%) required reoperation within 30 days. On logistic regression, odds of complication were associated non-Hispanic black race/ethnicity (OR 1.6, 95% CI: 1.2, 2.2, $p = 0.002$), developmental delay (OR 2.2, 95% CI: 1.4, 3.4, $p < 0.001$), and older age (OR 1.1, 95% CI: 1.1, 1.1, $p < 0.001$).

Urinary continence surgery – age and presence of CKD

A total of 1,322 individuals underwent surgery for urinary incontinence at a mean age of 9.5 years (SD 4.0). About half were female (53%) and only 30% were listed as having spina bifida (Table 4). The slight majority (57%) had surgery before age 10 years, and there was no association of age at surgery and race/ethnicity on bivariate analysis, logistic regression, or GLM. Of the 601 individuals undergoing bladder augmentation, 345 (57%) had preoperative creatinine documented, allowing for estimation of GFR. Overall, 20% (121/601) had a known eGFR < 90mL/min/1.73m^2 indicating CKD stage ≥2. On bivariate analysis, race/ethnicity was associated with CKD, with 15% of non-Hispanic whites having CKD stage ≥2 by eGFR, compared with 22% of non-Hispanic blacks and 21% of Hispanics ($p<0.001$). However, on adjusted logistic regression analysis, CKD stage ≥2 was not associated with race/ethnicity, while adjusting for surgical risk score, sex, and age. Looking at the subset of spina bifida patients in the entire NSQIPP cohort (n=9588), non-Hispanic black patients had the lowest proportion undergoing continence procedures at 1.8%, compared with 3.6% of non-Hispanic whites and

4.2% of Hispanics (p = 0.002). On logistic regression analysis, decreased odds of continence surgery was associated with male sex (OR 0.6, 95% CI: 0.5, 0.8, p < 0.001), developmental delay (0.7, 95% CI: 0.5, 0.8, p = 0.001), surgical risk score (0.2, 95% CI: 0.1, 0.3, p < 0.001), and non-Hispanic black race (OR 0.6, 95% CI: 0.4, 0.9, p = 0.017).

The continence surgery group had a 30-day complication rate of 20% (268/1,322), with urinary tract infection (10%) and surgical site infection (6%) occurring most commonly. Twelve percent were readmitted within 30 days, and 6% (83/1,322) required reoperation. On logistic regression analysis, odds of complication were not associated with race/ethnicity. Mean post-operative length of stay was 6.6 days (SD 5.9). Using a GLM, longer post-operative hospital length of stay was associated with non-Hispanic black race/ethnicity, male sex, obesity, and older age. Non-Hispanic black patients had an estimated 0.7 days longer length of stay as compared to non-Hispanic whites (95% CI: 0.4, 1.1, p < 0.001).

Discussion

This study suggests that racial and ethnic disparities exist in timing of pediatric urology surgeries and 30-day complications. Differences were seen in timing of hypospadias repair and orchiopexy, but not in urinary continence surgery. Cryptorchidism affects up to 4% of newborns, with about 1% persisting at age one year[12]. Delaying orchiopexy can reduce fertility potential and earlier surgery can reduce the risk of future testicular tumors[13-15]. Current AUA guidelines were updated in 2014 and recommend that orchiopexy occur between 6-18 months of age if the testis has not descended by 6 months[3]. Previous AAP recommendations from 1996 suggested surgery be performed around one year of age[16]. In 2010, Kokorowski and colleagues evaluated the likelihood of having surgery for cryptorchidism by two years of age utilizing the Pediatric Health Information System (PHIS), an administrative database containing utilization data from

up to 45 pediatric hospitals[17]. Of about 28,000 children who underwent orchiopexy between 1999 and 2008, 43% had surgery by age two, and the mean age of surgery was 4.4 years. Adjusted models suggested that Hispanic white (OR 1.18) and non-Hispanic white race (OR 1.33) were associated with greater odds of surgery by age two years compared with black race. Those with private insurance were also more likely to have early surgery (OR 1.12). The hospital at which surgery was performed was the greatest predictor of timing of surgery, with significant variation seen throughout the 31 hospitals assessed. Among the institutions, the proportion who had surgery by age two years ranged from 30% to 54%. Racial and ethnic disparities were not the focus of this study, but it illustrates the variation in care across the US despite clear guidelines.

A similar investigation compared timing of orchiopexy using PHIS as well as Innovus i3, a United Healthcare insurance claims database. Individuals from 2002 to 2007 were evaluated, and analysis was limited to boys ≤5 years of age to exclude those with ascending testes[18]. In the Innovus group, only those with continuous insurance from birth were included and 87% had surgery by 18 months. Age at referral was associated with age at surgery. Continuity of primary care, type of referring provider and number of well-care visits were associated with timely surgery. Race and ethnicity were not associated with timely surgery on adjusted analyses, though >25% of race/ethnicity variables were unknown and only 3% of the population was reported as black. This group's assessment of PHIS found that less than 60% of the PHIS cohort had surgery by 18 months with a lower rate (54%) seen in publicly insured individuals. Private insurance and use of laparoscopic surgery were associated with timely surgery as well as volume of treating hospital. However, co-morbidities and individual hospital were not included for analysis, as they were in the previously mentioned PHIS study. The difference between continuously privately

insured patients and publicly insured patients was marked, and race/ethnicity was not evaluated given a high number of missing data. The timeliness in Innovus was significantly higher than in our NSQIPP analysis despite our cohort being more recent. Even if we restricted our age to ≤5 years as this group did, only 63% had surgery by 18 months compared to 87% in a privately insured group with continuous care. This suggests that continuous access to health care may be an important factor in achieving timely assessment, referral, and surgery for boys with cryptorchidism.

Racial disparities were investigated in a retrospective institutional cohort study, in which Savoie et al found that only 27% of patients had surgery by 18 months of age[19]. Examining 1,209 patients <18 years from 2005-2014, median age of referral was 3.2 years, and median age at surgery was 3.7 years. On adjusted analyses, race/ethnicity was not associated with time of referral or repair, but insurance status was, with public insurance associated with twice the odds of having a delayed repair. A group in Melbourne, AUS found that late referrals resulted in an orchiopexy rate of only 19% by 2 years of age[20]. Guidelines were subsequently created, implemented, and disseminated to general practitioners and parents. A follow-up analysis showed a reduction in median age of surgery from 4 years to 2 years. The recent AUA guidelines clearly define appropriate timing of referral. However, implementation and dissemination has not been standardized, and there is likely variation depending on the practice and hospital environment.

Our findings show that surgery is performed earlier on average than in previous cohorts from the 1990s and 2000s. While this NSQIPP patient population may differ from that of PHIS and Innovus, it captures cases from all across the US and is not confined to freestanding children's hospitals as PHIS is. Freestanding children's hospitals may serve patients from a

wider encatchment area, resulting in delayed referrals and assessment. Conversely, these institutions may have providers that are more up to date on recommendations and may be more likely to suggest early orchiopexy. Comparing PHIS institutions with others and considering hospital volume may provide valuable insight into the role of the institution. Unfortunately, NSQIPP does not indicate the hospital's location, volume, or practice type, so this may cause potential confounding in our results. However, the majority of previous studies did not focus on race/ethnicity as an exposure of interest, making our findings unique[21]. Co-morbidities were also not incorporated to other analyses, which can significantly impact the timing of surgery, as an orchiopexy will often be delayed if there are more pressing health issues or concern regarding anesthesia risk. While adjusting for co-morbidities using a validated surgical risk score, race/ethnicity is clearly associated with age at time of orchiopexy in our cohort. We hypothesize that reasons for this delay include delayed referral and disparities in access to quality care. The several month delay seen here may result in decreased fertility for non-white groups though this cohort's fertility will not be known for several years. Testicular malignancy would also not manifest for several years in our cohort, but minority patients are known to already have worse outcomes with testicular cancer and thus action to improve timing of orchiopexy is warranted[22].

Using NSQIPP to evaluate orchiopexy has its limitations. Since NSQIPP does not primarily aim to collect information on open orchiopexies, many children undergoing primary orchiopexy were not captured. Instead, many undergoing concurrent minor procedures were included for analysis, which is evidenced by the high proportion with surgical risk scores $\geq$2. Laparoscopic orchiopexy is a procedure of interest in NSQIPP and thus comprised the majority of the orchiopexy cohort, which is not typical for an orchiopexy group as open orchiopexies are performed much more frequently. Examining a dataset that includes all orchiopexies should be

investigated in further studies to confirm these findings. In addition, insurance type is a significant exposure in previous studies, and this cannot assessed in NSQIPP. Whether this would impact age at surgery is unknown, nor the extent of the effect as compared with race and ethnicity. Given these limitations, understanding referral patterns, insurance status, and hospital type would be important to incorporate in future investigations.

Timing of hypospadias is more controversial than orchiopexy, as recommendations are not driven by physiologic changes such as testicular health and malignancy reduction. However, due to anesthetic risk minimized after 6 months of age, and genital awareness beginning around 18 months, hypospadias repair between 6-12 months or 6-18 months is typically recommended[16,23,24]. While having hypospadias unrepaired does not cause organ damage or increase malignancy risk as cryptorchidism can, it may impact sexual function, ability to urinate while standing, or fertility[24,25]. In addition, delaying repair may result in a higher complication rate, though this has not been prospectively evaluated, given the current recommendations for early repair[26,27]. Disparities in timing of surgery has not been thoroughly investigated, though delaying hypospadias surgery may have negative impact on self-image[28].

A higher proportion of patients in our cohort had hypospadias repair (82%) by 18 months compared with orchiopexy (51%). This is likely because hypospadias is typically noted at birth, and referral can be made any time after that. Conversely, cryptorchidism is followed until at least 6 months of age and if still present then, referral to a surgeon should be made. In addition, testes can be retractile, or ascend later in life necessitating repair at an older age. However, a similar racial and ethnic disparity in age at time of surgery was seen in the hypospadias group. Whites had repair several months earlier than other groups did, on average, with non-Hispanic blacks, Hispanics, and Asians having delays in surgery by several months. Interestingly, older children

had greater odds of short-term complications, suggesting earlier repair may reduce complications. Further follow-up would be ideal, as long-term complication rates are more common and impactful, as many require secondary procedures. Interestingly, non-Hispanic black race was associated with greater odds of 30-day complication, irrespective of age or co-morbidities. This is consistent with literature from other disciplines, warranting further investigation[29,30].

As with the orchiopexy analysis, payer and hospital data would further inform our analysis and may be potential confounders. In addition, hypospadias is typically performed by pediatric urologists, while orchiopexy is done by both pediatric surgeons and pediatric urologists. There are far fewer pediatric urologists than pediatric surgeons in the US, and thus patient location and distance from a specialist may also be a factor in timing of surgery. Non-white patients also have lower rates of circumcision, and mild cases of hypospadias are often discovered at time of evaluation for newborn circumcision[31]. Many parents do not notice subtle anatomic differences seen with hypospadias and it may go undiagnosed if circumcision is not pursued. The racial and ethnic disparities found in this analysis suggest a need for further investigation into why these differences exist, how they impact the patients and families, and how best to ameliorate them.

Urinary incontinence can significantly impact HRQoL for children and adults, and affects many individuals with spina bifida[6,32-34]. Evidence suggests incontinence affects HRQoL at older ages, particularly after the age of 10 years for patients with spina bifida. Surgery can help achieve continence by tightening the bladder outlet, increasing the bladder capacity, or creating a channel through which to catheterize the bladder. Current literature suggests ethnic disparities in spina bifida care, with a higher incidence in Hispanic patients, and increased mortality and

morbidity[35]. PHIS analysis suggests Hispanic patients may have higher odds of complication after bladder reconstruction surgery[36]. However, the role of race and ethnicity in the timing of urinary continence surgery has not been directly evaluated.

In our analysis, race and ethnicity were not associated with timing of urinary continence surgery, regardless of whether patients had spina bifida or not. The average age of surgery was 9.5 years and the proportion of patients with known spina bifida was low at 30%. This may be due to missing data, as spina bifida is typically a diagnosis for about half of similar cohorts. Kidney function laboratory values were also not routinely recorded in NSQIPP, and thus the true proportion of patients with CKD is unknown. In addition, GFR and thus CKD estimates are difficult in children with spina bifida, and thus may not be accurate. However, the Schwartz formula tends to overestimate GFR, and thus there may be an even higher prevalence of CKD in this population than is estimated here. If we presume that patients with missing creatinine values had normal kidney function, 16% (218/1322) of patients undergoing urinary continence surgery still had at least stage 2 CKD at a mean age of 9.5 years. This is far higher than the 6-12% estimated in a cohort of spina bifida patients with a mean age of 26 years[7]. Not all patients with CKD by eGFR had an ICD diagnosis of CKD in NSQIPP, and any preoperative illness that increased serum creatinine could result in an overestimation of CKD. However, this high prevalence is concerning and suggests inadequate care and warrants further investigation.

Interestingly, a smaller proportion of non-Hispanic black patients with spina bifida underwent urinary continence procedures as compared to non-Hispanic white patients. This may be due to differences in need for continence surgery, access to it, or desire for it. NSQIPP does not capture all individuals with spina bifida, and thus our data may be skewed. However, it is concerning that non-Hispanic black patients are not undergoing urinary continence surgery as

frequently when baseline incontinence rates should not differ. Surgery typically requires a significant lifestyle change with implementation of catheterization programs, daily irrigations, and a risk of significant morbidity and mortality with noncompliance. It is quite possible that there are patient and provider factors that introduce significant bias. Continuity of care is also important to successful neuropathic bladder management, and interrupted or difficult access to care can be a significant barrier. It has also been suggested that cultural differences result in more Hispanic patients having urinary incontinence with spina bifida and thus further investigation into the role of culture and bias is needed[37].

NSQIPP captures 30-day complications with high fidelity and there were no marked racial or ethnic associations after the procedures of interest[9]. However, the increased odds of short-term complications after hypospadias repair in non-Hispanic blacks is concerning. It is less likely a patient-related factor since co-morbidities were taken into account. Potential contributing factors are limited access to post-operative care, inadequate education and counseling after surgery, or barriers to appropriate follow-up. Caregivers are typically required to provide wound care, manage temporary catheter drainage, and administer medications several times a day for one to two weeks after surgery, which necessitates time away from work. In previous decades, patients would remain in the hospital for about a week to receive this care; currently, patients are sent home the day of surgery, leaving the burden of care on the patient's caregivers. This may unfairly put families with fewer resources at a disadvantage, contributing to the likelihood of complication. In contrast, orchiopexy does not require significant post-operative care, aside from pain control and possible bandage removal. Urinary continence surgery also requires significant attention and care after hospital discharge, with multiple catheters and medications to manage. However, these patients are older and able to participate in self-care, as well as communicate

their needs and pain, unlike infants and toddlers. While the Family Medical Leave Act ensures job security while taking time off to care for a child, it does not guarantee pay, making it much more difficult to ensure children are getting the postoperative care at home they need without unduly burdening the family financially. Broader protections may be needed to ensure that caregivers are equipped and supported in delivering postoperative care at home to reduce the likelihood of postoperative complications after complex surgery such as hypospadias repair.

Limitations of this study include the lack of insurance data, the fact that NSQIPP represents only a sample of cases, and the inability to identify hospital type, location, or volume. In addition, longitudinal data are not available to assess for previous diagnoses or procedures, nor is time of presentation for assessment for surgery. Language and distance from hospital may also be relevant barriers to care and these are not obtainable in NSQIPP. Despite these limitations, our cohort represents a large number of pediatric patients undergoing urologic procedures across the US at a diverse set of institutions. NSQIPP is also one of the few datasets dedicated to surgery with high-quality 30-day complication data and captures both inpatient and outpatient surgeries, making it a suitable dataset for this type of analysis. Lastly, race and ethnicity data are more complete than in many administrative datasets, allowing us to include these as exposures of interest.

Conclusion

This study supports previous work that suggests disparities in surgical care for cryptorchidism and urinary incontinence, and introduces the possibility of similar disparities in hypospadias care. These differences are concerning, and are unfortunately consistent with literature in adult surgical care where minority populations are at higher risk of inadequate or delayed care[38]. While this study establishes the presence of racial and ethnic disparities in

pediatric urology, it is unable to determine the reasons for it, nor account for potential confounders of insurance type, institution, or access to care. In addition, time to referral may be a large component of the delay, and these factors are not available in NSQIP. Payer or state-based data may provide details that are more specific and allow these potential confounders to be included in analysis. Understanding where the delay is and why it occurs will help inform strategies to address it, whether it be improved education of parents and primary care providers, streamlined referrals, reducing provider bias, or ensuring equitable access to services. In addition, speaking with families and primary care providers may provide greater insight into the process of diagnosis, referral, and surgical counseling for these three conditions. Despite guidelines, there are racial and ethnic differences in when children are having surgery for congenital conditions of cryptorchidism and hypospadias. Further research is needed to identify barriers to appropriate care and solutions to ensure equitable surgical care for all children.

Tables and Figures

Table 1 Characteristics of entire NSQIPP PUF Cohort 2012-2016

	All Patients (n = 369,176)
Sex, n (%)	
- Female	159,400 (43)
- Male	209,776 (57)
Race/Ethnicity, n (%)	
- Non-Hispanic White	219,695 (60)
- Non-Hispanic Black	47, 367 (13)
- Hispanic	55,900 (15)
- American Indian or Alaska Native	1,380 (0)
- Asian	11,165 (3)
- Native Hawaiian or Pacific Islander	1253 (0)
- Other/Unknown	32,416 (9)
Mean age in years (SD)	7.3 (5.7)
Procedure Type, n (%)	
- All urology	45,576 (12)
- Orchiopexy	4,230 (1)
- Hypospadias	10,954 (3)
- Urinary continence	1,322 (0)
Surgical Risk Score, n (%)	
- 0	209,011 (57)
- 1	111,720 (30)
- 2	24,230 (7)
- ≥3	24,215 (7)
Developmental Delay, n (%)	52,557 (14)
Chronic Kidney Disease, n (%)	
- Stage 0-1	72,243 (20)
- Stage 2	23,908 (6)
- Stage 3	9,613 (3)
- Stage 4	3,941 (1)
- Stage 5	1,400 (0)
- unknown	258,071 (70)

Table 2 Baseline characteristics and 30-day complications for orchiopexy group

	Orchiopexy (n = 4,230)
Race/Ethnicity, n (%)	
- Non-Hispanic White	2,200 (52)
- Non-Hispanic Black	672 (16)
- Hispanic	674 (16)
- American Indian or Alaska Native	18 (0)
- Asian	158 (4)
- Native Hawaiian or Pacific Islander	15 (0)
- Other/Unknown	493 (12)
Mean age in years (SD)	3.0 (3.4)
Laparoscopic orchiopexy, n (%)	2,319 (55)
Surgical Risk Score, n (%)	
- 0	1,370 (32)
- 1	2,301 (54)
- 2	281 (7)
- ≥3	278 (7)
Developmental Delay, n (%)	654 (15)
Orchiopexy before 18 months age, n (%)	2,178 (51)
- Non-Hispanic White	1,238 (56)
- Non-Hispanic Black	296 (44)
- Hispanic	319 (47)
- American Indian or Alaska Native	4 (22)
- Asian	81 (51)
- Native Hawaiian or Pacific Islander	10 (67)
- Other/Unknown	230 (47)
30-day complications, n (%)	156 (4)
- SSI	45 (1)
- Dehiscence	49 (1)
- Bleed	31 (1)

Table 3 Baseline characteristics and 30-day complications for hypospadias repair group

	Primary Hypospadias Repair (n = 10,954)
Race/Ethnicity, n (%)	
- Non-Hispanic White	6,827 (62)
- Non-Hispanic Black	1,530 (14)
- Hispanic	909 (8)
- American Indian or Alaska Native	38 (0)
- Asian	304 (3)
- Native Hawaiian or Pacific Islander	38 (0)
- Other/Unknown	1,308 (12)
Mean age in years (SD)	1.4 (2.1)
Type, n (%)	
- Distal	9,845 (90)
- Proximal	1,109 (10)
Surgical Risk Score, n (%)	
- 0	1,245 (11)
- 1	8,996 (82)
- 2	471 (4)
- ≥3	242 (0)
Developmental Delay, n (%)	461 (4)
Hypospadias repair before 18 months age, n (%)	8,934 (82)
- Non-Hispanic White	5,840 (86)
- Non-Hispanic Black	1,137 (75)
- Hispanic	685 (75)
- American Indian or Alaska Native	26 (68)
- Asian	208 (68)
- Native Hawaiian or Pacific Islander	28 (74)
- Other/Unknown	1,010 (77)
30-day complications, n (%)	290 (3)
- Dehiscence	187 (2)
- Bleed	51 (0)
- SSI	39 (0)
30-day readmissions, n (%)	76 (0)
30-day reoperations, n (%)	55 (0)

Table 4 Baseline characteristics and complications for urinary continence surgery group

	Urinary Continence Surgery Patients (n = 1322)
Sex, n (%)	
- Female	706 (53)
- Male	616 (47)
Race/Ethnicity, n (%)	
- Non-Hispanic White	906 (69)
- Non-Hispanic Black	125 (9)
- Hispanic	146 (11)
- American Indian or Alaska Native	12 (1)
- Asian	45 (3)
- Native Hawaiian or Pacific Islander	3 (0)
- Other/Unknown	85 (6)
Mean age in years (SD)	9.5 (4.0)
Type, n (%)	
- Appendicovesicostomy	963 (73)
- Enterocystoplasty	584 (44)
- Continent diversion	11 (1)
- Bladder outlet procedure	310 (23)
Surgical Risk Score, n (%)	
- 0	1,102 (83)
- 1	132 (10)
- 2	69 (5)
- ≥3	19 (1)
Developmental Delay, n (%)	328 (25)
Spina bifida, n (%)	401 (30)
Bladder exstrophy, n (%)	115 (9)
Chronic Kidney Disease, n (%)	
- Stage 0-1	461 (35)
- Stage 2	121 (9)
- Stage 3	56 (4)
- Stage 4	26 (2)
- Stage 5	15 (1)
- unknown	643 (49)
Postoperative length of stay in days (SD)	6.6 (5.9)
30-day complications, n (%)	268 (20)
- SSI	75 (6)
- UTI	133 (10)
- Dehiscence	60 (5)
30-day readmissions, n (%)	164 (12)
30-day reoperations, n (%)	83 (6)

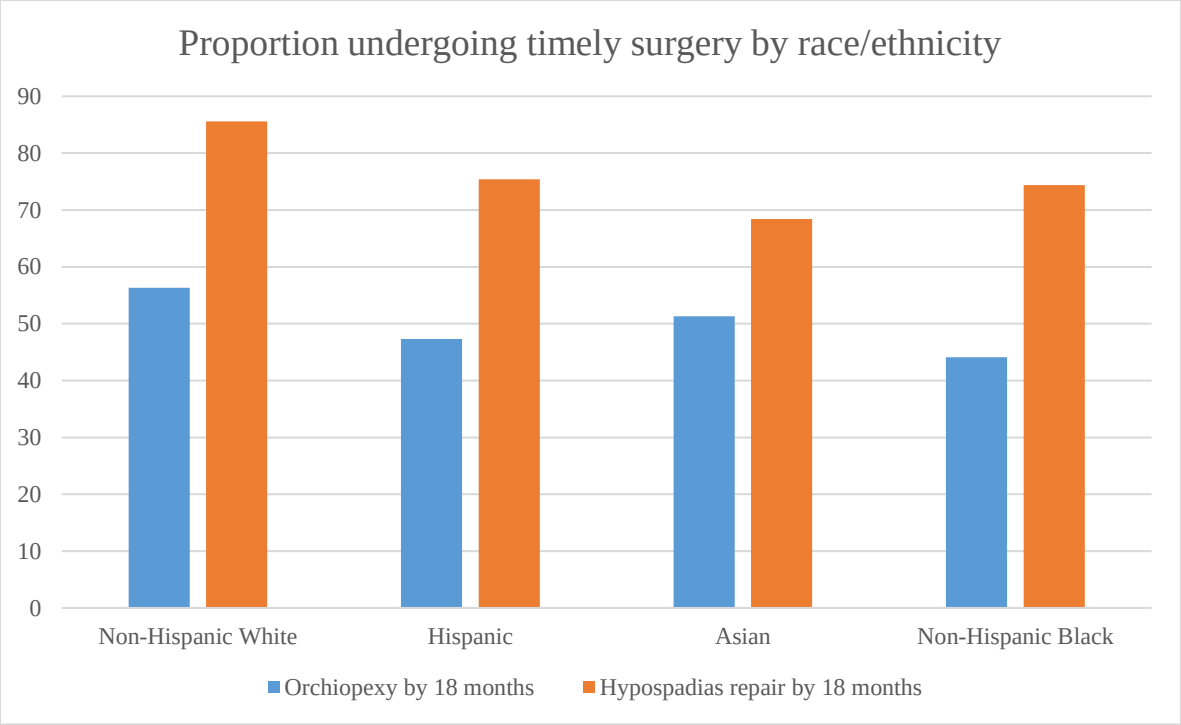
Table 5 Odds ratios of timely surgery by race/ethnicity

	Orchiopexy			Hypospadias Repair		
	OR	95% CI	p-value	OR	95% CI	p-value
Non-Hispanic White	Ref			ref		
Non-Hispanic Black	0.6	0.5, 0.7	<0.001	0.5	0.4, 0.6	<0.001
Hispanic	0.7	0.6, 0.9	<0.001	0.5	0.4, 0.6	<0.001
American Indian or Alaska Native	0.3	0.1, 0.8	0.018	0.3	0.2, 0.7	0.002
Asian	0.8	0.6, 1.1	0.280	0.4	0.3, 0.5	<0.001
Native Hawaiian or Pacific Islander	1.5	0.5, 4.4	0.492	0.5	0.2, 0.9	0.036
Other/Unknown	0.7	0.6, 0.8	<0.001	0.6	0.5, 0.7	<0.001

Table 6 Estimated mean age at time of surgery by race/ethnicity

	Orchiopexy			Hypospadias Repair		
	Age in years	95% CI	p-value	Age in years	95% CI	p-value
Non-Hispanic White	2.8	2.7, 3.0		1.2	1.2, 1.3	
Non-Hispanic Black	3.4	3.1, 4.3	<0.001	1.7	1.6, 1.8	<0.001
Hispanic	3.2	3.1, 3.9	0.007	1.6	1.5, 1.8	<0.001
American Indian or Alaska Native	3.7	2.5, 5.6	0.413	1.8	1.0, 2.6	0.146
Asian	2.8	2.3, 3.3	0.912	2.1	1.8, 2.4	<0.001
Native Hawaiian or Pacific Islander	2.8	1.5, 4.2	0.957	1.5	0.8, 2.2	0.396
Other/Unknown	2.9	2.7, 3.3	0.508	1.6	1.4, 1.7	<0.001

Figure 1 Proportion of individuals undergoing surgery by 18 months by race/ethnicity



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