Published in final edited form as:

J Urol. 2015 August ; 194(2): 506–511. doi:10.1016/j.juro.2015.01.096.

Hospital surgical volume and associated post-operative complications of pediatric urologic surgery in the United States

Hsin-Hsiao S. Wang¹, Rohit Tejawani², Haijing Zhang², John S. Wiener¹, and Jonathan C. Routh¹

¹Division of Urologic Surgery, Duke University Medical Center, Durham, NC

²Duke University School of Medicine, Durham, NC

Abstract

BACKGROUND—Hospital and provider surgical volume have been increasingly linked to surgical outcomes. However, this topic has rarely been addressed in children. Our objective was to investigate whether hospital surgical volume impacts complication rates in pediatric urology.

METHODS—We retrospectively reviewed the Nationwide Inpatient Sample (1998–2011) for pediatric (< 18 years) admissions for urologic procedures. We used ICD-9-CM codes to identify elective urologic interventions and National Surgical Quality Improvement Program (NSQIP) in-hospital post-operative complications. Annual hospital surgical volume was calculated and dichotomized as high-volume (>90th percentile) or non-high-volume hospitals (<90th percentile).

RESULTS—In total, we identified 158,804 urologic admissions (114,634 high-volume hospital admissions and 44,171 non-high-volume hospital admissions). 75% of hospitals performed fewer than 5 major pediatric urology cases per year. High-volume hospitals treated significantly younger patients (mean 5.4 vs 9.6 years, $p<0.001$), and were more likely to be teaching hospitals (93% vs 71%, $p<0.001$). The overall rate of NSQIP-identified postoperative complications was higher at non-high-volume hospitals (11.6%) than at high-volume hospitals (9.3%, $p=0.003$). After adjusting for confounding effects, patients treated at non-high-volume hospitals remained more likely to suffer multiple NSQIP-tracked postoperative complications: acute renal failure (OR 1.4, $p=0.04$), UTI (OR 1.3, $p=0.01$), post-op respiratory complications (OR 1.5, $p=0.01$), systemic sepsis (OR 2.0, $p<0.001$), post-op bleeding (OR 2.5, $p<0.001$), and in-hospital death (OR=2.2, $p=0.007$).

CONCLUSIONS—Urologic procedures performed on children at non-high-volume hospitals were associated with an elevated risk of in-hospital, NSQIP-identified postoperative complications, including a small but significant increase in postoperative mortality mostly in nephrectomy and percutaneous nephrolithotomy.

Corresponding Author: Jonathan C. Routh, MD, MPH, Division of Urologic Surgery, Duke University Medical Center, DUMC 3831, Durham, NC 27710, Office: (919) 684-6994, FAX: (919) 681-5507, jonathan.routh@duke.edu.

Conflicts of Interest/Financial Disclosures: Dr. Routh is supported by grant number K08-DK100534 from the National Institute of Diabetes and Digestive and Kidney Diseases.

Keywords

volume; complication; surgery; pediatric urology

INTRODUCTION

An increasing body of literature has demonstrated substantial differences in perioperative morbidity and mortality for adult patients treated at high-volume versus low-volume centers.^{1–3} Most studies have reported a strong relationship between surgical outcomes and both institutional and surgeon volume across multiple subspecialties: patients who undergo surgery at high-volume centers tend to have lower rates of perioperative complications, despite the tendency for these centers to treat a higher proportion of patients with more challenging preoperative comorbidities.^{1–4} The volume-outcome relationship has become increasingly relevant in recent years as preventable postoperative complications have come under greater scrutiny by public and private insurers, patient advocacy groups, and quality improvement organizations.

Studies exploring the volume-outcome relationship in adult urologic procedures have supported the notion that both high-volume centers and high-volume surgeons have better perioperative outcomes than low-volume centers.^{5–7} However, data describing the volume-outcome relationship in pediatric subspecialties, particularly pediatric urology, are relatively scarce.^{8–10} As patterns of care shift toward increased regionalization and selective referral, it is important to understand whether such changes are justified in the pediatric urologic population. We sought to determine the difference in rates of postoperative complications as identified by the American College of Surgeons National Surgical Quality Improvement Program (NSQIP) for elective pediatric urology procedures at high-volume and non-high volume centers over a 13-year period using the national database.

METHODS**Data source**

NIS is an all-payer database managed by the Healthcare Cost and Utilization Project (HCUP) and sponsored by the Agency for Healthcare Research and Quality (AHRQ). Data in the NIS are from a 20% stratified probability sample of US hospitals, including both children's and adult hospitals, based on five hospital characteristics including ownership status, number of beds, teaching status, urban/rural location, and geographic region. NIS includes post-stratification discharge weights that may be used to calculate national estimates.¹¹

Selection of Patients and Covariates

We identified all inpatient hospital encounters occurring between 1998 and 2011 for pediatric patients (< 18 years old) with an International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) diagnosis code for elective pediatric urologic procedures including ureteral reimplant, uretero-ureterostomy, pyeloplasty, radical nephrectomy, partial nephrectomy, bladder exstrophy repair, appendicovesicostomy, bladder

augmentation, vesicostomy, bladder neck sling, and percutaneous nephrolithotomy (see Appendix 1 for ICD-9-CM procedure codes for each procedure).

Predictor variables were *a priori* selected based on biologic plausibility and/or demonstrated associations in the literature. Covariates included basic patient demographics: age, gender, race, insurance payer (public vs. private), median local ZIP code household income (by quartiles), Elixhauser comorbidity index^{12, 13}, treatment year, as well as hospital level factors: hospital characteristics such as hospital teaching status (metropolitan non-teaching, metropolitan teaching, and non-metropolitan), geographic region (Northeast, South, Midwest, and West), hospital size, and pediatric urologic surgical volume. The pediatric urologic surgical volume was dichotomized as high volume (volume greater or equal than 90th percentile) and non-high volume (volume less than 90th percentile).

Outcome selection

The primary outcome was immediate postoperative complications during the same admission; these were identified by ICD-9-CM code (Appendix 2) which most closely corresponded to the complications described by the National Surgical Quality Improvement Program (NSQIP).¹⁴ We included superficial surgical site infection (SSI), deep SSI, peritoneal abscess, acute renal failure (ARF), UTI, postoperative urinary complications, postoperative respiratory complications, pneumonia, postoperative respiratory insufficiency, acute respiratory distress syndrome, systemic sepsis, pulmonary embolism, mechanical ventilation >96 hours, cerebrovascular accident, postoperative cardiac complications, acute myocardial infarction (MI), cardiac arrest, bleeding, and deep vein thrombus (DVT) as the main outcomes. We also examined in-hospital death, length of stay (LOS), and total hospital costs for each admission; due to the inpatient nature of the database, any complications occurring after discharge (including death) would not be captured by the database. Rare complications (≤ 15) were removed from the analysis as per AHRQ prohibitions against publication of rare events.

Statistical Analysis

Bivariate analyses were performed to compare patient demographics and hospital-level characteristics of pediatric urology patients treated in high volume center or non-high volume center. We used the Rao-Scott Chi-Square test, t-test, or Wilcoxon rank-sum test as appropriate based on data characteristics and distribution. All analyses were weighted using NIS-specific estimated weights and covariance matrices. NIS cost-to-charge files were used to convert hospital charges to cost. Due to file availability, cost was only estimated from 2001 to 2011. Multivariate logistic regression (NSQIP postoperative complications, in-hospital deaths) and negative binomial regression (LOS, cost) were fitted to examine factors, specifically hospital pediatric urologic surgical volume, that predicted the outcomes. Generalized estimating equations were used to account for NIS complex survey design in addition to hospital clustering effects.

An alpha of 0.05 and 95% confidence intervals (CI) were used as criteria for statistical significance. All analyses were performed using SAS 9.4 (SAS Institute, Cary, NC).

RESULTS

Demographics

In total, we identified 158,804 weighted pediatric urologic surgery admissions including 114,634 (72%) admissions at high-volume hospitals and 44,171 (28%) admissions at non-high-volume hospitals (Table 1). Mean patient age was 6.5 ± 0.1 years. Males constituted 43.4% of the overall cohort. Prior to weighting, 2,628 hospitals were analyzed. 75% of hospitals performed fewer than 5 major pediatric urology cases per year; in the remaining 25% of high volume hospitals, the mean annual number of pediatric urology cases was 52 (range 5–657).

Compared to patients treated in non-high volume hospitals, patients treated in high volume centers were significantly younger (mean 5.4 versus 9.6 years, $p < 0.001$), more likely to have public insurance (30.3% versus 26.7%, $p < 0.001$), and to undergo a procedure in a teaching hospital (93.6% versus 70.8%, $p < 0.001$).

Postoperative Complications

Complication rates did not vary significantly over time (range from 7.3 to 10.6%, $p = 0.95$ for trend). The overall rate of NSQIP-identified postoperative complications was significantly higher at non-high-volume hospitals (10.4%) than at high-volume hospitals (8.5%, $p = 0.003$).

On bivariate analysis (Table 2 and 3), patients who received pediatric urologic procedure in non-high-volume hospitals were more likely to suffer from postoperative respiratory complications (OR=1.58, $p = 0.01$), pneumonia (OR=1.59, $p = 0.02$), sepsis (OR=2.01, $p < 0.001$), cardiac complications (OR=2.55, $p < 0.001$), bleeding (OR=2.55, $p < 0.001$), and in-hospital death (OR=2.50, $p = 0.007$) compared to patients who received care in high-volume surgical centers. There were too few events for postoperative SSI (superficial and deep), peritoneal abscess, ARDS, pulmonary embolism, prolonged mechanical ventilation (> 96 hours), CVA, MI, cardiac arrest, and DVT to perform a thorough analysis; these complications were therefore excluded.

The in-hospital mortality by surgical procedures was detailed in Table 4. The procedure associated with highest in-hospital death rate was exstrophy repair (1.73%), followed by radical nephrectomy (1.58%), percutaneous nephrolithotomy (0.68%), vesicostomy (0.31%), and bladder augmentation (<0.2%). No mortality events were noted for other procedures.

After adjusting for age, gender, insurance status, Elixhauser index, treatment year, surgery type, hospital teaching status, hospital size, and geographic region (Table 3), patients treated at non-high-volume hospitals remained more likely to suffer from acute renal failure (OR=1.38, $p = 0.04$), UTI (OR=1.32, $p = 0.01$), post-op respiratory complications (OR=1.58, $p = 0.01$), systemic sepsis (OR=2.01, $p < 0.001$), post-op bleeding (OR=2.13, $p < 0.001$), and in-hospital death (OR=2.22, $p = 0.007$).

Economic Impact

On bivariate analysis, median LOS of admissions at high-volume surgical centers was not statistically significantly different than non-high-volume surgical centers (1.9 vs. 2.4 days,

p=0.07). However, after adjusting for confounding effects including age, insurance, year, comorbidity, teaching status, hospital region, hospital size, and surgery type, the reduction in LOS at high-volume surgical centers achieved statistical significance (RR=0.84, 95% CI 0.78–0.90, p<0.001).

There was no significant difference in terms of cost between admissions treated in non-high-volume hospitals or high-volume centers (7,605 vs. 8,054, p=0.54)

DISCUSSION

Though explored extensively in the adult population, the volume-outcome relationship for postoperative complications is less well characterized for pediatric urology patients. In our analysis of 158,804 weighted admissions, patients who underwent elective urologic procedures at non-high-volume hospitals were more likely to experience postoperative complications than those who were operated on at centers with high surgical volume.

In general, low complication rates are anticipated in pediatric urology patients due to the elective nature of the procedures, the pathologic processes involved, and the relatively good overall health of the patient population. Even so, our findings indicate institutional case volume is a significant determinant of postoperative complication risk in pediatric urologic patients undergoing procedures despite the low risk of post-operative complications. Patients not only experienced higher rates of acute renal failure, urinary tract infections, respiratory complications, sepsis, bleeding; more surprisingly, the odds of in-hospital death was more than doubled at non-high-volume hospitals compared to patients treated in high-volume centers. This finding becomes even more significant when one considers that high-volume centers typically treat sicker patients with problems which are more technically challenging. However, this finding is in line with existing literature for other adult and pediatric surgical subspecialties.

There remains a lack of consensus as to the underlying reasons for the differences in postoperative morbidity and mortality between high- and non-high-volume centers.^{1–4, 15} Further clouding this picture is the wide variability in criteria used by prior studies to define volume, analyses of outcomes, and degree of accounting for potential confounding factors.¹⁶ A recent systematic review of 135 studies covering 27 different procedures across multiple subspecialties found the strength of the volume-outcome relationship varies considerably by procedure type.¹⁷ Similarly, other studies have found that the volume-outcome relationship was most significant for high- and moderate-risk procedures; by contrast, complication rates for low-risk procedures were unaffected by center volume.¹⁸

The complexity of cases is presumably greater at high-volume centers compared to non-high-volume centers. Some authors have found comparable rates of complications irrespective of volume, but improved survivorship and decreased morbidity at high-volume centers – suggesting these centers may be better equipped and prepared to deal with complications when they arise.^{10, 19–21} It is also worth noting that while the vast majority of studies have demonstrated a morbidity and mortality benefit to patients undergoing surgery at high volume centers, the literature is not universally supportive of this notion.^{21–23}

Ultimately, postoperative complications are undoubtedly multifactorial; it is impossible to point to a single institutional attribute as having complete prognostic value for the development of complications during the postoperative period. Rather, we argue institutional case volume is one of a larger cluster of factors that shape postoperative outcomes and suggest our findings be viewed in this context. Practitioners on both the referral and operative ends of pediatric urologic patient management should use these results not as an absolute reference, but rather as an additional consideration when counseling patient families and making surgical referral decisions. In recent years, there have been continued trends towards centralization of care at high-volume hospitals and designation of surgical ‘centers of excellence’.^{24, 25} Our findings support the notion that these shifts may be beneficial for pediatric urologic patients in the context of postoperative outcomes.

The findings of our study must be interpreted in the context of study limitations. NIS represents a 20% stratified sample of US hospital admissions. As such, our reported results may not be generalizable to encounters not in the sample pool. However, NIS does provide meticulous tracking of discharge and hospital weights in order to minimize the risk of sampling bias²⁶. Additionally, NIS is a large retrospective administrative database that might be affected by miscoding bias. Our analysis relies on the accuracy of the diagnostic and procedure codes included in NIS; while the accuracy level of NIS is high for an administrative database, it is possible at least some portion of our cohort may be incorrectly coded. Furthermore, the NSQIP complications that we identified may represent associated co-morbidities and not true postoperative complications, as NIS does not provide temporal relationships between different diagnosis codes. Despite these limitations, as noted above, the NIS database is rigorously monitored and audited for coding accuracy and, therefore, represents a reasonably reliable panorama of the characteristics of an inpatient surgical cohort.

Because NIS represents admission-based rather than patient-based data, it is impossible to track a given patient across time. We were unable to assess neither longer-term outcomes nor whether individual patients had multiple admissions. The retrospective nature of NIS also limits the available data and possible analyses. For example, although NIS provides some provider-level information, provider performance could not be reliably tracked due to various data collection policies; therefore the analysis is limited to hospital-level surgical volume. We further were unable to track whether pre-surgical referral patterns affected the type of center patients to which were likely to be admitted.²⁷ Several studies in adults have identified individual surgeon volume and proficiency as greater determinants of patient outcomes than center volume alone²⁸; similar data have also been reported among children.^{8, 29} Though the design of our study did not permit for tracking of individual provider performance vis-à-vis volume, we anecdotally would expect surgeons at high-volume centers to likely be more experienced than those at lower-volume centers as a function of case volume leading to increased proficiency.⁸

Our analysis adds to the growing body of literature supporting the existence and significance of a volume-outcome relationship for pediatric urology centers and is among the largest of its kind in terms of patient encounters and procedures analyzed. Further investigation with additional data sources should be conducted to validate the generalizability of these findings.

Ways to mitigate the observed difference in patient outcomes via volume-based policies and cooperation between high and non-high volume centers must also be studied to ensure safe and consistent patient care. Future investigations should also include exploration of the extent to which individual provider volume and center volume are correlated relative to the NSQIP outcomes measured in this study. Though our study did not find a statistically significant difference in admission costs between high and non-high volume centers, the economic impact of our findings remains an important area for future exploration.

CONCLUSION

Patients undergoing elective pediatric urologic procedures at non-high volume hospitals – those below the 90th percentile for case volume – were significantly more likely to experience NSQIP-identified postoperative complications including acute renal failure, urinary tract infections, respiratory complications, sepsis, bleeding, and in-hospital death than those at high volume hospitals irrespective of patient demographics and institutional structural characteristics.

KEY TO ABBREVIATIONS

NSQIP	National Surgical Quality Improvement Program
NIS	Nationwide Inpatient Sample
ICD-9-CM	International Classification of Diseases, Ninth Revision, Clinical Modification
SSI	surgical site infection
ARF	acute renal failure
CVA	cerebrovascular accident
MI	myocardial infarction
DVT	deep vein thrombus
LOS	length of stay
CI	confidence interval
OR	odds ratio

References

1. Birkmeyer JD, Siewers AE, Finlayson EV, et al. Hospital volume and surgical mortality in the United States. *N Engl J Med.* 2002; 346:1128. [PubMed: 11948273]
2. Luft HS, Bunker JP, Enthoven AC. Should operations be regionalized? The empirical relation between surgical volume and mortality. *N Engl J Med.* 1979; 301:1364. [PubMed: 503167]
3. Luft HS, Hunt SS, Maerki SC. The volume-outcome relationship: practice-makes-perfect or selective-referral patterns? *Health Serv Res.* 1987; 22:157. [PubMed: 3112042]
4. Luft HS. The relation between surgical volume and mortality: an exploration of causal factors and alternative models. *Med Care.* 1980; 18:940. [PubMed: 7432019]
5. Trinh QD, Bjartell A, Freedland SJ, et al. A systematic review of the volume-outcome relationship for radical prostatectomy. *Eur Urol.* 2013; 64:786. [PubMed: 23664423]

6. Hu JC, Gold KF, Pashos CL, et al. Role of surgeon volume in radical prostatectomy outcomes. *J Clin Oncol*. 2003; 21:401. [PubMed: 12560426]
7. Joudi FN, Konety BR. The impact of provider volume on outcomes from urological cancer therapy. *J Urol*. 2005; 174:432. [PubMed: 16006859]
8. Borenstein SH, To T, Wajja A, et al. Effect of subspecialty training and volume on outcome after pediatric inguinal hernia repair. *J Pediatr Surg*. 2005; 40:75. [PubMed: 15868562]
9. Hornik CP, He X, Jacobs JP, et al. Relative impact of surgeon and center volume on early mortality after the Norwood operation. *Ann Thorac Surg*. 2012; 93:1992. [PubMed: 22516833]
10. Pasquali SK, Li JS, Burstein DS, et al. Association of center volume with mortality and complications in pediatric heart surgery. *Pediatrics*. 2012; 129:e370. [PubMed: 22232310]
11. Cote GA, Imler TD, Xu H, et al. Lower provider volume is associated with higher failure rates for endoscopic retrograde cholangiopancreatography. *Med Care*. 2013; 51:1040. [PubMed: 24226304]
12. Elixhauser A, Steiner C, Harris DR, et al. Comorbidity measures for use with administrative data. *Med Care*. 1998; 36:8. [PubMed: 9431328]
13. HCUP Comorbidity Software. Healthcare Cost and Utilization Project (HCUP). 2014.
14. Khuri SF, Daley J, Henderson W, et al. The Department of Veterans Affairs' NSQIP: the first national, validated, outcome-based, risk-adjusted, and peer-controlled program for the measurement and enhancement of the quality of surgical care. National VA Surgical Quality Improvement Program. *Ann Surg*. 1998; 228:491. [PubMed: 9790339]
15. Reames BN, Ghaferi AA, Birkmeyer JD, et al. Hospital Volume and Operative Mortality in the Modern Era. *Ann Surg*. 2013
16. McAteer JP, LaRiviere CA, Drugas GT, et al. Influence of surgeon experience, hospital volume, and specialty designation on outcomes in pediatric surgery: a systematic review. *JAMA Pediatr*. 2013; 167:468. [PubMed: 23529612]
17. Halm EA, Lee C, Chassin MR. Is volume related to outcome in health care? A systematic review and methodologic critique of the literature. *Ann Intern Med*. 2002; 137:511. [PubMed: 12230353]
18. Vinocur JM, Menk JS, Connett J, et al. Surgical volume and center effects on early mortality after pediatric cardiac surgery: 25-year North American experience from a multi-institutional registry. *Pediatr Cardiol*. 2013; 34:1226. [PubMed: 23377381]
19. Ghaferi AA, Birkmeyer JD, Dimick JB. Complications, failure to rescue, and mortality with major inpatient surgery in medicare patients. *Ann Surg*. 2009; 250:1029. [PubMed: 19953723]
20. Wong SL, Revels SL, Yin H, et al. Variation in Hospital Mortality Rates With Inpatient Cancer Surgery. *Ann Surg*. 2014
21. Juillard C, Lashoher A, Sewell CA, et al. A national analysis of the relationship between hospital volume, academic center status, and surgical outcomes for abdominal hysterectomy done for leiomyoma. *J Am Coll Surg*. 2009; 208:599. [PubMed: 19476796]
22. Gutierrez JC, Koniaris LG, Cheung MC, et al. Cancer care in the pediatric surgical patient: a paradigm to abolish volume-outcome disparities in surgery. *Surgery*. 2009; 145:76. [PubMed: 19081478]
23. Kristensen PK, Thillemann TM, Johnsen SP. Is Bigger Always Better? A Nationwide Study of Hip Fracture Unit Volume, 30-Day Mortality, Quality of In-Hospital Care, and Length of Hospital Stay. *Med Care*. 2014
24. Salazar JH, Goldstein SD, Yang J, et al. Regionalization of the surgical care of children: a risk-adjusted comparison of hospital surgical outcomes by geographic areas. *Surgery*. 2014; 156:467. [PubMed: 24953271]
25. Lorch SA, Myers S, Carr B. The regionalization of pediatric health care. *Pediatrics*. 2010; 126:1182. [PubMed: 21041285]
26. Healthcare Cost and Utilization Project (HCUP). Rockville, MD: Agency for Healthcare Research and Quality; 2014. HCUP NIS Related Reports.
27. Nuttall M, van der Meulen J, Phillips N, et al. A systematic review and critique of the literature relating hospital or surgeon volume to health outcomes for 3 urological cancer procedures. *J Urol*. 2004; 172:2145. [PubMed: 15538220]

28. Birkmeyer JD, Stukel TA, Siewers AE, et al. Surgeon volume and operative mortality in the United States. *N Engl J Med*. 2003; 349:2117. [PubMed: 14645640]
29. Tracy ET, Bennett KM, Danko ME, et al. Low volume is associated with worse patient outcomes for pediatric liver transplant centers. *J Pediatr Surg*. 2010; 45:108. [PubMed: 20105589]

Appendix 1

Procedures	ICD-9 codes
Subgroup: bladder/reflux	
Ureter-reimplant	56.74
Ureter-ureteroureterostomy	56.75
Excision of bladder tic, partial cystectomy	57.6
Subgroup: kidney (reconstruction)	
Pyeloplasty	55.87, 55.86
Subgroup: kidney (removal)	
Nephrectomy	55.5
Partial/heminephrectomy	55.4
Subgroup: bladder/bowel reconstruction	
Exstrophy closure	57.86
Appendicovesicostomy	57.88
Enterocystoplasty	57.87
Vesicostomy	57.21
Sling	59.4–59.6
Subgroup:Lithotripsy	
PCNL	55.03, 55.04

Appendix 2

Complications	ICD-9 codes
SSI (superficial)	998.32
SSI (deep)	998.31
Peritoneal abscess	567.22
UTI	599
Urinary complications	997.5
ARF	584.x, 586.x
Resp complications	997.3
Pneumonia	481–487, 507
Post-Op resp. insufficiency	518.5
ARDS	518.82
Systemic Sepsis	790.7, 038.x
PE	415.1, 415.11, 415.19
Vent >96h	96.72

Complications	ICD-9 codes
CVA	997.02
Cardiac Complications	997.1
MI	410.x
Cardiac arrest	427.5
Bleeding	285.1, 998.11
DVT	453.4, 453.40, 453.9

Table 1

Patient and hospital characteristics by high volume or non-high volume surgical centers

Characteristics	Total n=158,804	High-Volume (n=114,634, %)	Non-High-Volume (n=44,171, %)	P-value
Age in years (mean, SD)	6.5 (0.1)	5.4 (0.1)	9.6 (0.2)	<0.001
Patient Age, By Category				
0–1 years	44,828	34,984 (30.5%)	9,843 (22.3%)	<0.001
1–3 years	24,029	19,536 (17.0%)	4,493 (10.2%)	
3–6 years	25,996	20,609 (18.0%)	5,388 (12.2%)	
6–12 years	34,619	26,592 (23.2%)	8,027 (18.2%)	
12–18 years	17,843	9,762 (8.5%)	8,081 (18.3%)	
18–21 years	11,490	3,151 (2.7%)	8,339 (18.9%)	
Gender				
Male	69,035	49,457 (43.1%)	19,578 (44.3%)	0.02
Female	86,369	63,490 (55.4%)	22,879 (51.8%)	
Race				
White	82,635	60,822 (53.1%)	21,813 (49.4%)	0.50
Black	7,409	5,175 (4.5%)	2,234 (5.1%)	
Others	29,664	22,376 (19.5%)	7,287 (16.5%)	
Insurance				
Public	46,587	34,784 (30.3%)	11,802 (26.7%)	0.01
Private	100,225	72,208 (63.0%)	28,018 (63.4%)	
Others	11,992	7,642 (6.7%)	4,351 (9.9%)	
Treatment year				
1998–2004	82,136	59,107 (51.6%)	23,028 (52.1%)	0.89
2005–2011	76,671	55,526 (48.4%)	21,143 (47.9%)	
Surgery type				
Reimplant	74,585	59,406 (51.8%)	15,179 (34.4%)	<0.001
Ureteroureterostomy	1,835	1,515 (1.3%)	320 (0.7%)	
Pyeloplasty	36,672	24,286 (21.2%)	12,386 (28.0%)	
Radical Nephrectomy	24,420	15,729 (13.7%)	8,691 (19.7%)	
Partial Nephrectomy	5,870	4,155 (3.6%)	1,715 (3.9%)	
Exstrophy closure	865	730 (0.6%)	134 (0.3%)	
Appendicovesicostomy	2,770	2,214 (1.9%)	556 (1.3%)	
Augment	6,818	5,561 (4.9%)	1,257 (2.8%)	
Vesicostomy	7,468	5,992 (5.2%)	1,476 (3.3%)	
Bladder Neck Sling	1,158	673 (0.6%)	485 (1.1%)	
PCNL	7,975	3,931 (3.4%)	4,044 (9.2%)	
Hospital region				
Northeast	33,493	24,984 (21.8%)	8,509 (19.3%)	

Characteristics	Total n=158,804	High-Volume (n=114,634, %)	Non-High-Volume (n=44,171, %)	P-value
Midwest	36,037	24,250 (21.2%)	11,788 (26.7%)	0.69
South	50,038	37,664 (32.9%)	12,374 (28.0%)	
West	39,236	27,737 (24.2%)	11,500 (26.0%)	
Teaching hospital				<0.001
Yes	138,516	107,242 (93.6%)	31,274 (70.8%)	
No	19,917	7,183 (6.3%)	12,734 (28.8%)	
Hospital Size				0.15
Small	24,335	19,828 (17.3%)	4,507 (10.2%)	
Medium	39,569	29,870 (26.1%)	9,699 (22.0%)	
Large	94,529	64,727 (56.5%)	29,802 (67.5%)	
ZIP Code Median Income				0.45
Q1	20,174	14,024 (12.2%)	6,151 (13.9%)	
Q2	23,998	17,218 (15.0%)	6,781 (15.4%)	
Q3	25,625	18,217 (15.9%)	7,408 (16.8%)	
Q4	27,242	20,077 (17.5%)	7,165 (16.2%)	

Table 2

Post-operative complications and outcomes in patients treated in high volume and non-high volume surgical centers

NSQIP complications	Total n=158,804	High-volume center n=114,634 (%)	Non-high-volume center n=44,171 (%)	p value
ARF	1553	1,038 (0.9%)	520 (1.2%)	0.06
UTI	8136	5,761 (5.0%)	2,375 (5.4%)	0.43
Urinary Complications	2107	1,591 (1.4%)	516 (1.2%)	0.23
Respiratory Complications	1382	861 (0.8%)	521 (1.2%)	0.003
Pneumonia	606	378 (0.3%)	228 (0.5%)	0.02
Post-op Respiratory Insufficiency	487	348 (0.3%)	139 (0.3%)	0.88
Systemic Sepsis	697	347 (0.3%)	350 (0.8%)	<0.001
Cardiac Complications	232	134 (0.1%)	98 (0.2%)	0.03
Bleeding	1117	569 (0.5%)	548 (1.2%)	<0.001
In-Hospital Death	478	246 (0.2%)	236 (0.5%)	0.01

Table 3

Multivariate analysis of the association of hospital surgical volume and post-operative complications

NSQIP complications	unadjusted OR (95%CI)	adjusted OR* (95%CI)	p value*
ARF	1.30 (0.99–1.73)	1.38 (1.02–1.87)	0.04
UTI	1.08 (0.90–1.29)	1.32 (1.07–1.63)	0.01
Urinary Complications	0.84 (0.64–1.11)	0.97 (0.73–1.29)	0.84
Respiratory Complications	1.58 (1.15–2.16)	1.46 (1.08–1.98)	0.01
Pneumonia	1.59 (1.09–2.33)	1.33 (0.89–1.99)	0.17
Post-op Respiratory Insufficiency	1.04 (0.63–1.71)	1.24 (0.77–2.00)	0.39
Systemic Sepsis	2.64 (1.86–3.76)	2.01 (1.40–2.90)	<0.001
Cardiac Complications	1.89 (1.05–3.42)	1.65 (0.91–2.99)	0.10
Bleeding	2.55 (1.91–3.41)	2.13 (1.56–2.89)	<0.001
In-Hospital Death	2.50 (1.24–5.04)	2.22 (1.24–3.98)	0.007

Table 4

In-hospital mortality by surgery type

Surgery type	total cases	total death	%	High volume center n=114,634	%*	Non-high volume center n=44,171	%*
reimplant	74585	0	-	-	-	-	-
UU	1835	0	-	-	-	-	-
pyeloplasty	36672	0	-	-	-	-	-
RN	24420	386	1.6	197	0.17	188	0.43
PN	5870	0	-	-	-	-	-
exstrophy closure	865	15	1.7	5	0.01	10	0.02
appendicovesicostomy	2770	0	-	-	-	-	-
augment	6818	5	0.1	0	0	5	0.01
vesicostomy	7468	23	0.3	19	0.02	5	0.01
sling	1158	0	-	-	-	-	-
PCNL	7975	54	0.7	26	0.02	28	0.06