Published in final edited form as:

J Pediatr Urol. 2016 December ; 12(6): 388.e1–388.e7. doi:10.1016/j.jpuro.2016.05.034.

Increased pediatric sub-specialization is associated with decreased surgical complication rates for inpatient pediatric urology procedures

R. Tejwani^a, H-H. S. Wang^a, B. J. Young^a, N. H. Greene^b, S. Wolf^c, J. S. Wiener^a, and J. C. Routh^{a,*}

^aDivision of Urologic Surgery, Duke University Medical Center, Durham, NC, USA

^bDivision of Pediatric Anesthesia, Duke University Medical Center, Durham, NC, USA

^cDepartment of Biostatistics and Bioinformatics, Duke University Medical Center, Durham, NC, USA

Summary

Introduction—Increased case volumes and training are associated with better surgical outcomes. However, the impact of pediatric urology sub-specialization on perioperative complication rates is unknown.

Objectives—To determine the presence and magnitude of difference in rates of common postoperative complications for elective pediatric urology procedures between specialization levels of urologic surgeons. The Nationwide Inpatient Sample (NIS), a nationally representative administrative database, was used.

Study Design—The NIS (1998–2009) was retrospectively reviewed for pediatric (< 18 years) admissions, using ICD-9-CM codes to identify urologic surgeries and National Surgical Quality Improvement Program (NSQIP) inpatient postoperative complications. Degree of pediatric sub-specialization was calculated using a Pediatric Proportion Index (PPI), defined as the ratio of children to total patients operated on by each provider. The providers were grouped into PPI quartiles: Q1, 0–25% specialization; Q2, 25–50%; Q3, 50–75%; Q4, 75–100%. Weighted multivariate analysis was performed to test for associations between PPI and surgical complications.

Results—A total of 71,479 weighted inpatient admissions were identified. Patient age decreased with increasing specialization: Q1, 7.9 vs Q2, 4.8 vs Q3, 4.8 vs Q4, 4.6 years, $P<0.01$). Specialization was not associated with race ($P>0.20$), gender ($P>0.50$), or comorbidity scores ($P=0.10$). Mortality (1.5% vs 0.2% vs 0.3% vs 0.4%, $P<0.01$) and complication rates (15.5% vs

* **Corresponding author:** Division of Urologic Surgery, Duke University Medical Center, DUMC 3831, Durham, NC 27710, USA. Tel.: (919) 684-6994; fax: (919) 681-5507. jonathan.routh@duke.edu (J. C. Routh, MD, MPH).

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Ethical Approval: This protocol was reviewed by the Institutional Review Board and deemed to be exempt.

11.7% vs 9.6% vs 10.9%, $P<0.0001$) both decreased with increasing specialization. Patients treated by more highly specialized surgeons incurred slightly higher costs (Q2, +4%; Q3, +1%; Q4 + 2%) but experienced shorter length of hospital stay (Q2, -5%; Q3, -10%; Q4, -3%) compared with the least specialized providers. A greater proportion of patients treated by Q1 and Q3 specialized urologists had CCS 2 than those seen by Q2 or Q4 urologists (12.5% and 12.2%, respectively vs 8.4% and 10.9%, respectively, $P=0.04$). Adjusting for confounding effects, increased pediatric specialization was associated with decreased postoperative complications: Q2 OR 0.78, CI 0.58–1.05; Q3 OR 0.60, CI 0.44–0.84; Q4 OR 0.70, CI 0.58–0.84; $P<0.01$.

Discussion—Providers with proportionally higher volumes of pediatric patients achieved better postoperative outcomes than their less sub-specialized counterparts. This may have arisen from increased exposure to pediatric anatomy and physiology, and greater familiarity with pediatric techniques.

Limitation—The NIS admission-based retrospective design did not enable assessment of long-term outcomes, repeated admissions, or to track a particular patient across time. The study was similarly limited in evaluating the effect of pre-surgical referral patterns on patient distributions.

Conclusions—Increased pediatric sub-specialization among urologists was associated with a decreased risk of mortality and surgical complications in children undergoing inpatient urologic procedures.

Keywords

Urology; Postoperative complications; Pediatric; Specialization

Introduction

In recent years, professional bodies and policy makers have shown interest in identifying physician and hospital attributes associated with improved patient outcomes. Previous studies have found that increased case volumes, high center operative volumes, and resident training for pediatric surgery are associated with a decreased likelihood of postoperative mortality across several surgical subspecialties [1–7]. Explanations for these relationships vary, but are believed to stem from greater familiarity with pediatric anatomy, physiology, and surgical techniques better suited for children [8–10]. There may also be effects of the pediatric anesthesiology sub-specialization, which are likely heavily correlated with the surgical sub-specialization [11–13]. However, these studies remain limited; within urology, little is known about the impact of the pediatric sub-specialization on the likelihood of postoperative complications.

Understanding the degree to which the pediatric sub-specialization affects patient outcomes is particularly salient to urology, given the variability in training, practice environment, and case-mix amongst urologists operating on children. Despite growth in the number of pediatric urology fellowship programs, the nationwide number of urologists with certificates in the added qualification of pediatric urology remains relatively small [14]. A significant number of pediatric urologic surgeries are currently performed by general urologists. Rhee et al. previously demonstrated that a surgeon's degree of sub-specialization might be represented using a provider's Pediatric Proportion Index (PPI) (i.e. the relative proportion

of pediatric versus total surgeries by a given surgeon) [1]. However, they did not find a mortality difference among high-volume and low-volume urologists. It is suspected that this null outcome was at least in part due to the fact that very few pediatric urologic surgeries were associated with a high mortality rate. However, complications do occur in pediatric urologic surgeries, and it was hypothesized that complications might differ depending on each urologist's degree of pediatric specialization.

The present study sought to determine the presence of well-defined postoperative complications for elective pediatric urology procedures between pediatric urologic surgeons across a range of pediatric sub-specializations using the Nationwide Inpatient Sample (NIS), which is a contemporary, nationally representative administrative database.

Methods

Data source

The 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). The NIS is derived from a 20% stratified probability sample of hospitals in the USA, 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. The NIS includes post-stratification discharge weights that may be used to calculate national estimates [15]. This data set also includes individual surgeon identifiers, allowing for provider-specific analyses.

Selection of patients

All inpatient hospital encounters occurring between 1998–2009 for pediatric patients (<18 years old) were identified with an International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) diagnosis code for elective, inpatient pediatric urologic procedures, including: ureteral reimplantation, 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 codes). Patients were excluded if they did not have an identified urologist or if their urologist did not qualify to receive a PPI.

Calculation of Pediatric Proportion Index

The PPI was calculated, on an annual basis for each surgeon, as the ratio of children to all patients operated on in a given year, in order to account for year-to-year case-mix changes and variation in patient population and training during the period surveyed [1]. A urologist must have performed at least 21 surgeries in a given year to receive a PPI. Urologists were classified into four categories of specialization, as determined by quartiles: Q1, 0–25% specialization; Q2, 25–50%; Q3, 50–75%; Q4, 75–100%.

Outcome selection

The primary outcome was immediate postoperative complications during the operative admission; these were identified by the ICD-9-CM code (Appendix 2) that most closely

corresponded to the complications described by the National Surgical Quality Improvement Program (NSQIP) [16]. Included were: superficial or deep surgical site infection (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, myocardial infarction (MI), cardiac arrest, bleeding, and deep vein thrombosis (DVT). The probability of at least one complication occurring postoperatively was modeled. Also examined were: in-hospital mortality, cost, and length of stay (LOS) for each admission; however, due to the inpatient nature of the database used, any complications occurring after discharge (including death) would not be captured by this analysis. The NIS cost-to-charge files were used to convert hospital charges to costs. Due to a lack of conversion file availability, cost analyses were only analyzed from 2001 onward. Rare complications (n = 15) were not reported, as per AHRQ requirements in order to preserve anonymity.

Statistical analysis

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, number of comorbidities present for each patient, procedure performed, and the hospital at which the surgery was performed. Hospital level characteristics regarding center location (urban vs rural) and academic status (teaching vs non-teaching) were also extracted.

Descriptive statistics were calculated to compare the different levels of pediatric specialization. Wald Chi-squared and ANOVA were used where appropriate. Chi-squared was used when a Wald Chi-Squared was not computable, which occurred if a value for a categorical variable did not occur in a subgroup (i.e. 0–25% PPI). All analyses were weighted using NIS-specific estimated weights and covariance matrices. Additionally performed were: a generalized estimating equation adjusting for hospital ID, age, gender, Charlson Comorbidity Scores (CCS), and procedure to test for an association between the principal predictor of interest – PPI (by quartile) – and NSQIP-identified postoperative complications. Race was excluded from the model due to the frequency with which this variable was missing from the dataset. Patients within the same hospital tended to have somewhat similar outcomes, which induced a correlation structure within the data. GEE is a robust method of analysis unaffected by mis-specification of correlation structure.

As secondary analyses, LOS and total costs were modeled as outcomes, adjusting for the same set of variables, and a generalized linear mixed model with log transformation and hospitals were fitted as the random effect. To estimate cost, cost-to-charge data from HCUP were used. For model diagnostics, the residuals were checked against both the linear predictors and quartiles, with models showing a good fit for both conditional and marginal residuals. As a sensitivity analysis the models were adjusted by race, while including ‘missing’ as a category. A two-sided alpha of 0.05 was used as criteria for statistical significance. All analyses were performed using SAS 9.4 (SAS Institute, Cary, NC).

Results

Demographics

A total of 71,479 weighted inpatient surgical admissions and 2168 urologists were identified (Table 1). Admissions were predominantly female (55.2%) and white (59%). Admissions to Q2, Q3, and Q4 urologists were younger than to Q1 urologists: Q1, 7.9; Q2, 4.8; Q3, 4.8; Q4, 4.6 years; $P<0.01$. No significant variations in gender ($P=0.07$) or race ($P=0.24$) were observed. More specialized urologists did not treat a significantly higher proportion of admissions with CCS 1: Q1, 16.9%; Q2, 12.2%; Q3, 15.7%; Q4, 13.9%; $P=0.1$. Urologists with a PPI of 0–25% and 50–75% had a greater proportion of admissions with CCS 2 than Q2 or Q4 urologists: Q1, 12.5%; Q2, 8.4%; Q3, 12.2%; Q4, 10.9%; $P=0.04$.

Cost analysis

When compared with those treated by least specialized urologists, surgical admissions by more specialized urologists incurred marginally higher costs: Q2, +4%, $P<0.01$; Q3, +1%, $P=0.05$; Q4, +2%, $P<0.01$).

Length of stay

Admissions by a Q4 (most specialized) urologist had a 3% shorter LOS than those treated by a Q1 (least specialized) urologist ($P=0.05$). Admissions by Q2 and Q3 urologists had 5% and 10% shorter LOS than those treated by Q1 urologists ($P<0.01$).

Postoperative complications

Increased specialization was associated with decreased mortality: Q1, 1.5%; Q2, 0.2%; Q3, 0.3%; Q4, 0.4%; $P<0.01$). Likewise, increased specialization was associated with decreased complication rates (Table 2): Q1, 15.5%; Q2, 11.7%; Q3, 9.6%; Q4, 10.9%; $P<0.0001$). A greater proportion of admissions treated by the least-specialized urologists developed acute renal failure (Q1, 2.5% vs Q2, 1.5% vs Q4, 1% vs Q4, 1.4%, $P=0.03$), non-specified respiratory complications (2.3% vs 1.6% vs 1.1% vs 1.2%, $P=0.006$), postoperative respiratory insufficiency (0.9% vs 0.4% vs 0.3% vs 0.5%, $P=0.007$), acute respiratory failure (0.8% vs 0.3% vs 0.3%, $P=0.02$), systemic sepsis (1.4% vs 0.9% vs 0.6% vs 0.8%, $P=0.05$), cardiac arrest (Q1, 0.3%; Q4, 0.1%; $P<0.05$), bleeding (2.6% vs 0.8% vs 0.6% vs 1%, $P<0.0001$), non-specified renal complications (4.5% vs 1.5% vs 1.3% vs 1.1%, $P<0.001$), and non-specified ureteral complications (2.1% vs 0.3% vs 0.4% vs 0.4%, $P<0.001$) than those treated by more specialized urologists. After adjusting for other confounders (Table 3), increased sub-specialization was associated with a decreased probability of an admission developing a postoperative complication: Q2, OR 0.78, CI 0.58–1.05, $P=0.1$; Q3, OR 0.60, CI 0.44–0.84, $P<0.01$; Q4, OR 0.70, CI 0.58–0.84, $P<0.01$.

Discussion

Although the association between pediatric sub-specialization and mortality has been previously established, the association between sub-specialization and postoperative complications has not yet been investigated [1]. The present study sought to determine

whether increased pediatric urologic sub-specialization – as defined by PPI quartiles – was associated with a decreased incidence of NSQIP-defined postoperative complications.

In a nationwide analysis, increased pediatric specialization was associated with a decreased risk of postoperative complications amongst children undergoing elective urologic procedures. After adjusting for age, gender, comorbidity score, and hospital-level clustering, children operated on by highly specialized urologists had a 30–32% reduction in their odds of developing in-hospital, postoperative complications relative to least specialized urologists. In particular, a greater proportion of patients treated by the least specialized urologists experienced in-hospital mortality, renal and ureteral complications, renal failure, sepsis, respiratory complications, postoperative bleeding, and respiratory insufficiency than those treated by urologists with greater pediatric specialization.

These findings are consistent with previous studies of other specialties [2,8,17–19]. Echoing the present findings, sub-specialist treatment was associated with better or comparable length of stay and costs, and lower postoperative complication and mortality rates, despite such surgeons often operating on younger and sicker patients. Higher operative success, better patient management, and decreased morbidity were also noted in children treated by specialized surgeons [7,20–22].

Although the findings of the present study support the notion that surgeons operating on a greater proportion of children have better outcomes relative to those who primarily operate on adults, the analysis does not provide insight into the underlying cause of this phenomenon. Numerous previous studies have demonstrated close relationships between surgeon and center operative volumes and improved patient outcomes. Explanations for the pediatric volume-outcome relationship are believed to stem from the unique anatomical and physiological variances in children, and greater provider familiarity with child-specific pathologies and surgical techniques [2,6,23–26]. Given the incentives for such providers to participate in pediatric-specific research and continuing medical education, sub-specialists may also be more likely to use newer technologies and surgical approaches. Importantly, the analysis only focused on providers with high *relative* volumes of pediatric patients; it did not assess whether *absolute* volumes at various thresholds had an impact on pediatric complication rates.

The present findings lend support to the notion that formal pediatric sub-specialization via fellowship training and board certification of added qualification in pediatric urology may lead to improved patient outcomes. The American Board of Urology mandates that a candidate for sub-specialty certification in pediatric urology must maintain a practice that is 75% devoted to pediatric urology. However, there may be urologists who treat a relatively large proportion of children in their practice, despite not having completed a pediatric fellowship.

Contrary to expectations, there was no significant trend in co-morbidity scores by specialization. Anecdotally, such patients would seem more likely to be referred to highly specialized pediatric urologists for management of their urologic conditions. There are several potential reasons for this discrepancy. First, highly specialized urologists may be

operating on older and healthier children at ambulatory surgical centers rather than as inpatients; because NIS is drawn exclusively from inpatient admissions, these surgeries would not have been captured in the analysis. Similarly, given the concentration of pediatric urologists at urban and academic medical centers, it is possible that referrals to highly specialized pediatric urologists may be impractical, and occur with less frequency than might otherwise be expected. Alternatively, children seen by highly specialized urologists might often be younger than those seen by less sub-specialized providers, possibly reflective of a greater number of neonatal and early childhood admissions; thus, those patients may simply not yet have manifested other ailments. Further investigation of provider referral patterns and age distributions of common comorbidities in pediatric urologic patients might help to explain this observation.

The findings of the present study must be interpreted in the context of its limitations. The NIS represents a 20% stratified sample of hospital admissions in the USA; as such, the reported results may not be generalizable to all encounters in the USA. However, the NIS provides meticulous tracking of discharge and hospital weights in order to minimize the risk of sampling bias. Additionally, the NIS is a large, retrospective, administrative database that might be affected by miscoding bias. The present analysis was sensitive to the accuracy of diagnostic and procedure coding in the NIS. While the accuracy level of the NIS is high for an administrative database, it is possible that at least some portion of the present cohort may have been incorrectly coded. Furthermore, the NSQIP complications that were identified may have represented associated co-morbidities, and not true postoperative complications, as the NIS does not provide temporal relationships between different diagnosis codes. Despite these limitations, the NIS database is rigorously monitored and audited for coding accuracy and represents a reasonably reliable panorama of the characteristics of an inpatient surgical cohort. It is also difficult to distinguish between the specific contributions that a pediatric subspecialist surgeon may have from that of a pediatric subspecialist anesthesiologist. For example, respiratory complications were significantly higher among less specialized pediatric urologic surgeons, which may be because they would be more likely to work with an anesthesiologist unfamiliar with pediatric-specific perioperative issues. The improved outcome may also be because the surgeon would take a longer amount of time to perform the same procedure, which could put the child at a higher risk of a perioperative respiratory complication.

Because the NIS represents admission-based rather than patient-based data, it is impossible to track a given patient across time. For the present study neither long-term outcomes nor repeated admissions could be accessed. Further, although the NIS provides some provider-level information, the analysis is limited to hospital-level surgical volume. The present study was therefore unable to track whether pre-surgical referral patterns affected the type of center to which patients were likely to be admitted [27]. Several adult studies have identified surgeon volume and proficiency as greater determinants of patient outcomes than center volume alone [5]; similar data have also been reported among children [28, 29]. Although the design of the present study did not permit for tracking of individual provider performance vis-à-vis volume, it would be expected that surgeons at high-volume centers be more experienced than those at low-volume centers, as a function of case volume leading to increased proficiency [28].

Conclusions

Children undergoing elective pediatric urologic procedures were less likely to experience NSQIP-defined postoperative complications when treated by more specialized pediatric urologists.

Acknowledgments

Conflicts of Interest/Financial disclosures: Dr. Routh was supported by grant number K08-DK100534 from the National Institute of Diabetes and Digestive and Kidney Diseases. The funding sources had no role in the collection, analysis or interpretation of data, in the writing of the manuscript, or in the decision to submit the manuscript for publication.

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Appendix 1

Elective urologic procedure codes for study inclusion.

Procedure	ICD9 Code
Ureteral reimplant	56.74, 59.3
Ureteroureterostomy	56.75
Pyeloplasty	55.86, 55.87
Radical nephrectomy	55.5

Procedure	ICD9 Code
Partial nephrectomy	55.4
Bladder exstrophy repair	57.86
Appendicovesicostomy	57.88
Bladder augmentation	57.87
Vesicostomy	57.21
Bladder neck sling	59.4, 59.5, 59.6
PCNL	55.03, 55.04

Appendix 2

NSQIP-defined postoperative complication ICD-9-CM codes

Procedure	ICD9 Code
SSI	998.32, 998.31, 567.22
Acute renal failure	584, 586
UTI	599.0
Urinary complications	997.5
Respiratory complications	997.3, 518.4, 518.81, 518.82, 514,
Pneumonia	481, 482, 483, 484, 485, 486, 487, 507
Postop. resp. insufficiency	518.5
ARDS	518.82
Acute resp. failure	518.81
Systemic sepsis	790.7, 038
Pulmonary embolus	415.1, 415.11, 415.19
CVA	997.02
Cardiac complications	997.1
MI	410
Cardiac arrhythmia	427.5
Bleeding	285.1, 998.11
DVT	453.4, 453.40, 453.9

Summary Table

Multivariate analysis of the association of postoperative outcomes and Pediatric Proportion Index.

Outcomes	Unadjusted Odds Ratio (95% CI)	P-value	Adjusted Odds Ratio (95% CI) [^]	P-value
Postoperative complications				
0–25% PPI	Reference		Reference	
25–50% PPI	0.72 (0.61, 0.85)	<0.001	0.78 (0.57, 1.06)	0.11
50–75% PPI	0.59 (0.48, 0.72)	<0.001	0.60 (0.43, 0.83)	<0.001
>75% PPI	0.68 (0.60, 0.76)	<0.001	0.68 (0.56, 0.82)	<0.001
Costs				
0–25% PPI	Reference		Reference	
25–50% PPI	0.99 (0.97, 1.01)	0.20	1.04 (1.03, 1.04)	<0.001
50–75% PPI	1.12 (1.09, 1.14)	<0.001	1.01 (1.00, 1.01)	0.07
>75% PPI	0.98 (0.97, 1.00)	0.02	1.02 (1.01, 1.03)	<0.001
LOS				
0–25% PPI	Reference		Reference	
25–50% PPI	0.83 (0.80, 0.86)	<0.001	0.95 (0.92, 0.99)	<0.001
50–75% PPI	0.84 (0.81, 0.88)	<0.001	0.90 (0.87, 0.94)	<0.001
>75% PPI	0.93 (0.90, 0.95)	<0.001	0.97 (0.94, 1.00)	0.053

[^] Adjusted for age, gender, race, comorbidity score, procedure and hospital clustering

PPI, Pediatric Proportion Index

Table 1

Patient and hospital characteristics by degree of urologist pediatric specialization.

	0-25% (n=14,506)	>25-50% (n=9841)	>50-75% (n=7143)	>75% (n=39,989)	Total (n=71,479)	P-value
Age (Mean (STD))	7.9 (0.2)	4.8 (0.1)	4.8(0.2)	4.6 (0.1)	5.3 (0.1)	<0.01 ¹
Race, n (%)						
White	7603 (52.4%)	5798 (58.9%)	4196 (58.7%)	24,603 (61.5%)	42,200 (59%)	0.24 ¹
Black	1164 (8%)	498 (5.1%)	431 (6%)	3225 (8.1%)	5315 (7.4%)	
Hispanic	1635 (11.3%)	1265 (12.8%)	720 (10.1%)	5787 (14.5%)	9405 (13.2%)	
Asian or Pacific Islander	143 (1%)	97 (1%)	101 (1.4%)	519 (1.3%)	860 (1.2%)	
Native American	30 (0.2%)	*	*	125 (0.3%)	185 (0.3%)	
Other	409 (2.8%)	316 (3.2%)	386 (5.4%)	1485 (3.7%)	2595 (3.6%)	0.07 ¹
Missing	3526 (24.3%)	1856 (18.9%)	1297 (18.2%)	4249 (10.6%)	10,925 (15.3%)	
Gender, n (%)						
Female	7575 (52.2%)	5625 (57.2%)	3832 (53.7%)	22,449 (56.2%)	39,480 (55.2%)	0.10 ¹
Male	6927 (47.8%)	4217 (42.8%)	3307 (46.3%)	17,531 (43.8%)	31,980 (44.8%)	
Patients with 1 Comorbidity Score, n (%)	2459 (16.9%)	1205 (12.2%)	1121 (15.7%)	5556 (13.9%)	10,340 (14.5%)	0.04 ¹
	12,049 (83.1%)	8636 (87.8%)	6023 (84.3%)	34,435 (86.1%)	61,140 (85.5%)	
Comorbidity Score, n (%)						
0	12,049 (83.1%)	8636 (87.8%)	6023 (84.3%)	34,435 (86.1%)	61,140 (85.5%)	0.04 ¹
1	645 (4.4%)	378 (3.8%)	253 (3.5%)	1198 (3%)	2470 (3.5%)	
2	1470 (10.1%)	653 (6.6%)	656 (9.2%)	3276 (8.2%)	6055 (8.5%)	
>3	344 (2.4%)	175 (1.8%)	214 (3%)	1083 (2.7%)	1815 (2.5%)	

Table 2

Postoperative complications and outcomes in patients by degree of urologist pediatric specialization.

	0-25% (n=14,506)	>25-50% (n=9841)	>50-75% (n=7143)	>75% (n=39,989)	Total (n=71,479)	P-value
In-hospital mortality, n (%)						
Dead	221 (1.5%)	24 (0.2%)	24 (0.3%)	160 (0.4%)	425 (0.6%)	<0.001
Alive	14,286 (98.5%)	9818 (99.8%)	7120 (99.7%)	39,831 (99.6%)	71,055 (99.4%)	
1 inpatient complication, n (%)						
Yes	2254 (15.5%)	1150 (11.7%)	686 (9.6%)	4351 (10.9%)	8440 (11.8%)	<0.001
No	12,253 (84.5%)	8692 (88.3%)	6458 (90.4%)	35,639 (89.1%)	63,040 (88.2%)	
Number of complications, n (%)						
0	12,253 (84.5%)	8692 (88.3%)	6458 (90.4%)	35,639 (89.1%)	63,040 (88.2%)	<0.001
1	1734 (12%)	901 (9.2%)	578 (8.1%)	3605 (9%)	6815 (9.5%)	
2	357 (2.5%)	172 (1.7%)	85 (1.2%)	511 (1.3%)	1125 (1.6%)	
3	78 (0.5%)	49 (0.5%)	20 (0.3%)	141 (0.4%)	285 (0.4%)	
4	65 (0.4%)	*	*	60 (0.1%)	140 (0.2%)	
5	22 (0.1%)	16 (0.2%)	*	36 (0.1%)	70 (0.1%)	
Postoperative complication by diagnosis, n (%)						
SSI	29 (0.2%)	20 (0.2%)	*	43 (0.1%)	105 (0.1%)	0.61
Peritoneal abscess	*	*	*	24 (0.1%)	40 (0.1%)	0.81
Acute renal failure	359 (2.5%)	152 (1.5%)	72 (1%)	554 (1.4%)	1135 (1.6%)	0.03
UTTI NOS	984 (6.8%)	620 (6.3%)	351 (4.9%)	2337 (5.8%)	4290 (6%)	0.36
Urinary complications	281 (1.9%)	190 (1.9%)	132 (1.8%)	651 (1.6%)	1250 (1.8%)	0.79
Respiratory complications	333 (2.3%)	155 (1.6%)	77 (1.1%)	466 (1.2%)	1030 (1.4%)	0.006
Pneumonia	108 (0.7%)	56 (0.6%)	25 (0.3%)	204 (0.5%)	390 (0.5%)	0.35
ARDS	19 (0.1%)	*	*	23 (0.1%)	60 (0.1%)	0.53

	0-25% (n=14,506)	>25-50% (n=9841)	>50-75% (n=7143)	>75% (n=39,989)	Total (n=71,479)	P-value
Acute respiratory failure	121 (0.8%)	29 (0.3%)	*	132 (0.3%)	290 (0.4%)	0.02
Postoperative respiratory insufficiency	134 (0.9%)	44 (0.4%)	24 (0.3%)	194 (0.5%)	395 (0.6%)	0.007
Systemic sepsis	205 (1.4%)	90 (0.9%)	41 (0.6%)	315 (0.8%)	650 (0.9%)	0.05
Cardiac complication	21 (0.1%)	31 (0.3%)	23 (0.3%)	56 (0.1%)	130 (0.2%)	0.31
Cardiac arrest	49 (0.3%)	*	*	37 (0.1%)	100 (0.1%)	0.05
Bleeding	379 (2.6%)	83 (0.8%)	43 (0.6%)	403 (1%)	905 (1.3%)	<0.001
Renal complications	657 (4.5%)	144 (1.5%)	93 (1.3%)	457 (1.1%)	1350 (1.9%)	<0.001
Ureter complications	298 (2.1%)	34 (0.3%)	26 (0.4%)	150 (0.4%)	505 (0.7%)	<0.001

* Cells with 15 patients excluded per AHRQ reporting guidelines

Table 3

Multivariable analysis of the association of Pediatric Proportion Index and complications, costs, and length of stay.

Outcomes	Unadjusted Odds Ratio (95%CI)	P-value	Adjusted Odds Ratio (95%CI) [^]	P-value
Complications post surgery (Y/N)				
0–25% PPI	Reference		Reference	
25–50% PPI	0.72 (0.61, 0.85)	<0.001	0.78 (0.57, 1.06)	0.11
50–75% PPI	0.59 (0.48, 0.72)	<0.001	0.60 (0.43, 0.83)	<0.001
>75% PPI	0.68 (0.60, 0.76)	<0.001	0.68 (0.56, 0.82)	<0.001
Costs				
0–25% PPI	Reference		Reference	
25–50% PPI	0.99 (0.97, 1.01)	0.20	1.04 (1.03, 1.04)	<0.001
50–75% PPI	1.12 (1.09, 1.14)	<0.001	1.01 (1.00, 1.01)	0.07
>75% PPI	0.98 (0.97, 1.00)	0.02	1.02 (1.01, 1.03)	<0.001
Length of stay				
0–25% PPI	Reference		Reference	
25–50% PPI	0.83 (0.80, 0.86)	<0.001	0.95 (0.92, 0.99)	<0.001
50–75% PPI	0.84 (0.81, 0.88)	<0.001	0.90 (0.87, 0.94)	<0.001
>75% PPI	0.93 (0.90, 0.95)	<0.001	0.97 (0.94, 1.00)	0.053

[^] Adjusted for age, gender, race, comorbidity score, procedure and hospital clustering

PPI, Pediatric Proportion Index