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ORIGINAL ARTICLE

The recent evolution of the breadth of practice for pediatric surgeons in the United States, 2005–2014

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Abstract

Purpose Our objective was to determine if there was an association between subspecialist supply and a specific sub-set of procedures performed by pediatric surgeons over a 10-year period.

Methods Data source was the Pediatric Health Information Systems database. Included were patients < 12 years who underwent one of nine outpatient surgical procedures between 1/1/2005 and 12/31/2014. Procedures were grouped into categories: pediatric surgery cases (PS), overlapping otolaryngology cases (OO), and overlapping urology cases (OU). Outcomes were number of cases performed by pediatric surgeons per pediatric surgeon, and proportion of cases performed by pediatric surgeons. Linear regression was used to test for association and temporal trends.

Results Included were 193,695 procedures, 18.9% PS, 4.8% OO, and 76.3% OU. There was a strong association between specialty supply and number of cases performed by pediatric surgeons. Temporally, there was no change in proportion of pediatric surgeons who performed PS cases ($R^2 = 0.08$, $p = 0.08$), but a downward trend in proportion of OO ($R^2 = 0.82$, $p < 0.001$) and OU cases. ($R^2 = 0.79$; $p < 0.001$.)

Conclusion We found an association between physician supply and pediatric surgeon case type, and a reduction in OO and OU cases performed by pediatric surgeons. These findings suggest a narrowing of case-mix for pediatric surgeons.

Keywords Pediatric surgery · Pediatric urology · Pediatric otolaryngology · Workforce

Introduction

Within the field of surgery, pediatric surgery evolved into a subspecialty as the treatment of congenital anomalies, childhood injuries and acquired pediatric surgical diseases developed. The origin of pediatric surgery dates back to 1937 when the first training program emerged at Children's Hospital Boston [1], and slowly expanded until the American Board of Surgery approved pediatric surgery as a subspecialty in 1973 [2–4]. Unlike other surgical subspecialties where the scope of practice narrows with fellowship training, in pediatric surgery training, the age range of patients narrows to the first two decades of life and expands to include multi-systemic pediatric conditions involving the neck, chest, abdomen, pelvis, and connective tissues [5].

The surgical workforce has changed dramatically over the last 25 years, and workforce researchers have differing opinions about whether there is currently a glut or a dearth of pediatric surgeons in the United States [1, 4, 6–9]. The pediatric surgical workforce was estimated to be 1150 surgeons in 2009, and a survey of American Pediatric Surgical Association members suggested 280 additional pediatric surgeons were needed to fulfill workforce demands in the United States [10]. From 1960 to 2010, the number of American pediatric surgery training programs multiplied over fivefold, resulting in the number of board-certified pediatric surgeons increasing from less than 225 to 1130 despite minimal change in the United States' birth rate from 1970 to 2015 [4, 11]. Concomitantly, there has also been an increase

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in the number of pediatric urology and pediatric otolaryngology fellowship training programs [4, 12]. The Accreditation Council for Graduate Medical Education (ACGME) reports that, between the 2007/2008 and 2013/2014 academic years, the number of pediatric otolaryngology programs saw a dramatic increase of 133% (from 9 to 21), while both pediatric surgery and pediatric urology residency programs increased 29% and 27% (from 35 to 45, and 22 to 28), respectively [13]. The overlapping scope of practice between pediatric surgeons and other pediatric subspecialists is not well understood.

We hypothesized that the increasing supply of pediatric otolaryngologists and pediatric urologists may be impacting the number of overlapping head and neck, and urology procedures being performed by pediatric surgeons in the United States. The purpose of this study was to determine if there was an association between change in supply of specialty surgeons and change in the proportion of a specific subset of procedures performed by pediatric surgeons over a 10-year study period and if there was a relationship, to report the proportional change among pediatric surgeons.

Materials and methods

Data for this study were obtained from the Pediatric Health Information System (PHIS), an administrative database containing billing data from 49 not-for-profit, tertiary care pediatric hospitals in the United States. Data from all inpatient, emergency department, and ambulatory surgery admissions, including admissions to satellite locations, are captured in the database. These hospitals are affiliated with the Children's Hospital Association. Data quality and reliability are assured through a joint effort between the Association and participating hospitals, while the data warehouse function for the database is managed by Truven Health Analytics. Data are de-identified, but linked at the time of data submission and are subjected to reliability and validity checks before inclusion in the database. This study was approved by the Institutional Review Board at Connecticut Children's Medical Center.

Our target population was children aged from birth to 12 years undergoing one of nine outpatient procedures between January 1, 2005 and December 31, 2014. We identified nine ambulatory surgeries which are performed by pediatric surgeons, six of which may also be performed by otolaryngologists or urologists. Procedures were identified by International Classification of Diseases, Ninth Revision (ICD-9) procedure codes and grouped into three categories: (1) pediatric surgery cases defined as anal fistulotomy (49.44, 49.12), umbilical herniorrhaphy (53.4–53.49), and port placement (86.07); (2) overlapping otolaryngology cases defined as thyroglossal duct cyst excision (06.7), branchial cleft excision (29.2, 29.52), and cervical lymph node excision (40.21); and (3) overlapping urology cases defined as unilateral inguinal herniorrhaphy (17.1–17.13, 53.00–53.05), orchiopexy (62.5), and circumcision (64.0). Patients undergoing concurrent surgical procedures and records with surgeon type not specified or other than pediatric surgery, otolaryngology, or urology were excluded. Demographic variables were extracted for cohort description only.

Number of physicians per year was calculated by extracting records from all inpatient, ambulatory surgery, and observational discharges between January 1, 2005 and December 31, 2014. As individual physicians are identified by a unique identifier, we defined the number of physicians per year as the number of unique identifiers appearing for each year.

Analyses were performed using SPSS 17.0 (IBM Corporation, Armonk, NY). Proportions were used for outcomes to account for a change in physician and/or surgical volume across time. To determine temporal trends among case categories, the primary outcome was defined as the proportion of pediatric surgery cases, overlapping otolaryngology cases, or overlapping urology cases performed by pediatric surgeons (i.e., # cases by pediatric surgeons ÷ total number of cases). To determine association between physician supply and number of surgeries performed by pediatric surgeons, the primary outcome was defined as the proportion of category cases performed per pediatric surgeon (i.e., # cases by pediatric surgeons ÷ number of pediatric surgeons). Bivariate linear regression was used to test for association and temporal trend. All tests were two sided, with a p value of < 0.05 considered significant.

Results

Of 335,525 records identified, 118,071 (35.2%) were excluded due to concurrent procedures, 18,554 (5.5%) for surgeon type not specified, and 5205 (1.5%) for surgeon type other than pediatric surgery, otolaryngology, or urology. This resulted in a final cohort of 193,695 patients treated at 44 PHIS hospitals. The majority of the cohort was male (83.5%) Caucasians (54.7%) with a median age at intervention of 3 years (IQR 1–6 years). Approximately 19% of procedures were classified as pediatric surgery cases, 4.8% as overlapping otolaryngology cases, and 76.3% were overlapping urology cases.

Pediatric surgeons performed nearly all of the pediatric surgery cases, and there was no overlap between otolaryngologists and urologists in overlapping case categories (Fig. 1). Temporal analysis of case categories found no change in proportion of pediatric surgery cases performed by pediatric surgeons over the study period ($R^2 = 0.08$,

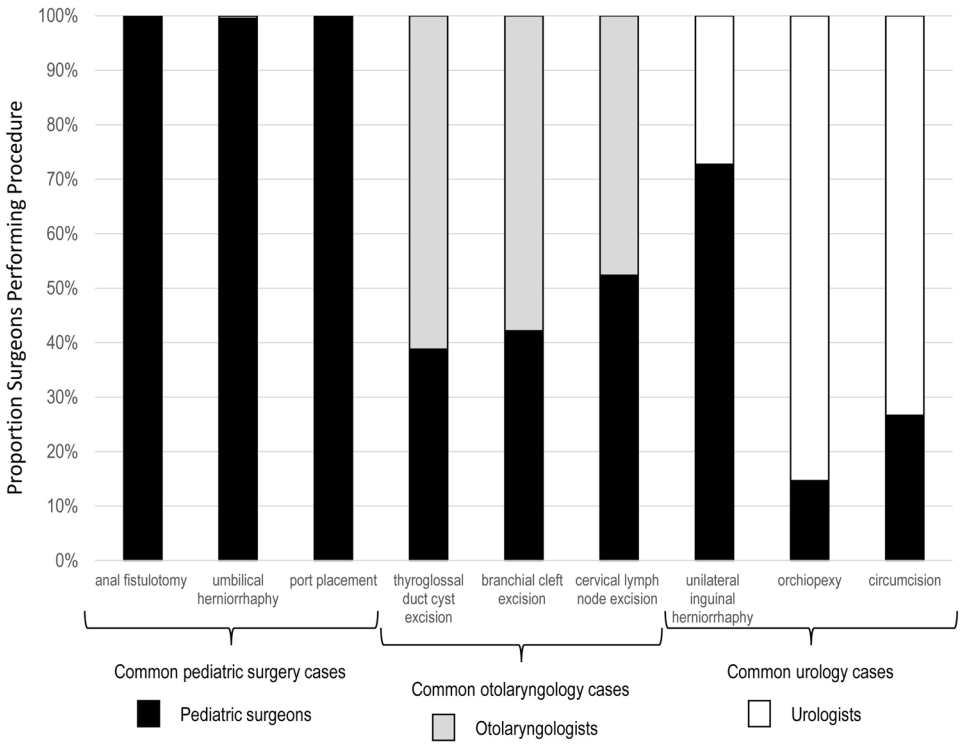

Fig. 1 Proportion of PHIS procedures performed by pediatric surgeons, otolaryngologists, and urologists. The graph shows no overlap between otolaryngologist and urologists in overlapping case categories, and pediatric surgeons performing almost 100% of pediatric surgery cases, except in umbilical herniorrhaphy, which had 0.4% of cases performed by urologists

$p = 0.08$). However, both overlapping otolaryngology cases and overlapping urology cases showed a significant downward trend in the proportion of pediatric surgeons performing these procedures over the study period ($p < 0.001$ for both) (Fig. 2) The proportion of overlapping otolaryngology cases performed by pediatric surgeons declined from 61.7 to 35.1% between 2005 and 2014, and proportion of overlapping urology cases fell from 49.2 to 30.8% over the same time period.

There was an increase in the number of physicians across study years, with pediatric surgeons experiencing a 66.9% increase from 314 in 2005 to 524 in 2014. Number of otolaryngologists increased 56.8% (from 489 in 2005 to 767 in 2014), and urologists increased 58.6% (from 145 in 2005 to 230 in 2014). Linear regression found a strong association

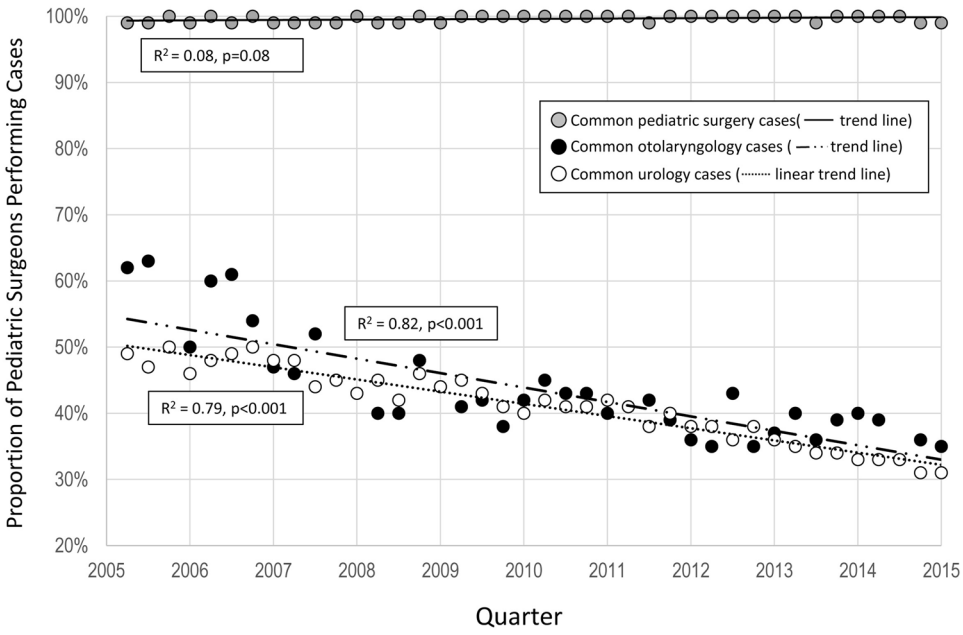

Fig. 2 Temporal trend in proportion of procedures performed by pediatric surgeons at PHIS hospitals by quarter between 2005 and 2014. This graph shows a strong downward trend in proportions of both overlapping otolaryngology cases and overlapping urology cases performed by pediatric surgeons, while proportion of pediatric surgeon cases performed by pediatric surgeons remained the same. As the proportion of cases performed by pediatric surgeons (i.e., # of cases by pediatric surgeons ÷ # of cases) was used in the regression, both physician and surgical volume were adjusted for

between number of overlapping otolaryngology cases performed per pediatric surgeon per year and number of otolaryngologists per year ($R^2 = 0.97$, $p < 0.001$) (Fig. 3). A strong association was also found between number of overlapping urology cases performed per pediatric surgeon per year and number of urologists per year ($R^2 = 0.72$, $p = 0.002$) (Fig. 4).

Discussion

This study found a strong downward trend in the proportion of overlapping otolaryngology cases ($R^2 = 0.82$) and overlapping urology cases ($R^2 = 0.79$) performed by pediatric surgeons, while the proportion of pediatric surgeon cases remained stable across the study period. Although the number of pediatric surgeons reflected in the PHIS database increased during the study period, the proportion of overlapping otolaryngology cases and overlapping urology cases performed by pediatric surgeons decreased significantly over the last decade, with a 43.1% decrease in the proportion of overlapping otolaryngology cases and a 37.4% decrease in the proportion of overlapping urology cases. In fact, the number of pediatric surgeons represented in PHIS grew at a higher rate than either otolaryngology or urology (66.9% vs 56.8% and 58.6%, respectively). These increases are not only attributed to new physicians entering the market, but

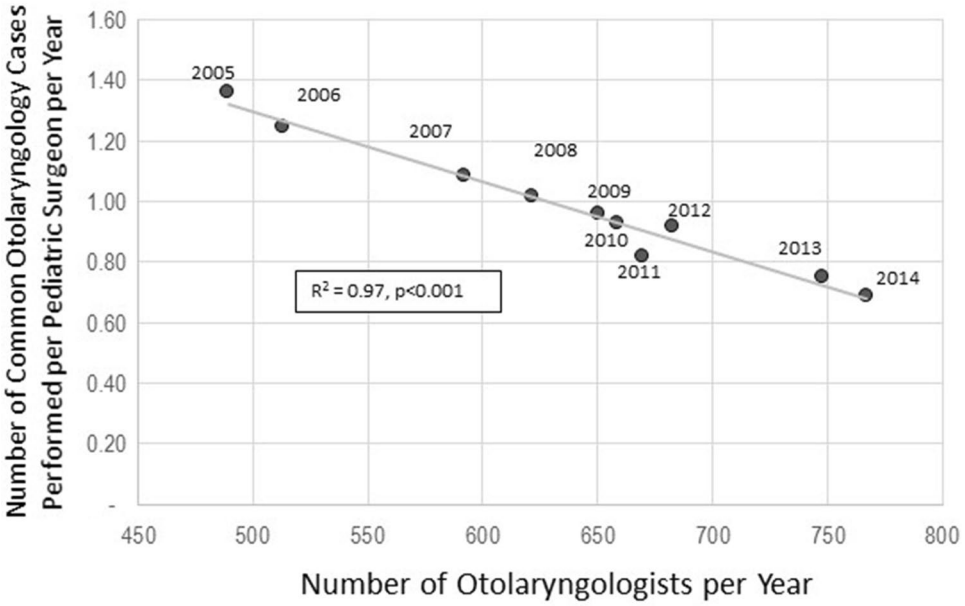

Fig. 3 Association between number of overlapping otolaryngology cases performed by pediatric surgeons per pediatric surgeon and number of otolaryngologists. This figure shows a strong association between number of otolaryngologists and the number of overlapping otolaryngology cases performed per pediatric surgeon. The *y*-axis is the number of overlapping otolaryngology cases performed by pediatric surgeons ÷ the number of pediatric surgeons. As the number of otolaryngologists increased over time, the number of procedures performed per pediatric surgeon fell

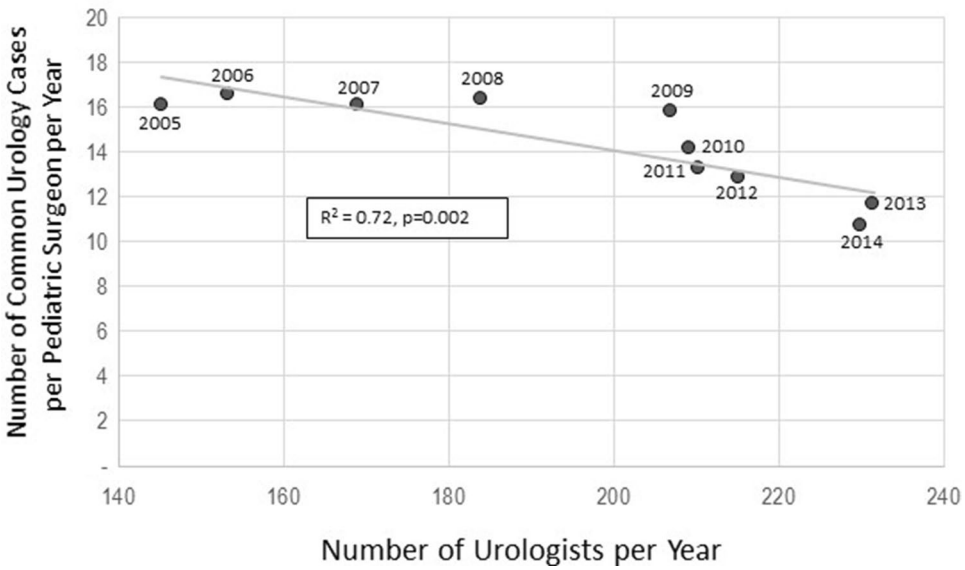

Fig. 4 Association between number of overlapping urology cases performed by pediatric surgeons per pediatric surgeon and number of urologists. This figure shows a strong association between number of urologists and the number of overlapping urology cases performed per pediatric surgeon. The *y*-axis is the number of overlapping urology cases performed by pediatric surgeons ÷ the number of pediatric surgeons. The R^2 shows that 72% of variability in the number of overlapping urology cases per pediatric surgeon is explained by the number of urologists per year

also physician migration and new hospitals joining the PHIS database.

This study found a strong association between physician supply and the types of cases pediatric surgeons were performing. Linear regression found 97% of the variation in number of overlapping otolaryngology cases performed by pediatric surgeons was attributed to a change in the number of otolaryngologists, and 72% of variation in the number of overlapping urology cases performed by pediatric surgeons was attributed to change in the number of urologists.

Although our data cannot prove causality, it is possible that the influx of additional pediatric surgical subspecialists into the surgical workforce, specifically pediatric urologists and pediatric otolaryngologists, may influence the practice patterns and case-mix of American pediatric surgeons as the procedure boundaries across these specialties are relatively fluid.

While we could identify no other studies which looked specifically at how two pediatric surgical subspecialties with an overlapping scope of practice impacted one another over time, the differences in genitourinary procedures being performed by pediatric surgeons and pediatric urologists were recently evaluated by Chan et al. Using the Vizient-AAMC Faculty Practice Solutions Center database 2009–2014 data, this study determined that pediatric surgeons operate on younger patients and treat more inguinal hernias, while pediatric urologists treat more children with undescended testes and hydroceles [14]. Our findings support Chan et al.'s findings on hernia repair as we found 68.3% of inguinal hernias were repaired by pediatric surgeons, with only 31.7% repaired by urologists.

Another study by Bruns et al. used 2004–2013 PHIS data to evaluate trends in pediatric surgical practice over time to determine if the ratio of "mundane"- and "index"-type cases changed as more pediatric surgeons entered the surgical workforce. Similar to the present study, they measured the procedure volume for umbilical herniorrhaphy at PHIS hospitals over a decade and found it to be stable over time (3.7–5.0% of the total "mundane" procedure volume) [15]. The authors concluded that "mundane"-type procedures are taking up an increasing proportion of pediatric surgeons' case load, but they did not investigate how these trends might be related to the increasing supply of other pediatric surgical subspecialists.

Perhaps, the most important implication of these studies relates to the pediatric surgical workforce and pediatric surgery resident training. The results of this study suggest that American pediatric surgeons are performing fewer outpatient neck and genitourinary procedures as the composition of the surgical subspecialty workforce changes. However, these types of surgical procedures are still routinely performed by pediatric surgery residents during their training, and are part of the core content for pediatric surgery by the American Board of Surgery on In-training, Qualifying, and Certifying examinations [16]. Proficiency in performing the types of outpatient procedures investigated in this study likely has more to do with competency of the individual surgeon and less with that surgeon's subspecialty training [17–19]. However, it is important to determine, as accurately as possible, which factors (including surgeon subspecialty) produce the safest and best possible surgical outcomes [20, 21].

Several limitations should be considered when interpreting the results from this study. Most importantly, PHIS categorization of subspecialty does not specify pediatric designation for either otolaryngologists or urologists, only pediatric surgeons. Therefore, there is a possibility that adult ENT and urologic surgeons with privileges at a PHIS hospital could be included in our analysis. Second, PHIS data include only tertiary care centers, limiting the external validity of our findings. Also, administrative databases such as PHIS have the potential to contain miscoded or inaccurate information. However, the Children's Health Corporation of America reduces these data problems using validity and reliability checks.

Finally, patients undergoing concurrent procedures, and cases where the "surgeon type" was not specified or were classified as something other than pediatric surgery, otolaryngology, or urology were excluded. These exclusions could have introduced unknown bias into our sample. However, exclusions for surgeon type, which we felt presented the highest risk for bias introduction, comprised only 7% of the total records identified. Despite these limitations, the data in this study were relatively straightforward to obtain and most likely give a reasonable depiction of trends among tertiary care centers in the United States.

Conclusions

In this cohort, we found an association between physician supply and the types of cases pediatric surgeons were performing. Also found was a reduction in overlapping otolaryngology and urology cases performed by pediatric surgeons independent of physician and surgical volume. The proportion of overlapping otolaryngology cases performed by pediatric surgeons fell by almost half, while the proportion of overlapping urology cases performed by pediatric surgeons fell by 37% between 2005 and 2014. These findings illustrate a possible narrowing of case-mix for pediatric surgeons where there is overlap of performance of procedures with other surgical specialists. This study raises important questions that have relevance to pediatric surgery resident education, and pediatric surgery workforce planning.

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Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

Ethical approval For this type of study formal consent is not required.

References

1. Fingeret AL, Stolar CJ, Cowles RA (2013 Jan) Trends in operative experience of pediatric surgical residents in the United States and Canada. J Pediatr Surg 48(1):88–94
2. Coran AG, Adzick NS, Krummel TM et al (2012) Pediatric surgery, 7th edn. Elsevier, Philadelphia
3. Sømme S, Bronsert M, Morrato E, Ziegler M (2013) Frequency and variety of inpatient surgical procedures in the United States. Pediatrics 132(6):e1466–e1472
4. Fonkalsrud EW, O'Neill JA, Jabaji Z, Dunn JC (2013) Changing relationship of pediatric surgical workforce to patient demographics. Am J Surg 207:275–280
5. Sømme S, Bronsert M, Kempe A, Morrato EH, Ziegler M (2012) Alignment of training curriculum and surgical practice: implications for competency, manpower, and practice modeling. Eur J Pediatr Surg 22(1):74–79
6. Nakayama DK, Newman KD (2008) Pediatric surgery workforce: population and economic issues. J Pediatr Surg 43(8):1426–1431
7. O'Neill JA Jr, Gautam S, Geiger JD, Sigmund HE, Holder TM, Bloss RS et al (2000) A longitudinal analysis of the pediatric surgeon workforce. Ann Surg 232(3):442–453
8. Ricketts TC, Adamson WT, Fraher EP, Knapton A, Geiger JD, Abdullah F et al (2017 Mar) Future supply of pediatric surgeons: analytical study of the current and projected supply of pediatric surgeons in the context of rapidly changing process for specialty and subspecialty training. Ann Surg 265(3):609–615
9. Sheldon GF (2007) Surgical workforce since the 1975 study of surgical services in the United States: an update. Ann Surg 246(4):541–545
10. Nakayama DK, Burd RS, Newman KD (2009) Pediatric surgery workforce: supply and demand. J Pediatr Surg 44(9):1677–1682
11. Martin JA, Hamilton BE, Osterman MJK, Driscoll AK, Mathews TJ (2017) Births: final data for 2015. National vital statistics report; vol 66, no 1. National Center for Health Statistics, Hyattsville
12. Poley S, Ricketts T, Belsky D, Gaul K (2010) Pediatric surgeons: subspecialists increase faster than generalists. Bull Am Coll Surg 95(10):35–38
13. American Council for Graduate Medical Education (ACGME). Data resource book. http://www.acgme.org/About-Us/Publications-and-Resources/Graduate-Medical-Education-Data-Resource-Book. Accessed 2 May 2018
14. Chan YY, Durbin-Johnson B, Kurzrock EA (2016 Nov) Pediatric inguinal and scrotal surgery—practice patterns in US academic centers. J Pediatr Surg 51(11):1786–1790
15. Bruns NE, Shah MA, Dorsey AN, Ponsky TA, Soldes OS (2016 Jun) Pediatric surgery—a changing field: national trends in pediatric surgical practice. J Pediatr Surg 51(6):1034–1038
16. Children's surgery verification: quality improvement program. Optimal resources for children's surgical care v.1. American College of Surgeons. Available at: https://www.facs.org/~/media/files/quality%20programs/csv/acs%20csv_standardsmanual.ashx. Accessed 26 Aug 2017
17. Behr CA, Hesketh AJ, Akerman M, Dolgin SE, Cowles RA (2015 Jan) Recent trends in the operative experience of junior pediatric surgical attendings: a study of APSA applicant case logs. J Pediatr Surg 50(1):186–190
18. Albanese MA, Mejicano G, Mullan P, Kokotailo P, Gruppen L (2008) Defining characteristics of educational competencies. Med Educ 42(3):248–255
19. Govaerts MJ (2008) Educational competencies or education for professional competence? Med Educ 42(3):234–236
20. Livingston EH, Cao J (2010) Procedure volume as a predictor of surgical outcomes. JAMA 304(1):95–97
21. Barnhart DC, Oldham K, Meyers RL (2013 Dec) Time to get on the bus: children's surgery and where we need to go. Pediatrics 132(6):e1659–e1660