**Association of Children’s Hospital Status on Value for Common Surgical Conditions**

Mehul V. Raval, MD, MS; Audra J. Reiter, MD, MPH; Ian M. McCarthy, PhD

Author Affiliations

From the Department of Surgery and Pediatrics, Surgical Outcomes and Quality Improvement Center, Center for Healthcare Studies, Institute of Public Health and Medicine, Northwestern University Feinberg School of Medicine, Ann & Robert H. Lurie Children’s Hospital of Chicago, Chicago, IL (MVR/AJR) and the Department of Economics, Emory University, Atlanta, GA (IMM)

Corresponding Author:

Dr. Mehul V. Raval

Surgical Outcomes and Quality Improvement Center

633 N. St Clair Street, 20th floor, Chicago, IL 60611

mraval@luriechildrens.org

Manuscript Word Count: 2,995

Abstract Word Count: 349

Date of Revision: 4/29/22

**KEY POINTS**

**Question:** Do children’s hospitals provide higher value care for routine surgical procedures as compared to non-children’s hospitals?

**Findings:** In this cohort study, negotiated payments for commonly performed surgical procedures in children were significantly higher at children’s hospitals than non-children’s hospitals. Inpatient procedures were 39% higher and outpatient were 34% higher.

**Meaning:** Children’s hospitals have lower overall value care for routine surgical procedures based on clinical outcomes and payments data. Further research is needed to evaluate mechanisms to decrease costs and improve value at both children’s hospitals and non-children’s hospitals.

**ABSTRACT**

**Importance:** While children’s hospitals (CH) provide a significant proportion of highly specialized pediatric care in the United States, the value of CH compared to non-children’s hospitals (NCH) for routine surgical procedures is unknown.

**Objective:** To determine the value of CH for routine surgical procedures by assessing clinical outcomes and payment data.

**Design, Setting, and Participants:** Retrospective cohort study of pediatric patients undergoing one of 13 commonly performed surgical procedures between 2010 and 2015 with 90-day follow-up using administrative data from the Health Care Cost Institute (HCCI). Data analysis took place from July 2019 to December 2021.

**Exposure:** The primary exposure was tier of CH status, defined using self-reported pediatric services, affiliation with pediatric focused programs, and validated based on proportion of pediatric admissions.

**Main Outcomes and Measures:** Payments for common surgical procedures from private insurers and overall complication and readmission rates at 30, 60, and 90 days.

**Results:** There were 368,220 pediatric patients who underwent one of the surgical procedures of interest. 220,899 (60.0%) of the patients were male. 118,977 (32.3%) had their procedure at freestanding CH (CH-A), 75,256 (20.4%) at CH attached to an adult hospital (CH-B), and 173,987 (47.3%) at NCH. The average payment for all procedures at CH-A was $6,533.56, at CH-B $5,847.50, and at NCH $5,034.25. The overall complication rate was 0.004±0.06 at CH-A, 0.01±0.07 at CH-B, and 0.003±0.06 at NCH. Readmission rates at 30, 60, and 90 days were similar across all hospital types. After adjusting for zip code, year, surgery, surgery setting, and observable patient, hospital, and county characteristics, we estimate payments for inpatient common procedures were 39% higher at CH-A than at NCH. Payments for outpatient common procedures were 34% higher at CH-A than at NCH.

**Conclusions and Relevance:** In this cohort study, children who underwent common surgical procedures had equivalent clinical outcomes at CH and NCH but the procedures were associated with higher payments and, thus, overall lower value care. To ensure delivery of optimal value to patients and payers, further research is needed to evaluate mechanisms to ensure access, decrease costs, and improve value at both CH and NCH.

**INTRODUCTION**

Though children’s hospitals (CH) comprise less than 5% of hospitals in the United States, CH account for 40% of pediatric inpatient days and 50% of costs for pediatric care.1 CH often provide high-volume, specialized, and resource-intensive care to children who require highly trained providers and innovative technologies. One example is congenital heart surgery where mortality rates are lowest at high-volume, specialized centers.2,3 For this type of highly specialized pediatric care, the value proposition of higher costs at CH is arguably justified by demonstrable improved outcomes and quality.4 In 2009, 40 freestanding CH accounted for greater than $10 billion of annual U.S. healthcare expenditure, and the top 10 CH profited over $800 million.5 Contemporary pediatric care has witnessed significant regionalization in the last decade, and there are efforts underway to centralize the delivery of children’s surgical care to specialized centers.6–9.

Although CH have been shown to provide higher quality care than non-children’s hospitals (NCH) for highly specialized procedures, there aredata to suggest the cost of common and routine procedures is also greater at CH than NCH.10,11 Despite surgical interventions representing high-risk and costly experiences in our healthcare system, little attention has been directed at surgeons, surgical care or surgical payment reform, transparency of surgical outcomes, and consumer/patient empowerment in choices surrounding surgical care.12,13 Of the 50 most prevalent and costly pediatric inpatient conditions, 32 are surgical.14 Furthermore, surgical care accounts for a high proportion of overall healthcare spending.15 The financial and clinical implications of trends and policies related to children’s surgical care have not been fully evaluated and may result in a significant rise in healthcare costs without demonstrable improvement in quality.6,16

The primary objective of this study was to determine the value of CH for routine surgical procedures by assessing clinical outcomes and payments data. We compared quality by assessing complication and readmission rates, and price, using payment data, of commonly performed surgeries at CH and NCH. We then explored the extent to which quality and price differences could be explained by patient and hospital characteristics versus other economic factors such as hospital and insurer market structure.

**METHODS**

**Study Design and Data Source**

This was a retrospectivecohort study using version one of the Health Care Cost Institute (HCCI) dataset. The HCCI provides de-identified administrative cost and utilization data for over 10 million beneficiaries in the United States covered by private insurance and is ideal for evaluating variation in hospital-level pricing and payments. These data consist of claims submitted to HCCI by Aetna, Humana, Kaiser Permanente, and UnitedHealthcare.17 We focus on the pediatric population, where the HCCI data purportedly cover roughly 25% of all claims for privately-insured children in the U.S.18 HCCI data have previously been used to evaluate variations in prices between states and Metropolitan Statistical Areas (MSA).19 The Ann and Robert H. Lurie Children’s Hospital of Chicago’s institutional review board deemed this study exempt from review. A waiver of informed consent was granted because the study was determined to be minimal risk and because data are deidentified. This study follows Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) reporting guidelines for cohort studies.20

**Study Cohort**

We analyzed claims data from January 2010 to September 2015 from HCCI.1719 From this population of privately-insured beneficiaries, we included patients 18 years of age or less, who underwent commonly performed pediatric surgical procedures. We examined outcomes and costs following 13 procedures: anterior cruciate ligament (ACL) reconstruction, anti-reflux surgery, appendectomy, humerus fracture repair, tympanostomy tube placement, tonsillectomy and adenoidectomy, strabismus surgery, posterior spinal fusion, cholecystectomy, umbilical hernia repair, inguinal hernia repair, orchiopexy, and circumcision. Patients who underwent multiple procedures at the same visit (e.g., both tonsillectomy and tympanostomy) were classified as concurrent procedures. Final procedure inclusion was determined through a combination of literature review and clinical judgement to purposefully capture inpatient and outpatient populations and to represent the full spectrum of children’s surgical procedures performed at most hospitals.14 Procedures were identified with Current Procedural Terminology (CPT) and International Classification of Diseases, Ninth Revision (ICD-9) procedure codes using facility and professional claims (Supplemental Table 1). We excluded newborns, patients who were transferred, and outliers, defined as payments below the 5th or above the 95th percentile of payment ratios.

**Hospital Classification**

CH were distinguished from NCH using a previously described methodology.21 In brief, hospitals were categorized using a combination of self-reported pediatric services on the American Hospital Association (AHA) Survey followed by validation using publicly available data on hospital membership in various pediatric programs such as the Children’s Hospital Association, Children’s Oncology Group, and American College of Surgeons National Surgical Quality Improvement Program-Pediatric. Using this methodology, three tiers of hospitals were created. A final validation used Health Care Cost Institute claims data to determine the proportion of pediatric admissions at each hospital. Further, hospitals were classified as teaching or non-teaching if they reported being a member of the Council of Teaching Hospital of the Association of American Medical Colleges on the AHA survey.

**Outcome Measures**

Postoperative outcomes were identified using ICD-9 codes using facility and professional claims for wound complications, surgical site infections, urinary tract infections, renal insufficiency, pneumonia, respiratory failure, sepsis, deep vein thromboses, pulmonary embolism, cardiac complications, intraoperative complications, and 30-day, 60-day, and 90-day readmissions (Supplemental Table 2). These occurrences include emergency department claims that were part of a hospital facility, critical access hospital, or surgery center. Negotiated payment rates and patient characteristics for each procedure were obtained from the HCCI database.

**Statistical Analysis**

We tested for differences in unadjusted mean payments and quality outcomes by hospital type. For complications, we employed the chi-squared test; and for prices, we used the t-test and non-parametric Kruskal-Wallis test.

Then, we examined differences in payments and quality with regressions, where we controlled for observable patient variables (gender and co-morbidities), the presence of complex chronic conditions, procedure type, and hospital characteristics. Complex chronic conditions were accounted for using methodologies outlined by Feudtner, et al.22–25 We employed regression models with market, year, and procedure fixed effects to examine differences in mean prices and complication rates conditional on covariates. More formally, we estimated by ordinary least squares (OLS) the following regression model:

where denotes the outcome (e.g., log price) for patient i with insurance product g at hospital h, market m, and year/month t; denotes patient and procedure characteristics including an indicator for the procedure, whether the patient has any complex chronic conditions, the inpatient vs outpatient setting, and whether the patient is female; denotes hospital characteristics from the AHA survey data, including bed size, number of nurse, physician, resident, and other full time equivalents, total hospital discharges, total Medicare discharges, and total Medicaid discharges; denotes market-level variables from the American Community Survey, including percentage of residents of different age categories, race, income, and education; CH denotes an indicator for whether the hospital is a children's hospital; and capture fixed effects for the patient's insurance product (the insurance group ID) and year/month fixed effects; and is an error term. Standard errors are robust to heteroskedasticity and clustering at the hospital level. In cases where the outcomes were binary, such as for 90-day readmissions or complications, we estimated the same specification using a generalized linear model with a binomial family and a logit link function.

The regression specification included a set of indicator variables for the care setting (inpatient vs outpatient) and the specific procedure; however, these indicator variables likely do not fully capture important differences between CH and NCH. Therefore, in addition to an overall analysis of all procedures and all settings, we estimated this regression separately for each procedure and separately for the inpatient and outpatient settings. For prices, there are 26 regressions total, but not all results are available for these individual analyses due to small sample sizes. Similarly, for regressions involving quality outcomes, we focused on the full inpatient sample due to low counts of readmissions or complications for individual procedures or outpatient-only procedures.

All HCCI data were accessed remotely via Citrix Workspace. The claims data were stored in a Vertica database, from which an analytic dataset was created and managed using SAS version 9.4 (SAS Institute Inc, Cary, NC). All statistical analyses were performed using Stata version 15 (StataCorp) and R (the R Project for Statistical Computing).

**RESULTS**

**Patient and Hospital Characteristics**

Of the 67,939,211 patients represented in HCCI data spanning from January 1, 2010 to December 31, 2015, 22,878,572 (33.7%) were 18 years or less. Of these patients, 368,220 (1.6%) were identified to have undergone one of the index surgical procedures of interest. This cohort of patients was assigned to CH, subdivided into 118,977 (32.3%) at freestanding children’s hospitals (CH-A), 75,256 (20.4%) at children’s hospital attached to adult hospitals (CH-B), and 173,987 (47.3%) at NCH (Figure 1).

The 368,220 patients included in this analysis were seen across 12,669 hospitals. 280 (2.2%) were Tier A Children’s Hospitals, 1,079 (8.5%) were Tier B Children’s Hospitals, and 11,310 (89.3%) were Non-Children’s Hospitals. 61% of the patients were male at CH-A, 63% at CH-B, and 58% at NCH. The average number of beds at CH-A was 263, CH-B was 647, and NCH was 210. 98% of CH-A were nonprofit hospitals whereas 72% of CH-B and NCH were nonprofit. Teaching institutions made up 36% of CH-A, 56% of CH-B, and 6% of NCH (Table 1).

**Surgical Procedures**

A variety of surgical procedures across multiple pediatric surgical subspecialties were evaluated. Tonsillectomy and adenoidectomy was the most common procedure performed with 104,163 cases, 27.5% were performed at CH-A, 17.6% at CH-B, and 54.9% at NCH. Cholecystectomy was the least common procedure with 426 cases, 17.8% were performed at CH-A, 20.4% at CH-B, and 61.7% at NCH. There were 45,565 patients who had concurrent procedures done under the same anesthetic, 31.5% at CH-A, 20.4% at CH-B, and 48.1% at NCH (Table 1).

**Payments**

The mean payment from commercial insurers for all procedures was $6,553.56 (SD $6,399.97) at CH-A, $5,847.50 (SD $4,947.47) at CH-B, and $5,034.25 (SD $4,787.07) at NCH. Appendectomy for acute appendicitis had the largest difference in payments with CH-A receiving $5,618.75 more in payment than NCH. Posterior spinal fusion was the only procedure where NCH received higher payments than CH, with NCH receiving $406.50 more than CH-A and $1,947.06 more than CH-B (Figure 2).

**Complications**

There was no significant difference in the rate of surgical complications or readmissions within 30, 60, or 90 days of surgery at any of the hospital types. The overall complication rate was 0.004±0.06 at CH-A, 0.01±0.07 at CH-B, and 0.003±0.06 at NCH. Readmission rates at 30, 60, and 90 days were similar across all hospital types (Table 2). Adjusting for observable characteristics, we again see no significant difference in readmissions or complications among CH-A or CH-B compared to NCH. For example, a coefficient estimate of 0.23 (from Table 3) implies an estimated 1.26 increase in the odds of a complication, or a 26% increase in complication rates, for CH-A compared to NCH. However, given the low rates of complications overall, this change in odds equates to less than a 0.15% higher complication rate for CH-A compared to NCH.

**Log Negotiated Hospital Payments**

After adjusting for zip code, year, month, surgery, surgery setting, complex chronic conditions, and observable patient, hospital, and county characteristics, we estimated payments for inpatient common procedures were 39% higher at CH-A than at NCH and 2% lower at CH-B than NCH. Payments for outpatient common procedures were 34% higher at CH-A than at NCH and 3% higher at CH-B than NCH. Inpatient and outpatient appendectomy, humerus fracture repair, and tonsillectomy payments were higher at CH-A than NCH. Inpatient appendectomy, humerus fracture repair, and tonsillectomy payments were lower at CH-B than NCH. Outpatient appendectomy, humerus fracture repair, and tonsillectomy payments were higher at CH-B than NCH (Table 3).

**DISCUSSION**

There is increasing desire for consumers to understand the value proposition for rising healthcare expenditures in terms of clinical outcomes and costs.13 Value-based purchasing strategies for employer health plans have been discussed for over a decade but have been slow in adoption.26,27 The slow adoption surrounds poor definitions of value both in terms of outcomes and costs. Our study demonstrates for commonly performed pediatric procedures, CH have comparable clinical outcomes, but higher costs, and, thus, lower value compared to NCH. To our knowledge, no prior studies have examined the value of CH for commonly performed procedures using payment data.

Prior studies attempting to assess value rely upon costs estimated using hospital-level charges rather than actual payments.28,29 Hospital charges are problematic because they rely upon inflated figures that typically far exceed negotiated payments. Further, charge-to-cost conversion ratios are hospital-specific and preclude reliable hospital comparison. In contrast, we utilized payments from private insurance carriers which are superior to charges and estimated costs as payments are a direct measure of prices paid for care. Payment data provide a better measure of the costs of care from a patient and societal perspective. Financial transparency is lacking and has been a barrier to this kind of work in the past. Using a novel approach made possible by access to the HCCI dataset of hospital payments, our research is the first to examine actual payments across CH and NCH from four of the nation’s largest insurers.

Another challenge to assess value is that outcomes for common procedures in children are favorable with low rates of complications. Our study found there was no significant difference in the rate of surgical complications or 90-day readmissions at any of the hospital types. Complications for children undergoing surgery are typically driven by procedure complexity and patient comorbidities. While some surgical procedures evaluated (e.g., spine surgery) may have increased complexity (e.g., severity of scoliosis), our results were consistent across the continuum of procedures studied. We attempted to limit procedural selection to the least complex procedural coding groups (e.g., posterior spine approaches versus anterior approaches). Further, we purposely sampled inpatient and outpatient procedures from a wide variety of children’s surgical subspecialities including general surgery, otolaryngology, orthopedic surgery, urology, ophthalmology, and neurosurgery. In pediatric populations, complications such as readmission are, in large part, driven by complex chronic conditions.30 Children undergoing the routine surgical procedures evaluated tend to be healthy. Our study adjusted for pediatric complex chronic conditions using the Feudtner classification system22–25 and still demonstrated higher payments to CH than NCH. While CH typically care for a high proportion of patients with complex chronic conditions, accounting for patient complexity in our models as well as the selection of commonly performed surgical procedures attempts to ensure comparable assessment of CH and NCH.

It has been shown that clinical data is better than claims data when assessing complication rates, however, for the selected routine, commonly performed procedures with rare complication event rates, we expect claims data would be reliable. Additionally, we evaluated readmission rates which are considered a more reliable outcome metric regardless of if claims or clinical data are utilized.31

Variation exists in how hospitals are defined as CH in the pediatric literature. We used a previously described rigorous method to classify hospitals as either CH or NCH based on American Hospital Association (AHA) survey results, publicly available data, and proportion of pediatric discharges based on HCCI data to validate the classifications.21 Multiple sensitivity analyses were performed to compare CH-A to CH-B to NCH, etc. and we found consistent results.21

Finally, CH may receive higher payments than NCH on routine surgical procedures because of higher costs and lower reimbursements associated with pediatric populations. NCH may be able to spread care delivery costs across larger cohorts of patients including adult populations who may have higher reimbursement rates.32 Further, CH care for a disproportionate number of uninsured or publicly-insured patients compared to NCH.33,34 Last, freestanding CH are typically smaller than NCH with fewer beds and lower overall volumes leading to higher equipment and supply costs. While these trends may justify higher payments to CH for delivery of similar care as NCH, evaluation from the patient/consumer perspective demonstrates lower individual value at CH.

**Limitations**

This study has several limitations. First, HCCI data reflect payments and care delivery for employer-based/privately-insured patient populations. Depending on the state, Medicaid (including Medical Assistance, Children's Health Insurance Plan (CHIP) or other government-assistance plan coverage) ranges from 17% (Utah) to 56% (New Mexico).35 Our results may be biased and thus have limited generalizability to publicly-insured populations. Nevertheless, the large sample sizes and variable private insurance plans (with high and low deductible plans included) may increase the generalizability of our findings. Second, although these analyses clustered CH categories, we were unable to account for specific payments or outcomes based on nuances such as surgeon specialization. This may lead to unmeasured differences in patient or physician characteristics across the hospital-types assessed. Third, we did not evaluate referral practices and patient/family preferences toward undergoing surgical care at CH as compared to NCH. There may be a premium patients and families are willing to pay to undergo care at CH, assumingpatients and families have freedom to select the definitive treating facilities and are not limited by insurer or policy factors. Last, using data from 2010 to 2015 may be criticized as dated. These analyses were conducted using the most contemporary data available at the initiation of this multiyear project and required extramural funding. As noted, payment data of this scope are rare, and this study represents one of the first of its type. With healthcare spending rising and pediatric care increasingly concentrated among specialized CH, our estimates may underestimate present-day payment differentials.

**CONCLUSIONS**

For commonly performed surgical procedures in children, clinical outcomes are equivalent at CH and NCH but are associated with higher payments and, thus, lower overall value care. These results may not reflect all aspects of healthcare delivery that may define value for an individual patient and there may be a premium for which patients/families and insurers are willing to pay for access to CH. Nevertheless, with increasing focus on value-based care, further research is needed to evaluate mechanisms to decrease costs and improve value at both CH and NCH.

**Acknowledgements/Funding:** This project was supported by grant number R01HS024712 from the Agency for Healthcare Research and Quality. The content is solely the responsibility of the authors and does not necessarily represent the official views of the Agency for Healthcare Research and Quality.

**REFERENCES**

1. *All Children Need Children’s Hospitals*. 2nd ed. National Association of Children’s Hospitals and Related Institutions; 2007. Accessed October 21, 2021. https://www.upstate.edu/gch/pdf/academics/allchildren.pdf

2. Allen SW, Gauvreau K, Bloom BT, Jenkins KJ. Evidence-based referral results in significantly reduced mortality after congenital heart surgery. *Pediatrics*. 2003;112(1 I):24-28. doi:10.1542/PEDS.112.1.24

3. Chang RKR, Klitzner TSS. Can regionalization decrease the number of deaths for children who undergo cardiac surgery? A theoretical analysis. *Pediatrics*. 2002;109(2):173-181. doi:10.1542/PEDS.109.2.173

4. Porter ME. What Is Value in Health Care? *http://dx.doi.org/101056/NEJMp1011024*. 2010;363(26):2477-2481. doi:10.1056/NEJMP1011024

5. Gaul G. Growing Size And Wealth Of Children’s Hospitals Fueling Questions About Spending. Kaiser Health News. Published 2011. Accessed October 21, 2021. http://khn.org/news/childrens-hospitals-part-one/

6. Lorch SA, Myers S, Carr B. The regionalization of pediatric health care. *Pediatrics*. 2010;126(6):1182-1190. doi:10.1542/PEDS.2010-1119

7. Goldin AB, Dasgupta R, Chen LE, et al. Optimizing resources for the surgical care of children: an American Pediatric Surgical Association Outcomes and Clinical Trials Committee consensus statement. *J Pediatr Surg*. 2014;49(5):818-822. doi:10.1016/J.JPEDSURG.2014.02.085

8. Oldham KT. Optimal resources for children’s surgical care. *J Pediatr Surg*. 2014;49(5):667-677. doi:10.1016/J.JPEDSURG.2014.02.046

9. Salazar JH, Goldstein SD, Yang J, et al. Regionalization of Pediatric Surgery: Trends Already Underway. *Ann Surg*. 2016;263(6):1062-1066. doi:10.1097/SLA.0000000000001666

10. Raval M V., Cohen ME, Barsness KA, Bentrem DJ, Phillips JD, Reynolds M. Does hospital type affect pyloromyotomy outcomes? Analysis of the Kids’ Inpatient Database. *Surgery*. 2010;148(2):411-419. doi:10.1016/J.SURG.2010.04.015

11. Tian Y, Heiss KF, Wulkan ML, Raval M V. Assessment of variation in care and outcomes for pediatric appendicitis at children’s and non-children’s hospitals. *J Pediatr Surg*. 2015;50(11):1885-1892. doi:10.1016/J.JPEDSURG.2015.06.012

12. Dupree JM, Patel K, Singer SJ, et al. Attention to surgeons and surgical care is largely missing from early medicare accountable care organizations. *Health Aff*. 2014;33(6):972-979. doi:10.1377/hlthaff.2013.1300

13. Huckman RS, Kelley MA. Public reporting, consumerism, and patient empowerment. *N Engl J Med*. 2013;369(20):1875-1877. doi:10.1056/NEJMP1310419

14. Keren R, Luan X, Localio R, et al. Prioritization of comparative effectiveness research topics in hospital pediatrics. *Arch Pediatr Adolesc Med*. 2012;166(12):1155-1164. doi:10.1001/archpediatrics.2012.1266

15. Kaye DR, Luckenbaugh AN, Oerline MK, et al. Understanding the Costs Associated With Surgical Care Delivery in the Medicare Population. *Ann Surg*. 2020;271(1):23-28. doi:10.1097/SLA.0000000000003165

16. Kastenberg ZJ, Lee HC, Profit J, Gould JB, Sylvester KG. Effect of deregionalized care on mortality in very low-birth-weight infants with necrotizing enterocolitis. *JAMA Pediatr*. 2015;169(1):26-32. doi:10.1001/JAMAPEDIATRICS.2014.2085

17. Health Care Cost Institute. Data. Accessed October 21, 2021. https://healthcostinstitute.org/data

18. *Children’s Health Spending: 2010-2014*.; 2016. Accessed November 22, 2021. https://healthcostinstitute.org/images/pdfs/2016-Kids-Report-5.16.16.pdf

19. Newman D, Parente ST, Barrette E, Kennedy K. Prices For Common Medical Services Vary Substantially Among The Commercially Insured. *Health Aff (Millwood)*. 2016;35(5):923-927. doi:10.1377/HLTHAFF.2015.1379

20. von Elm E, Altman D, Egger M, Pocock S, Gotzsche P, Vandenbroucke J. The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) Statement: guidelines for reporting observational studies. *Ann Intern Med*. 2007;147(8):573-577.

21. Piper KN, Baxter KJ, McCarthy I, Raval M V. Distinguishing Children’s Hospitals From Non-Children’s Hospitals in Large Claims Data. *Hosp Pediatr*. 2020;10(2):123-128. doi:10.1542/HPEDS.2019-0218

22. Feudtner C, Feinstein JA, Zhong W, Hall M, Dai D. Pediatric complex chronic conditions classification system version 2: updated for ICD-10 and complex medical technology dependence and transplantation. *BMC Pediatr*. 2014;14(1):199. doi:10.1186/1471-2431-14-199

23. Feudtner C, Hays RM, Haynes G, Geyer JR, Neff JM, Koepsell TD. Deaths attributed to pediatric complex chronic conditions: national trends and implications for supportive care services. *Pediatrics*. 2001;107(6). doi:10.1542/PEDS.107.6.E99

24. Berry JG, Hall DE, Kuo DZ, et al. Hospital Utilization and Characteristics of Patients Experiencing Recurrent Readmissions Within Children’s Hospitals. *JAMA*. 2011;305(7):682-690. doi:10.1001/JAMA.2011.122

25. Feudtner C, Christakis D, Connell F. Pediatric deaths attributable to complex chronic conditions: a population-based study of Washington State, 1980-1997 - PubMed. *Pediatrics*. 2000;106(1):205-209. Accessed December 17, 2021. https://pubmed.ncbi.nlm.nih.gov/10888693/

26. Rosenthal MB, Landon BE, Normand S-LT, Frank RG, Ahmad TS, Epstein AM. Employers’ use of value-based purchasing strategies. *JAMA*. 2007;298(19):2281-2288. doi:10.1001/JAMA.298.19.2281

27. Porter ME. A Strategy for Health Care Reform — Toward a Value-Based System. *http://dx.doi.org/101056/NEJMp0904131*. 2009;361(2):109-112. doi:10.1056/NEJMP0904131

28. Lee VS, Kawamoto K, Hess R, et al. Implementation of a Value-Driven Outcomes Program to Identify High Variability in Clinical Costs and Outcomes and Association With Reduced Cost and Improved Quality. *JAMA*. 2016;316(10):1061-1072. doi:10.1001/JAMA.2016.12226

29. Mehrotra A, Schleifer D, Shefrin A, Ducas A. Defining the Goals of Health Care Price Transparency: Not Just Shopping Around. *NEJM Catal*. Published online 2018. Accessed October 21, 2021. https://catalyst.nejm.org/doi/full/10.1056/CAT.18.0146

30. Simon TD, Berry J, Feudtner C, et al. Children with complex chronic conditions in inpatient hospital settings in the United States. *Pediatrics*. 2010;126(4):647-655. doi:10.1542/PEDS.2009-3266

31. Lawson EH, Louie R, Zingmond DS, et al. A comparison of clinical registry versus administrative claims data for reporting of 30-day surgical complications. *Ann Surg*. 2012;256(6):973-981. doi:10.1097/SLA.0B013E31826B4C4F

32. Massoumi RL, Childers CP, Lee SL. Underrepresentation of pediatric operations in the relative value unit updating process. *J Pediatr Surg*. 2021;56(6):1101-1106. doi:10.1016/J.JPEDSURG.2021.02.026

33. VonAchen P, Gaur D, Wickremasinghe W, et al. Assessment of Underpayment for Inpatient Care at Children’s Hospitals. *JAMA Pediatr*. 2021;175(9):972-974. doi:10.1001/JAMAPEDIATRICS.2021.1133

34. Campbell BT, Campbell J, Campbell DA, Hirschl RB. Billing and reimbursement for pediatric surgical services: a unique assessment of a complex process. *J Pediatr Surg*. 2004;39(6):991-994. doi:10.1016/J.JPEDSURG.2004.02.037

35. Health Insurance Coverage of Children 0-18 | KFF. Accessed October 21, 2021. https://www.kff.org/other/state-indicator/children-0-18/?currentTimeframe=0&sortModel=%7B%22colId%22:%22Location%22,%22sort%22:%22asc%22%7D

Figure 1: Data merge and cohort selection to assess the value of children’s hospitals for common surgical procedures

HCCI: Health Care Cost Institute

NPI: National Provider Identifier

Table 1: Characteristics of patients undergoing surgery at Children’s Hospitals and Non-Children’s Hospitals

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Total | Children's Hospitals (CH) | | Non-Children's Hospitals (NCH) |
| Characteristics |  | Tier A | Tier B |  |
| Hospitals | 12,669 | 280 | 1,079 | 11,310 |
| Patients | 368,220 | 118,977 | 75,256 | 173,987 |
| Patient-Level Characteristics |  |  |  |  |
| Female | 147,321 | 46,401 (39%) | 27,845 (37%) | 73,075 (42%) |
| Male | 220,899 | 72,576 (61%) | 47,411 (63%) | 100,912 (58%) |
| Hospital-Level Characteristics |  |  |  |  |
| Bed Size (mean) | --- | 263 | 647 | 210 |
| Nonprofit (mean) | 9,194 (72.6%) | 274 (98%) | 777 (72%) | 8,143 (72%) |
| Teaching (mean) | 1,384 (10.9%) | 101 (36%) | 604 (56%) | 679 (6%) |
| Procedures |  |  |  |  |
| Strabismus Surgery | 13,615 | 6,339 | 3,232 | 4,044 |
| Tympanostomy Tube Placement | 99,254 | 33,614 | 15,108 | 50,532 |
| Tonsillectomy and Adenoidectomy | 104,163 | 28,640 | 18,302 | 57,221 |
| Repair of Humerus Fracture | 14,719 | 5,480 | 3,749 | 5,490 |
| ACL Repair | 736 | 123 | 107 | 506 |
| Posterior Spinal Fusion for Scoliosis | 4,384 | 2,027 | 1,282 | 1,075 |
| Anti-Reflux Surgery | 876 | 312 | 387 | 177 |
| Cholecystectomy | 426 | 76 | 87 | 263 |
| Appendectomy for Acute Appendicitis | 35,471 | 8,906 | 8,303 | 18,262 |
| Umbilical Hernia Repair | 8,241 | 3,535 | 2,682 | 2,024 |
| Inguinal Hernia Repair, Nonobstructive | 16,273 | 6,503 | 5,261 | 4,509 |
| Orchiopexy for Undescended Testicles | 7,831 | 3,199 | 2,605 | 2,027 |
| Circumcision | 16,666 | 5,864 | 4,857 | 5,945 |
| Concurrent Procedures | 45,565 | 14,359 | 9,294 | 21,912 |

Figure 2: Mean payments from commercial insurers using Health Care Cost Institute data for common procedures at Children’s Hospitals and Non-Children’s Hospitals

CH-A: Children’s Hospital Tier A (freestanding children’s hospital)

CH-B: Children’s Hospital Tier B (children’s hospital attached to adult hospital)

NCH: Non-Children’s Hospital

Table 2: Rate of surgical complications and readmissions

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **Any Complication** | | | **Readmissions** | | | | | | | | |
|  |  | | | **30-Day** | | | **60-Day** | | | **90-Day** | | |
| Procedures | CH-A | CH-B | NCH | CH-A | CH-B | NCH | CH-A | CH-B | NCH | CH-A | CH-B | NCH |
| Rate (SD) | Rate (SD) | Rate (SD) | Rate (SD) | Rate (SD) | Rate (SD) | Rate (SD) | Rate (SD) | Rate (SD) | Rate (SD) | Rate (SD) | Rate (SD) |
| All Procedures | <0.01 (0.06) | 0.01 (0.07) | <0.01 (0.06) | 0.01 (0.1) | 0.01 (0.11) | 0.01 (0.08) | 0.01 (0.12) | 0.01 (0.12) | 0.01 (0.1) | 0.02 (0.13) | 0.02 (0.13) | 0.01 (0.1) |
| Tonsillectomy and Adenoidectomy | <0.01 (0.04) | <0.01 (0.04) | <0.01 (0.02) | 0.01 (0.11) | 0.01 (0.11) | 0.01 (0.08) | 0.01 (0.12) | 0.01 (0.12) | 0.01 (0.08) | 0.02 (0.12) | 0.02 (0.13) | 0.01 (0.09) |
| Repair of Humerus Fracture | <0.01 (0.02) | <0.01 (0.04) | <0.01 (0.04) | 0.01 (0.07) | 0.01 (0.08) | 0.01 (0.11) | 0.01 (0.09) | 0.01 (0.09) | 0.01 (0.12) | 0.01 (0.11) | 0.01 (0.1) | 0.02 (0.13) |
| Posterior Spinal Fusion for Scoliosis | 0.05 (0.21) | 0.06 (0.23) | 0.05 (0.21) | 0.04 (0.2) | 0.04 (0.19) | 0.03 (0.17) | 0.05 (0.22) | 0.05 (0.21) | 0.03 (0.18) | 0.05 (0.22) | 0.05 (0.22) | 0.04 (0.2) |
| Appendectomy for Acute Appendicitis | 0.03 (0.16) | 0.03 (0.17) | 0.02 (0.15) | 0.03 (0.17) | 0.03 (0.17) | 0.02 (0.15) | 0.03 (0.18) | 0.04 (0.18) | 0.03 (0.16) | 0.04 (0.19) | 0.04 (0.19) | 0.03 (0.17) |

CH-A: Children’s Hospital Tier A (freestanding children’s hospital)

CH-B: Children’s Hospital Tier B (children’s hospital attached to adult hospital)

NCH: Non-Children’s Hospitals

SD: Standard Deviation

Table 3: Regression coefficients for 90-day complications, 90-day readmissions, and log negotiated hospital payments by commercial insurers after adjusting for zip code, year, month, surgery, surgery setting, complex chronic conditions, and observable patient, hospital, and county characteristics.



|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Hospital Type | Outcomes Coefficientsᵠ | | Hospital Payment Coefficients‡ | | | | | | | |
| 90-day Complications | 90-day Readmissions | All Procedures | | Appendectomy | | Humerus Fracture | | Tonsillectomy | |
| All Inpatient Procedures  (p-value) | All Inpatient Procedures  (p-value) | Inpatient (p-value) | Outpatient (p-value) | Inpatient (p-value) | Outpatient (p-value) | Inpatient (p-value) | Outpatient (p-value) | Inpatient (p-value) | Outpatient (p-value) |
| CH-A | 0.23 (0.68) | 0.26 (0.56) | 0.39 (<0.001) | 0.34 (<0.001) | 0.43 (<0.001) | 0.33 (0.16) | 0.15 (0.61) | 0.27  (0.30) | 0.30 (0.12) | 0.46 (<0.001) |
| CH-B | -0.05 (0.81) | -0.02 (0.93) | -0.02 (0.54) | 0.03 (0.42) | -0.03 (0.41) | 0.11 (0.30) | -0.06 (0.51) | 0.20  (0.16) | -0.04 (0.63) | 0.02 (0.47) |
| NCH | Ref | Ref | Ref | Ref | Ref | Ref | Ref | Ref | Ref | Ref |

CH-A: Freestanding children’s hospitalCH-B: Children’s hospital attached to an adult hospital

NCH: Non-children’s hospital

Ref: Reference

ᵠ: Regression coefficients are estimated using a generalized linear model with a binomial family and logit link function

‡: Regression coefficients are estimated using an ordinary least squares model