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Reducing cost and waste in pediatric laparoscopic procedures☆

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ABSTRACT

Background: In 2017 the healthcare cost in the United States accounted for 17.9% of the Gross Domestic Product (GDP). Furthermore, healthcare facilities produce more than 4 billion pounds of waste annually. Interhospital and intersurgeon variabilities in surgical procedures are some of the drivers of high healthcare cost and waste. We sought to determine the effect of a monthly surgeon report card detailing the utilization and cost of disposable and reusable surgical supplies on cost and waste reduction for pediatric laparoscopic procedures.
Methods: Starting in July 2017, surgeons were provided with an individual report with supply cost per case, high cost, and disposable supply utilization, and clinical outcomes. Cost, utilization, and clinical outcomes six quarters before and after the intervention were compared.
Results: A total of 998 pediatric laparoscopic procedures were analyzed. We reduced the median supply cost per case by 43% after the intervention with total cost savings of $71,035 for the first four quarters. We also reduced the use of disposable trocars by 56% and the use of disposable harmonics and staplers by 33%.
Conclusions: Using a periodic surgeon report card, we significantly reduced supply cost and utilization of disposable items for all pediatric laparoscopic procedures performed at the University of Wisconsin American Family Children's Hospital.
Type of study: Cost effectiveness study.
Level of evidence: Level III.

In 2017, the cost of healthcare in the United States accounted for 17.9% of the Gross Domestic Product (GDP) [1]. With the growing public awareness of high healthcare cost, there is an increasing emphasis on value-based healthcare, which is defined as health outcomes achieved per dollar spent [2]. One clear way to achieve value-based healthcare is to reduce waste. It is estimated that the cost of waste in U.S. health care ranges from $760 billion to $935 billion [3]. Furthermore, healthcare facilities produce more than 4 billion pounds of waste annually, with operating rooms and labor-delivery units accounting for about 70% of the hospital waste [4]. Changes are needed at the national and organizational level. However, the choice of consumables used in the operating room is an area where the surgeons can have a direct financial and environmental impact.

Interhospital and intersurgeon variability in surgical procedures has been cited as one of the drivers of high healthcare cost and waste [5–8]. At the same time, higher cost does not always result in better care [7], even for a complex surgical procedure such as a pancreaticoduodenectomy [9]. In addition to surgeon preference, lack of knowledge of the cost of surgical supplies is one of the main reasons for the variability. Although earlier studies did not show cost reduction with cost transparency, more recent reports showed periodic or real-time feedback on cost successfully reduces variability and cost without compromising clinical outcomes [9–15]. In pediatric surgery, since laparoscopic appendectomy is the most common surgical procedure, much effort has been made to streamline the surgical management of appendicitis [11,13]. However, there are a limited number of studies on whether similar efforts can be made for all laparoscopic procedures performed by general pediatric surgeons without sacrificing clinical outcomes.

In this quality improvement intervention, we used a monthly report card detailing the utilization and cost of disposable, high-cost surgical supplies for individual surgeons. We determined whether we could reduce the cost and waste in pediatric laparoscopic procedures without affecting clinical outcomes using this approach.

1. Methods

1.1. Participants

The study population consisted of pediatric surgical patients who underwent laparoscopic procedures at the University of Wisconsin American Family Children's Hospital in Madison between January

☆ *How this paper will improve care: Using monthly surgeon report cards to increase awareness of surgical supply costs and the utilization of disposable and high-cost items, surgeons can bring changes to reduce cost and waste in pediatric laparoscopic procedures without affecting clinical outcomes.*

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2016 and March 2019. Baseline data included four pediatric surgeons, and postintervention data included the same four surgeons. One surgeon joined the division after the intervention period and was therefore excluded from the analysis. Six quarters before the intervention (January 1, 2016, to June 30, 2017) were compared to 6 quarters after the intervention (October 1, 2017, to March 31, 2019). All children 19 years or younger who underwent laparoscopic procedures were included in the analysis. The procedures included in the analysis are shown in Table 2. For the analysis of laparoscopic appendectomy, interval appendectomy, as well as laparoscopic appendectomy for both perforated and nonperforated appendicitis, were included. If a patient underwent procedures other than a laparoscopic appendectomy, they were excluded from the analysis of laparoscopic appendectomies. This study was done as a part of the Division of Pediatric Surgery's quality improvement initiatives and was exempt from institutional review board (IRB) review.

1.2. Data source

Actual medical supply cost data were obtained from the Materials Management Information System (MMIS) PeopleSoft. Surgical procedure-specific cost data were obtained from electronic health records (EHRs) (Epic), and the local coalescing software program QlikView. Patient demographics, procedure time, and length of stay were obtained through EHRs, and the complication data were obtained through the ACS NSQIP Pediatric database based on Current Procedural Terminology (CPT) codes. NSQIP morbidities included pneumonia, reintubation without ventilator dependent renal insufficiency or renal failure, urinary tract infection, bloodstream infection associated to a central line, coma greater than 24 h without preoperative coma, seizure, peripheral nerve injury, any cerebral intraventricular hemorrhage, CVA/stroke or intracranial hemorrhage, cardiac arrest requiring CPR, venous thrombosis requiring therapy, sepsis, superficial, deep or organ/space infection, bleeding event requiring transfusion equal to or greater than 25 ml/kg and deep wound disruption.

1.3. Intervention design

Before the intervention, each surgeon was shown the actual cost of surgical supplies used in laparoscopic procedures before the intervention and the percentage of the total supply cost before the intervention that was because of high-cost items. Each report showed the data for every surgeon broken down by surgeon. In our analysis, each surgeon was compared to their colleagues, with specifics on both the number of items used and cost of those items per case and per quarter. For laparoscopic appendectomy specifically, surgeons were encouraged to use reusable trocars, ENDOLOOP™ ligatures or sutures instead of staplers, electrocautery instead of harmonics and a finger of a sterile size 9 glove instead of an Endo Catch™ specimen retrieval pouch to retrieve the appendix. Quality of patient outcomes was also compared in terms of hospital acquired conditions (HACs) such as surgical site infections (SSIs), hospital length of stay, patient readmission rates, and total operating room and procedure times. After the initial meeting, each surgeon was provided with an individual report with supply cost per case, supply utilization and clinical outcomes for themselves and their colleagues. The reports were delivered monthly for the first 6 months and quarterly thereafter. The reports were reviewed in group meetings to generate discussions and consensus. Individual procedure “receipts” showing the cost of the items used were delivered as early as the day after surgery. Baseline data (January 1, 2016–June 30, 2017) was compared to postintervention data (October 2017–March 31, 2019) with the surgeon's examination of their procedure medical supply costs and ensuing discussion used as the focal point for measuring before and after data.

1.4. Analysis of cost data

Cost data were extracted at an individual patient level for individual items used for a given procedure. The analysis focused on the total cost of used supplies; therefore, the indirect variable cost, and indirect fixed cost and professional charge were not included in the analysis. Decrease in supply cost achieved for the first four quarters after the intervention is defined as cost savings, and afterward it is referred to as cost avoidance. Decrease in supply cost each quarter was defined as the difference between the mean supply cost before the intervention and mean supply cost after the intervention multiplied by the number of cases for that quarter. Cost avoidance was calculated in the same way.

1.5. Statistical analysis

Patient characteristics were analyzed descriptively. Cost measures, procedure length and length of stay were summarized by median and interquartile range, and categorical measures were summarized by counts and percentages. Comparison of the cost, procedure time and length of stay was performed using the Wilcoxon rank sum test, and comparisons of complications and number of cases were performed using Fisher's exact test. To account for potential confounding, we fit a linear mixed effects model with random intercept on our primary outcomes. Adjustment variables included age of the patients and the procedure type. A random intercept for surgeon was used to account for clustering of observations by surgeon. Statistical analysis was performed using R 3.6.1.

2. Results

2.1. Demographic characteristics

Between January 2016 and March 2019, a total of 998 laparoscopic procedures were performed by the four surgeons and were included in the final analysis. There were 576 procedures before the intervention and 422 procedures after the intervention. The demographics of the patients included in the analysis are shown in Table 1.

2.2. Cost outcomes of all laparoscopic procedures

Between January 1, 2016 and March 31, 2019, there were a total of 998 laparoscopic procedures included in the analysis. One hundred and five procedures performed during the intervention period (July 2017–September 2017) were not included in the analysis. The median supply cost of all laparoscopic procedures decreased by 42.6% with the median cost of $446 (IQR $297–827) before the intervention and $256 (IQR $143–490) after the intervention ($p < 0.001$) (Fig. 1A). The percentage decrease of the median cost varied by surgeon between 18.5% and 62.4% (Fig. 1B). This resulted in a total cost savings of $71,035 for the first four quarters and a total cost avoidance of $38,875 for the subsequent two quarters. From the mixed effects model analysis which accounted for potential confounders, we found that intervention had a significant reduction on supply cost ($p = 0.012$).

Two of the high-cost items were ultrasonic vibration devices that both cut and cauterize tissue (average cost $465) and laparoscopic staplers (average cost $279) with reload staples (average cost $229). Before the intervention, 21% of the cases used the high-cost items, whereas after the intervention, 16% of the cases used the high-cost items ($p =$ ns).

The use of disposable trocars decreased from 1.8 trocars per case (IQR 1.7–1.9) before the intervention to 0.8 trocar per case (IQR 0.6–0.9) after the intervention ($p = 0.0022$). The use of disposable harmonic devices and staples decreased from 0.52 item per case (IQR 0.29–0.63) before the intervention to 0.23 item per case (IQR 0.036–0.46) after the intervention ($p = 0.023$) (Fig. 2).

Table 1
Patient demographic.

	Before (n = 576)	After (n = 422)	p-value
Age			
Mean (SD)	6.17 (6.07)	5.90 (5.82)	0.62
Median [min, max]	5.00 [0.00, 19.0]	4.00 [0.00, 17.0]	
BMI			
Mean (SD)	16.4 (7.13)	17.3 (18.2)	0.62
Median [min, max]	16.3 [0.00, 77.4]	16.3 [0.00, 291]	
Missing	0 (0%)	1 (0.2%)	
Gender			
F	216 (37.5%)	164 (38.9%)	0.69
M	360 (62.5%)	258(61.1%)	
Ethnicity			
Hispanic/Latino	75 (13.0%)	49 (11.6%)	0.57
Not Hispanic or Latino	492 (85.4%)	366 (86.7%)	
Patient declines to answer	4 (0.7%)	1 (0.2%)	
Unavailable	5 (0.9%)	6 (1.4%)	
Race			
American Indian or Alaska Native	13 (2.3%)	5 (1.2%)	0.69
Asian	27 (4.7%)	21 (5.0%)	
Black or African American	38 (6.6%)	32 (7.8%)	
Native Hawaiian or other Pacific Islander	3 (0.5%)	1 (0.2%)	
Patient declines to answer	16 (2.8%)	9 (2.1%)	
Unavailable	5 (0.9%)	7 (1.7%)	
White	474 (82.3%)	347 (82.2%)	
ASA status			
-	0 (0%)	1 (0.2%)	0.11
1	155 (26.9%)	121 (28.7%)	
2	257 (44.6%)	198 (46.9%)	
3	132 (22.9%)	91 (21.6%)	
4	32 (5.6%)	11 (2.6%)	

2.3. Clinical outcomes of all laparoscopic procedures

The number of laparoscopic procedures by type before and after the intervention is shown in Table 2. There was no significant difference between the number of procedures except for laparoscopic fundoplications ($p < 0.001$) and laparoscopic anorectal pull-through ($p = 0.032$). The median procedure time prior to intervention was 52 min (IQR 34–93 min) and 55 min after the intervention (IQR 37–96 min) ($p = 0.15$). The median total OR time was 97 min (IQR 76–148 min) before the intervention and 103 min (IQR 79–146 min) after the intervention ($p = 0.089$). The median total length of stay after the surgery was 1.11 days (IQR 0.35–3.66) before the intervention and 1.10 days (IQR 0.31–3.14 days) after the intervention ($p = 0.51$). There were 52 NSQIP complications before the intervention and 36 after the intervention ($p = 0.80$).

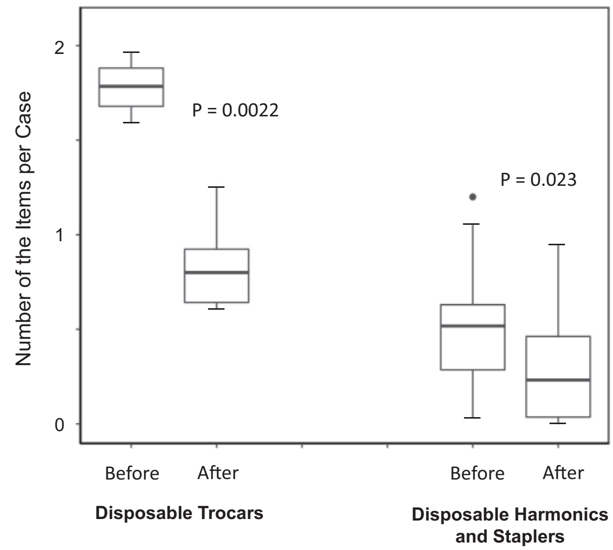

Fig. 2. Reduction in the use of disposable trocars, harmonic devices and staplers before the intervention (January 2016–June 2017) and after the intervention (October 2017–March 2019).

2.4. Cost outcomes of laparoscopic appendectomy

Before the intervention, the median supply cost of a laparoscopic appendectomy was $631 (IQR $330–1095.) Following the intervention, the median supply cost of a laparoscopic appendectomy was $235 (IQR $135–$565) ($p < 0.0001$) for the first four quarters with total savings of $25,407. For the next two additional quarters there was a total cost avoidance of $10,275 (Fig. 3A). The percentage decrease between surgeons varied between 73.0% and 87.5%, and two surgeons' costs increased by 1.3% and 46% (Fig. 3B).

2.5. Clinical outcomes of laparoscopic appendectomy

Median length of stay was 0.8 day (IQR 0.37–1.88) prior to intervention and 1.2 days (IQR 0.67–3.16) after the intervention ($p = 0.0014$). Median procedure time before the intervention was 50 min (IQR 39–62.5), and after the intervention it was 56 min (IQR 41.5–77) ($p < 0.001$). There were 12 postoperative complications before the intervention and 13 after the intervention ($p = 0.33$).

3. Discussion

At our institution, by improving the surgeons' knowledge of their utilization of individual surgical supplies as well as their cost through periodic report cards, we reduced the median supply cost per case by

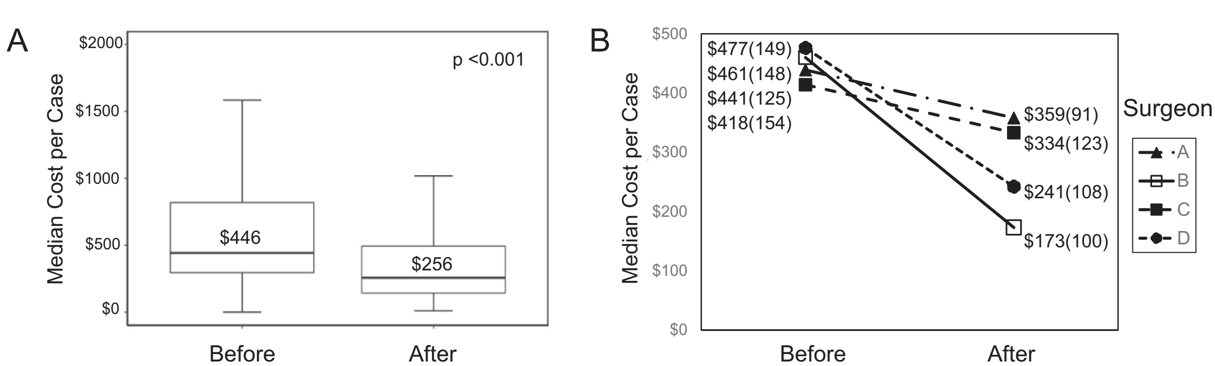

Fig. 1. Reduction in the median supply cost per case (A) and per individual surgeon (B) for all pediatric laparoscopic procedures before the intervention (January 2016–June 2017) and after the intervention (October 2017–March 2019). The number of procedures for each surgeon is shown in parentheses.

Table 2
List of included laparoscopic procedures.

	Before (n = 576)	After (n = 422)	P-value
Primary procedures			
Abdomen, colostomy, diverting loop, laparoscopy	1 (0.2%)	2 (0.5%)	0.58
Abdomen, laparoscopy	43 (7.5%)	36 (8.5%)	0.64
Abdomen, peritoneum & omentum; dx, laparoscopy	1 (0.2%)	0 (0%)	1
Anorectal pull-through, laparoscopic	4 (0.7%)	10 (2.4%)	0.03
Appendectomy, laparoscopy	167 (29.0%)	116 (27.5%)	0.53
Cholecystectomy, laparoscopy	14 (2.4%)	19 (4.5%)	0.11
Colostomy takedown, laparoscopy	1 (0.2%)	1 (0.2%)	1
Esophago/gastric, Nissen, Toupet, abdominal approach, laparoscopy	56 (9.7%)	19 (4.5%)	<0.001
Gastrostomy, tube placement, open/laparoscopy	110 (19.1%)	77 (18.2%)	0.63
Hernia repair, diaphragmatic/paraesophageal, laparoscopy	10 (1.7%)	4 (0.9%)	0.42
Herniorrhaphy, inguinal/femoral, laparoscopy	100 (17.4%)	83 (19.7%)	0.51
Herniorrhaphy, umbilical, laparoscopy	3 (0.5%)	2 (0.5%)	1
Herniorrhaphy; bilateral inguinal; laparoscopic	12 (2.1%)	9 (2.1%)	1
Ileostomy laparoscopy	7 (1.2%)	2 (0.5%)	0.32
Laparoscopy neuroblastoma	0 (0%)	2 (0.5%)	0.18
Laparoscopy, possible orchiopexy, abdominal approach	0 (0%)	1 (0.2%)	0.42
Peritoneal dialysis catheter insertion, laparoscopy	1 (0.2%)	2 (0.5%)	0.58
Pouch, colectomy, abd w/proctectomy w/ileoanal anastomosis/ileal reservoir/loop ileosomy, laparoscopy	4 (0.7%)	3 (0.7%)	1
PSARP, anorectoplasty w laparoscopic ileostomy	5 (0.9%)	6 (1.4%)	0.54
Pyloromyotomy, cutting, pyloric muscle, open or laparoscopy	20 (3.5%)	23 (5.5%)	0.16
Splenectomy, laparoscopy	6 (1.0%)	3 (0.7%)	0.74
Total/sigmoid colectomy, low anterior resection, laparoscopy	1 (0.2%)	0 (0%)	1
Urachal excision: laparoscopic	4 (0.7%)	5 (1.2%)	0.51
Ventral hernia repair, laparoscopy	6 (1.0%)	8 (1.9%)	0.29

42.6%, resulting in annual cost saving of $71,035. Furthermore, we were able to reduce the utilization of high-cost items as well as disposable items. There was no significant change in the number of complications, the total procedure time or the length of stay.

Other studies have reported cost savings of 20%–64% for pediatric laparoscopic appendectomy through standardizing surgical supply lists [11–13]. One large prospective study involving multiple adult surgical specialties showed cost reduction of 9.95% with a total one-year savings of $836,147 through the utilization of surgeon scorecards with cost information and departmental financial incentives [10]. However, to our knowledge, this study is the first study showing the effectiveness of report cards informing surgeons of the cost and their utilization of high-cost and disposable items in reducing overall cost, not only for laparoscopic appendectomy but for all pediatric laparoscopic procedures.

There are a few potential factors to which we can attribute our success. The first is cost awareness. Others have shown that surgeons across specialties and training levels have poor awareness of cost [16–18]. However, when they are shown the cost of individual items, given the same efficacy, they are likely to choose lower cost items [19,20]. Studies have also shown that the scorecard system can appeal to the competitive nature of physicians to bring about positive changes for value-based care [10,21]. For the first six months, we provided monthly feedback on total supply cost per case per surgeon allowing comparison of colleagues. After the first six months, the scorecard is now being provided every quarter. However, one study showed that the cost feedback alone might not be enough to bring about widespread change [22]. In addition to the regular cost report, the surgeons also met regularly to compare their utilization, cost, and quality data to their colleagues', generating discussions regarding the differences in usage of high-cost medical supply choices. This may be more difficult at a hospital-wide level but certainly is achievable at a division level.

Although we saw an overall reduction in disposable surgical supply cost, the percentage reduction was variable among the surgeons. For example, one surgeon continued to prefer laparoscopic staplers in a high proportion of their cases, whereas another surgeon favored the use of sutures. An increase in the cost of the staplers during the postintervention period likely affected the overall cost per case for this surgeon. Additionally, one surgeon favored the use of the ultrasound vibration devices when their colleagues favored cautery. The variation among colleagues in the same surgical division performing the same procedures

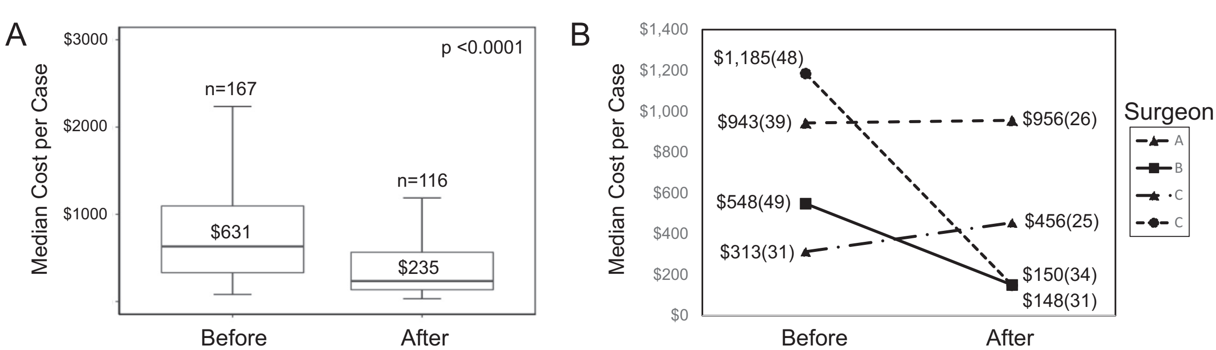

Fig. 3. Reduction in the median supply cost per case (A) and per individual surgeon (B) for pediatric laparoscopic appendectomy before the intervention (January 2016–June 2017) and after the intervention (October 2017–March 2019). The number of procedures for each surgeon is shown in parentheses.

was emphasized in the group discussions. One possible way to further decrease the surgeon-to-surgeon variability and increase the cost saving might be to implement financial or academic incentives [10,23].

This variation in surgeon preference may also have affected the procedure time of laparoscopic appendectomies. Although we observed a significant decrease in median supply cost for laparoscopic appendectomies, we also observed an increase in procedure time (6 min) and total length of stay (0.4 days) even though the procedure time and total length of stay for all procedures did not change significantly. When we examined each surgeon individually (data not shown), the surgeon who performed almost all of their laparoscopic appendectomies using electrocautery and sutures had no change in their procedure time whereas two surgeons who used both methods had an increase in their procedure time. One potential explanation is that by using one method most of the time, the surgeon was able to overcome the learning curve more quickly and become proficient with the new methods, therefore not affecting the length of the procedure. Although this needs to be further investigated, this highlights the importance of standardizing and adopting the new methods as a group to bring about effective cost savings [12,13]. One of the potential causes of the increase in total length of stay was a change in hospital staffing that occurred after the intervention period. Given the overall shorter length of stay after laparoscopic appendectomy compared to more complex procedures, delays in the discharge process may affect the total length of stay more significantly.

One of the potential limitations of this study that may affect the generalizability of the study's results is the small number of surgeons in our practice. However, despite the small size, the level of experience among the surgeons in our group varies from early to midcareer faculty. Also, there was still variability among surgeon preferences, even after the intervention, and we were still able to generate significant cost savings. Another limitation of this study is that, because we relied on NSQIP database for the report of complications, the number of complications may be underrepresented if patients presented to different hospitals postoperatively.

4. Conclusions

Using monthly and quarterly surgeon report cards detailing the utilization and cost of disposable and reusable surgical supplies, we were able to reduce supply cost per case and the utilization of disposable items for all pediatric laparoscopic procedures without increasing complications for University of Wisconsin pediatric surgeons from 2016 to 2019. Our result reinforces the idea that higher cost care does not equal better care and that surgeons should be the leaders in taking steps toward value-based and environmentally conscious health care.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jpedsurg.2020.09.052.

References

[1] Centers for Medicare & Medicaid Services. National health expenditure fact sheet. https://www.cms.gov/Research-Statistics-Data-and-Systems/Statistics-Trends-and-Reports/NationalHealthExpendData/NHE-Fact-Sheet.html;. accessed May 16, 2019.2019.
[2] Porter ME, Teisberg EO. How physicians can change the future of health care. JAMA. 2007;297(10):1103–11.
[3] Shrank WH, Rogstad TL, Parekh N. Waste in the US health care system: estimated costs and potential for savings. JAMA. 2019;322(15):1501–9.
[4] Kwakye G, Brat GA, Makary MA. Green surgical practices for health care. Arch Surg. 2011;146(2):131–6.
[5] Cameron DB, Graham DA, Milliren CE, et al. Quantifying the burden of interhospital cost variation in pediatric surgery: implications for the prioritization of comparative effectiveness research. JAMA Pediatr. 2017;171(2):e163926.
[6] Rice-Townsend S, Barnes JN, Hall M, et al. Variation in practice and resource utilization associated with the diagnosis and management of appendicitis at freestanding children's hospitals: implications for value-based comparative analysis. Ann Surg. 2014;259(6):1228–34.
[7] Tsugawa Y, Jha AK, Newhouse JP, et al. Variation in physician spending and association with patient outcomes. JAMA Intern Med. 2017;177(5):675–82.
[8] Zygourakis CC, Yoon S, Valencia V, et al. Operating room waste: disposable supply utilization in neurosurgical procedures. J Neurosurg. 2017;126(2):620–5.
[9] Gitelis M, Vigneswaran Y, Ujiki MB, et al. Educating surgeons on intraoperative disposable supply costs during laparoscopic cholecystectomy: a regional health system's experience. Am J Surg. 2015;209(3):488–92.
[10] Zygourakis CC, Valencia V, Moriates C, et al. Association between surgeon scorecard use and operating room costs. JAMA Surg. 2017;152(3):284–91.
[11] Robinson JR, Carter NH, Gibson C, et al. Improving the value of care for appendectomy through an individual surgeon-specific approach. J Pediatr Surg. 2018;53(6):1181–6.
[12] Skarda DE, Rollins M, Andrews S, et al. One hospital, one appendectomy: the cost effectiveness of a standardized doctor's preference card. J Pediatr Surg. 2015;50(6):919–22.
[13] Avansino JR, Goldin AB, Risley R, et al. Standardization of operative equipment reduces cost. J Pediatr Surg. 2013;48(9):1843–9.
[14] Simon KL, Frelich MJ, Gould JC. Picking apart surgical pick lists — reducing variation to decrease surgical costs. Am J Surg. 2018;215(1):19–22.
[15] Brauer DG, Hawkins WG, Strasberg SM, et al. Cost variation in a laparoscopic cholecystectomy and the association with outcomes across a single health system: implications for standardization and improved resource utilization. HPB (Oxford). 2015; 17(12):1113–8.
[16] Okike K, O'Toole RV, Pollak AN, et al. Survey finds few orthopedic surgeons know the costs of the devices they implant. Health Aff (Millwood). 2014;33(1):103–9.
[17] Jackson CR, Eavey RD, Francis DO. Surgeon awareness of operating room supply costs. Ann Otol Rhinol Laryngol. 2016;125(5):369–77.
[18] Paine AN, Krompf BL, Osler TM, et al. Surgeons and surgical trainees underestimate the total charges and reimbursements associated with commonly performed general surgery procedures. J Surg Educ. 2019;76(3):802–7.
[19] Tabib CH, Bahler CD, Hardacker TJ, et al. Reducing operating room costs through real-time cost information feedback: a pilot study. J Endourol. 2015;29(8):963–8.
[20] Guzman MJ, Gitelis ME, Linn JG, et al. A model of cost reduction and standardization: improved cost savings while maintaining the quality of care. Dis Colon Rectum. 2015;58(11):1104–7.
[21] Gunaratne K, Cleghorn MC, Jackson TD. The surgeon cost report card: a novel cost-performance feedback tool. JAMA Surg. 2016;151(1):79–80.
[22] Zhao B, Tyree GA, Lin TC, et al. Effects of a surgical receipt program on the supply costs of five general surgery procedures. J Surg Res. 2019;236:110–8.
[23] Dearing JW, Cox JG. Diffusion of innovations theory, principles, and practice. Health Aff (Millwood). 2018;37(2):183–90.