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# Assessment of variation in care and outcomes for pediatric appendicitis at children's and non-children's hospitals

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ABSTRACT

*Background:* Variation in care may indicate an opportunity for quality improvement and to decrease waste. Variation in appendicitis practice, resource use, and costs have not been well studied at non-children's hospitals (NCHs) where most children undergo care. The purpose of this study was to quantify variation in care for perforated pediatric appendicitis within and between children's hospitals (CHs) and NCH.
*Methods:* Using the 2012 Kids' Inpatient Database, 11,216 children with perforated appendicitis were identified. Comparisons between CH and NCH were made in regard to operative approach (open versus laparoscopic), central line (CL) and total parenteral nutrition (PN) use, complication rates, length of stay (LOS), and total costs.
*Results:* NCHs cared for 8051 patients (72%) with perforated appendicitis. CHs were more likely to perform a laparoscopy compared to NCHs (odds ratio (OR) 10.2, 95% confidence interval (95% CI) 5.7–18.2), and to utilize CL or PN than NCHs (CL OR 2.4 (95% CI 1.5–3.8), PN OR 2.6 (95% CI 1.4–4.9)). Composite complication rates were lower at CH (OR 0.5 (95% CI 0.4–0.6)). While LOS was not different between CH and NCH in the fully adjusted model, costs were higher at CH (OR 6.8 (95% CI 3.9–12.2)). Low and high outliers could be identified for each variable and outcome of interest with no consistent performance regardless of CH or NCH status.
*Conclusions:* Variation in operative approach, resource use, complications, LOS, and costs exist in the management of pediatric perforated appendicitis with greatest variation observed at NCH. Future quality improvement efforts should be tailored for implementation at both CH and high-volume NCH.


Each year there are over 80,000 appendectomies performed in children in the U.S. and appendectomy represents the primary reason why children undergo abdominal surgery [1]. It is estimated that 30%–40% of patients with appendicitis present with perforation and the postoperative course for these patients is often complicated by wound and intraabdominal infections and extended lengths of stay when compared to patients with acute appendicitis. Variation in resource utilization, management, and outcomes for children with appendicitis have been demonstrated at children's hospitals (CHs) but little is known about the incidence and nature of complications as well as outcomes at non-children's hospitals (NCHs) [2,3]. NCHs perform the vast majority of surgeries in children in the U.S. for common diseases such as appendicitis. Variation in the delivery of care has been identified as a key driver of healthcare costs and is a potential target for quality improvement efforts [4,5]. As efforts move forward to improve quality of care, optimize outcomes, and increase value in children's surgery, it is imperative to include assessment of resource utilization and outcomes at NCH for common surgical conditions such as appendectomy.

The purpose of this study was to evaluate variation in perforated appendicitis care within and between CH and NCH using a large, administrative data set. We hypothesize that the observed variations in care are greater when including a broader range of hospital types. Furthermore, we anticipate that the patient population, postoperative course, and costs for patients with appendicitis will be different when comparing CH and NCH.

## 1. Methods

### 1.1. Data source

For this retrospective cohort study inpatient admissions for pediatric appendicitis patients were examined using the 2012 Kids' Inpatient Database (KID), Healthcare Cost and Utilization Project (HCUP), and Agency for Healthcare Research and Quality [6]. The KID is the largest publicly-available all-payer pediatric inpatient care database in the U.S. and includes a sample of pediatric discharges from all community, nonrehabilitation hospitals. The KID is released every three years and 2012 is the most recent year available. Data from 2012 included inpatient hospitalizations from 44 states, 4100 hospitals, and over 3 million

*Abbreviations:* CH, children's hospitals; CL, central line; HCUP, Healthcare Cost and Utilization Project; ICD-9, *International Classification of Diseases, Ninth Revision*; KID, Kids' Inpatient Database; LOS, length of stay; NCH, non-children's hospitals; O/E, observed to expected; PN, parenteral nutrition.

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discharges. The data set provides demographic, clinical and payment information, severity of illness and comorbidity measures, *International Classification of Diseases, Ninth Revision, Clinical Modifications* (ICD-9) diagnostic and procedural codes, and basic characteristics about hospitals. Charge to cost conversion files are provided by HCUP [7]. This study was not considered human subject research by the Children's Healthcare of Atlanta Institutional Review Board and was exempt from review because of the de-identified nature of the KID.

### 1.2. Case selection

All KID discharges were searched for ICD-9 diagnostic codes for appendicitis (5400, 5401, 5409, 541) and procedure codes for appendectomy (4701, 4709) performed during 2012. We limited the population to patients aged 2–18 years and purposefully omitted patients undergoing incidental appendectomy. Patients who were born during the index hospitalization, transferred out, or had missing or invalid values for variables of interest were excluded (see Fig. 1). While some cost comparisons were made between patients with nonperforated and perforated appendicitis, the primary population in our study was hospitalizations for perforated appendicitis (5400 and 5401). In order to attempt to account for coding errors and increase sampling validity, only those patients with a length of stay (LOS) of greater than two days were considered a part of the final perforated appendicitis cohort [8].

### 1.3. Study definitions

In this study, freestanding children's hospitals were defined as CH, and other hospitals were considered as NCH owing to encrypted children hospital identifier provided by 2012 KID. This is an alteration to the hospital level data historically provided in the KID which also identified children's units nested within adult hospitals. The variables of interest for healthcare utilization included procedure type comparing laparoscopic and open surgical approach, as well as use of parenteral nutrition (PN) and central lines (CL). Outcomes of interest included complications, LOS and cost. Surgical approach (laparoscopic versus open appendectomy), utilization of PN and CL, and complications (sepsis, ileus, wound, urine, hemorrhage, and pulmonary) were identified by ICD-9 procedural and/or diagnostic codes (see Supplemental Table 1). While LOS and cost metrics from an administrative data source such as KID are reliable, the reliability of complications is admittedly less trustworthy [9]. For our purposes complication rates, with the inherent known limitations, were used to illustrate variation between centers and not as for their absolute value. LOS was provided in the database, and cost was estimated using total charge multiplied by the all-payer inpatient cost-to-charge ratios provided by HCUP. For each hospitalization, three composite variables were created for PN, CL, and complications. If LOS or cost of the hospitalization was greater than 90th percentile for the entire cohort, it was defined as extended LOS or high cost. In hospital-level assessment, rate-based measures were utilized to evaluate surgical approach, utilization of PN and CL as well as complications; hospital-specific median and interquartile range (IQR) were identified for LOS and cost. For rate-based measures, hospitals with less than 10 encounters were eliminated to avoid distortion from hospitals with small sample sizes. If the limits of 95% confidence intervals (CI) for rate-based variables were greater or less than the aggregate rate, the hospital was considered an outlier. When LOS and cost were assessed, if the IQR was greater or less than the median as calculated from all hospitals, the hospital was considered an outlier.

Other patient variables included age, gender, race, type of health insurance, median household income, patient location, comorbidities, and severity of illness. Comorbidities, including pulmonary diseases and obesity, were found using ICD-9 diagnostic codes and comorbidity measures provided by 2012 KID.

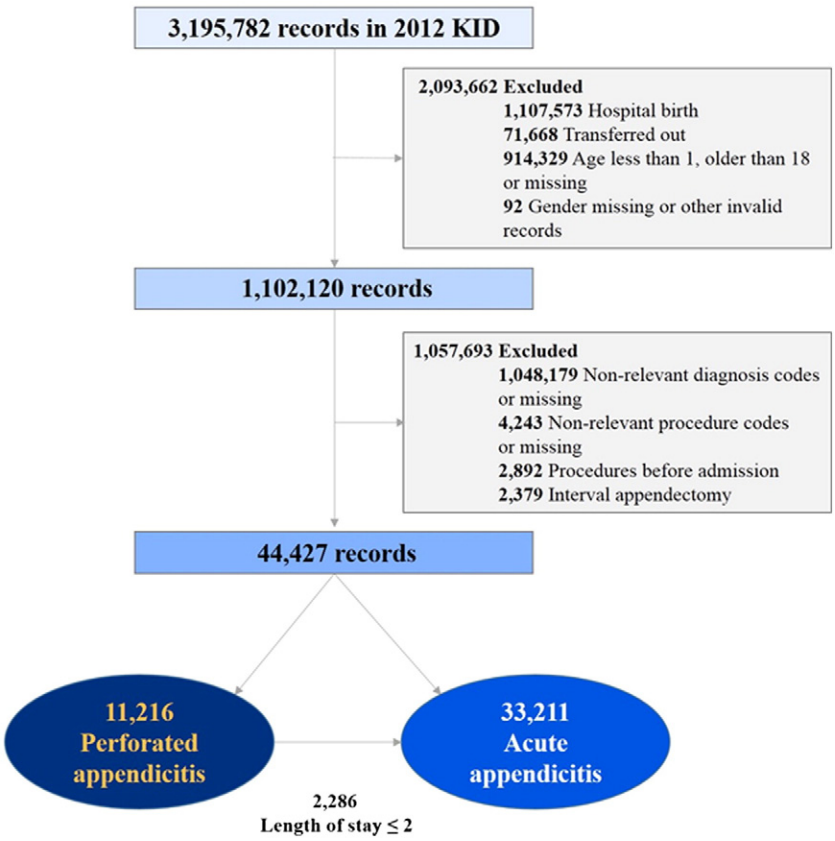


**Fig. 1.** Flow diagram of study selection of children undergoing appendectomy in the 2012 Kids' Inpatient Database (KID).