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Influence of hospital and patient location on early postoperative outcomes after appendectomy and pyloromyotomy☆,☆☆

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ABSTRACT

Background: The effects of hospital location and designation on postoperative pediatric outcomes remain unclear. We hypothesized that urban hospital outcomes would be superior to rural hospitals, and that outcomes at urban centers would differ for children from rural versus urban counties.
Methods: Retrospective cohort study of children undergoing appendectomy ($n = 129{,}507$) and pyloromyotomy ($n = 13{,}452$) using the 2006/2009 KID databases. Hospitals were characterized by specialty designation and classified as urban/rural. County of residence was classified as urban/rural. Outcomes included complications and length of stay. Multivariate regression models were used to adjust for confounding.
Results: Among appendectomy patients, treatment at urban hospitals was associated with reduced odds of any postoperative complication (OR = 0.77, 95% C.I. 0.70–0.85) and anesthesia-related complications (OR = 0.72, 95% C.I. 0.57–0.91). This association was strongest in the youngest children (<5 years) and at children's hospitals. For pyloromyotomy patients, urban hospitals were associated with reduced odds of any complication (OR = 0.43, 95% C.I. 0.24–0.75), anesthesia-related complications (OR = 0.14, 95% C.I. 0.05–0.37), and duodenal perforation (OR = 0.46, 95% C.I. 0.19–1.07). These associations were most significant at children's hospitals.
Conclusions: Postoperative outcomes appear to be improved at urban specialty hospitals relative to rural hospitals for certain common pediatric procedures. Identification of the factors driving this association may help inform resource optimization efforts in pediatric surgery.

Hospital and physician characteristics have long been thought to affect health care outcomes [1]. Studies suggest that center and practitioner operative volume and comfort level with certain procedures are important drivers of outcomes in adults [2–4]. A similarly rigorous body of evidence is missing in the pediatric surgical literature, and the effects of institution and surgeon-level variables on outcomes remain unclear. Specifically, the role of hospital location and designation, while shown to be important in the adult literature, has not been extensively evaluated in children's surgery, despite the fact that many procedures in children are performed at a wide variety of hospital types [5–8].

It has been suggested that the differences in outcomes between hospital types reflects differences in resources at specialized versus nonspecialized centers [9]. Studies looking at hospital designation and children's surgical outcomes have occasionally found superior outcomes at children's centers, but these studies are often small and results are inconsistent [10–13]. In addition, these studies do not specifically examine outcomes at rural centers. Recent studies in both adults and children suggest that outcomes may be inferior for specific procedures performed at rural centers [8,14]. Furthermore, patients undergoing treatment far from home, specifically rural residents treated at urban centers, may experience different care than their urban counterparts, either by virtue of lengthy travel distances or inherently different disease characteristics. As such, both hospital location and patient residence are important factors that may influence outcomes, and are key considerations in efforts to define referral standards for children with surgical conditions.

We hypothesized that postoperative outcomes for common procedures would be better for urban compared to rural hospitals, and that freestanding children's hospitals in particular would have the best outcomes. We also hypothesized that among children treated at urban hospitals, outcomes would differ based on the patient's county of residence (rural versus urban).

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1. Methods

1.1. Study design and setting

We performed a retrospective cohort study using the Healthcare Cost and Utilization Project's (HCUP) Kid's Inpatient Database (KID) [15]. This database includes a sample of pediatric discharges from community, nonrehabilitation hospitals across the United States. Thirty-eight states are represented in the 2006 edition of KID, and 44 states in the 2009 edition. The study utilized data from the 2006 and 2009 KID database releases. The University of Washington Institutional Review Board reviewed the study and determined it to be exempt from review.

1.2. Study subjects

The study included patients undergoing one of two procedures: nonincidental appendectomy and pyloromyotomy. Appendectomy admissions were defined as patients younger than age 20 years with a procedure code for appendectomy (ICD-9 47.0, 47.01, 47.09) in the absence of any procedure code for incidental appendectomy (47.1, 47.11, 47.19). Patients with neoplasms of the appendix, cecum or right colon were excluded. Pyloromyotomy admissions were defined as a procedure code for pyloromyotomy (43.3) in conjunction with a diagnostic code for infantile hypertrophic pyloric stenosis (750.5). Patients older than one year of age were excluded.

1.3. Variables of interest

The primary exposures of interest included hospital location and designation, as well as rurality of patients' county of residence. Hospital designations were defined using National Association of Children's Hospitals and Related Institutions (NACHRI) criteria as nonchildren's hospital, children's unit within a general hospital, and freestanding children's hospital. Hospital location was defined based on the United States Census Bureau's Core Based Statistical Area (CBSA) codes, with hospitals with CBSA type of *Metropolitan* or *Division* classified as urban (city population ≥50,000), and those with CBSA type *Micropolitan* or *Rural* classified as rural (city population <50,000). County of residence was classified according to the urban–rural classification scheme developed by the National Center for Health Statistics (NCHS), broken down as urban (counties with a metro area of ≥50,000 population) or rural (counties without a metro area of ≥50,000 population).

Primary outcomes consisted of postoperative complications during initial hospitalization and total length of stay. ICD-9 diagnostic codes were used to identify general postoperative complications, and included the following: cellulitis/abscess (682.2, 682.9), acute lymphadenitis (683), complications peculiar to specific procedure (996), complications of specific body systems (997.1–997.9), other complications including shock, hemorrhage, and infection (998.0–998.9), complications of medical care NEC (999), other vascular complications (999.2), other infectious complications (999.3–999.32), transfusion reactions (999.4–999.89), adverse effects of anesthesia (995.22, 995.4, 995.86, 995.89), iatrogenic postoperative pneumothorax (512.1), and postoperative pulmonary complications (518.4, 518.5, 997.3–997.39). Anesthesia complications (i.e. adverse effects of anesthesia and pulmonary complications) were also considered independently. For pyloromyotomy patients, iatrogenic duodenal perforation was looked at specifically using the code for accidental puncture or laceration during a procedure (998.2).

Covariates identified *a priori* were those we believed might differ systematically across hospital types and also might be correlated with our outcomes. For both procedures, covariates consisted of gender, race, payer status (Medicaid vs. non-Medicaid), and comorbid conditions. Chronic comorbidities for appendectomy patients were defined using ICD-9 diagnostic codes for a broad spectrum of previously defined diagnoses commonly considered as potential confounders in pediatric outcomes research [16]. Perforation status was included as a covariate (considered as both confounder and potential effect modifier) for appendectomy patients and defined as presence of a diagnostic code for perforated appendicitis (540.0, 540.1). For infants undergoing pyloromyotomy, since chronic comorbidities are not an issue, comorbid conditions primarily focused on congenital anomalies. Comorbidities for these patients included central nervous system anomalies (ICD-9 740.0–742.9), cardiovascular anomalies (745.0–747.4, 747.6, 747.8, 747.9), respiratory anomalies (748.0–748.9), cleft lip and palate (749.0–749.2), major gastrointestinal anomalies (750.3, 751.1–751.9), renal anomalies (753.0–753.9), congenital musculoskeletal anomalies (756.0–756.9), abdominal wall anomalies (756.7–756.79), chromosomal anomalies (758.0–758.9), other congenital anomalies (759.7–759.9), necrotizing enterocolitis (777.5–777.53), and major inborn errors of metabolism (270.0–272.9, 277.0–277.9).

1.4. Data analysis

Chi-square homogeneity tests were used to compare the distribution of patient characteristics across different hospital designations and locations, as well as across different patient locations (urban vs. rural residents). Multivariate logistic and generalized linear models were used to adjust for confounding. Two basic regression analyses were performed for each procedure: (1) hospital location and designation as exposure of interest; (2) rurality of county of residence as exposure of interest in patients treated at urban centers. All covariates were included *a priori* as potential confounders. For appendectomy analyses, age and perforation status were analyzed both as confounders and as potential effect modifiers by stratification. Risk estimates for binary outcomes are reported as odds ratios with 95% confidence intervals. For continuous outcomes, linear regression coefficients are reported along with 95% confidence intervals.

2. Results

2.1. Appendectomy

A total of 129,507 children who underwent appendectomy met criteria for inclusion in the study after exclusion of 115 patients with neoplasms. Mean age was 12.5 years, and 25.4% presented with perforation (Table 1). Twelve percent received their appendectomy in a rural hospital. Of those who received care in an urban hospital, two thirds were treated at nonchildren's hospitals. Almost 5% of all appendectomy patients experienced postoperative complications.

Patient characteristics differed significantly across hospital types. Children at rural hospitals tended to be older than those at urban freestanding children's hospitals (mean age 13.1 vs. 9.8 years, $p < 0.001$) (Appendix A). Urban centers treated a significantly greater percentage of minority patients than rural centers. Perforated appendicitis was also more frequent at urban specialty hospitals. Complication rates were generally lower at urban compared to rural hospitals, but mean hospital length of stay was longer at urban hospitals (2.4 days vs. 3.0 days, $p < 0.001$). Among children treated at urban hospitals, patients from urban counties were more likely to be nonwhite than those originating from rural counties (Appendix B). Both perforation (29.4% vs. 25.4%, $p < 0.001$) and chronic comorbidities (11.2% vs. 9.5%, $p < 0.001$) were more common among children from rural counties. Although little difference was noted in postoperative complications according to county of residence, children from rural counties had a mean length of stay nearly one day longer than urban children (3.8 days vs. 3.0 days, $p < 0.001$).

After multivariate adjustment, treatment at an urban hospital was associated with a greater than 20% reduced odds of complications relative to treatment at a rural hospital (OR = 0.77, 95% C.I. 0.70–0.85)