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## Effect of hospital type on the treatment of acute appendicitis in teenagers

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## ABSTRACT

**Background:** Teenagers receive appendicitis care at both adult and pediatric facilities. The purpose of this study was to evaluate outcomes following treatment of acute appendicitis in teenagers based on the type of hospital facility.

**Methods:** Patients aged 13–17 years with acute appendicitis who were discharged from acute care hospitals from 2009 to 2014 were identified using a statewide discharge dataset. Hospitals were classified as pediatric or adult and outcomes were compared.

**Results:** There were 5585 patients treated in adult hospitals and 1625 in pediatric hospitals. Fewer patients at adult hospitals had complicated appendicitis (20.4% vs. 33.0%,  $p < 0.01$ ). Open appendectomy occurred more often in adult hospitals compared to pediatric hospitals (12.6% vs. 6.0%,  $p < 0.01$ ). Pediatric hospitals had higher rates of non-operative management (10% vs. 3.4%,  $p < 0.01$ ) and percutaneous drain placement (1.2% vs. 0.4%,  $p < 0.01$ ). Postoperative complication rates did not significantly differ between hospital types.

**Conclusion:** Most teenagers undergo appendectomy at adult facilities; however, a greater proportion of younger patients and patients with complicated appendicitis is treated at pediatric hospitals. Treatment at a freestanding children's hospital results in lower rates of open procedures and no difference in complications. Opportunities may exist to standardize care across treating facilities to optimize outcomes and resource use.

**Type of study:** Prognosis study.

**Level of evidence:** II.

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Appendicitis is the most common surgical emergency in childhood, with the highest incidence occurring between the ages of 10 and 19 years [1]. Because of the frequency of the disease and the relative simplicity of the operation, it is managed by both pediatric and general surgeons [1–4]. Pediatric patients, including teenagers, are often referred to pediatric hospitals for definitive care. In fact, a recent analysis of the Kids' Inpatient Database (KID) found that non-cardiac pediatric surgical care has transitioned from low-volume to high-volume centers over the past decade, especially for low-risk procedures such as appendectomy [5].

Reported benefits of regionalization include improved outcomes at high-volume, high-specialty centers, as well as improved coordination of care within a geographic area [6]. Concerns with regionalization include excessive travel burden, delay in receiving care, and negative effects on the quality of care provided at low-volume hospitals [7]. Evidence suggests that certain populations may have improved

outcomes in specialized environments, including neonates, infants, seriously injured children and adolescents, and those with congenital heart disease [8]. A recent retrospective cohort study using the KID database found that postoperative complications were less likely at urban freestanding children's hospitals compared to rural hospitals, and that the association was strongest among younger children [9]. The data regarding outcomes of regionalization for older children with appendicitis are scarce. The purpose of this study is to determine if there is a difference in treatment and outcomes of acute appendicitis in teenagers between pediatric and adult hospitals.

## 1. Methods

IRB approval was not needed for this study as a de-identified database was used. Data were obtained from the Florida Agency for Health Care Administration (AHCA) database between 2009 and 2014. The dataset includes information on patients' residence, discharging hospital, and up to 30 DRG International Classification of Diseases-9th Rev. (ICD-9) codes and procedure codes as well as hospital charge data. The study population was limited to Florida residents with emergent and urgent admissions and discharges from acute care facilities listed as general or teaching hospitals. Hospitals were classified as freestanding pediatric or adult-only centers. Facilities with children's units within

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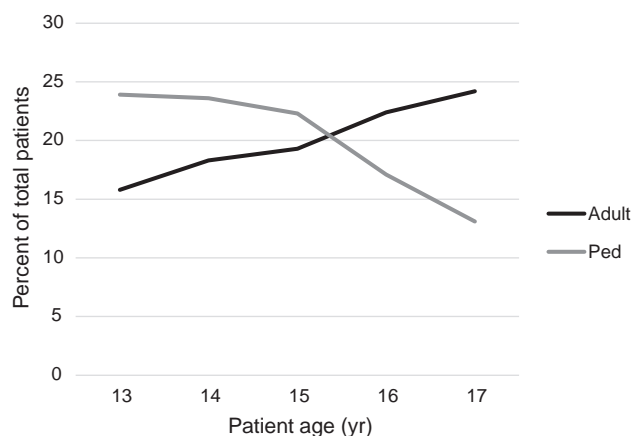


Fig. 1. Age of adolescents with appendicitis by hospital type.

adult hospitals were excluded as the database does not report surgeon specialty, thus we would be unable to differentiate the effects of hospital type and surgeon specialty.

The primary inclusion criteria were age 13 to 17 years and a principal diagnosis ICD-9 code of 540.0, 540.1, 540.9, or 541 corresponding to acute appendicitis. Complicated appendicitis was defined by a principal diagnosis code of 540.0 or 540.1, and uncomplicated was defined by a principal diagnosis code of 540.9 or 541. Operations were classified as open or laparoscopic based on reported ICD-9 procedure codes. Demographic and outcome information including age, gender, time to procedure, hospital length of stay, intensive care unit (ICU) admission, discharge status, and complications were collected. ICU admission was identified by the presence of ICU charges. Patients with a length of stay greater than 14 days were excluded as that is not the typical course of appendicitis and the results may be confounded by patients with other medical comorbidities. Continuous variables were analyzed by Student's *t* test and  $\chi^2$  was used for nominal data. Statistical significance was set at  $p < 0.05$ .

## 2. Results

There were 9497 patients aged 13–17 years with acute appendicitis during the study period from 148 adult hospitals ( $n = 5585$ ), 4 pediatric hospitals ( $n = 1625$ ), and 19 other hospitals ( $n = 2287$ ). There were 3448 (61.7%) male patients at adult hospitals and 947 (58.3%) at pediatric hospitals ( $p = 0.013$ ). Fig. 1 shows the trend in patient age by hospital type. Pediatric hospitals had a higher percentage of 13 year olds (23.9% vs. 15.8%,  $p < 0.01$ ) and the number of patients decreased with increasing age, whereas adult hospitals had a higher percentage of 17 year olds (24.2% vs. 13.1%,  $p < 0.01$ ) and the number of patients increased with increasing age.

Table 1 shows perioperative outcomes by hospital type. Fewer patients at adult hospitals had complicated appendicitis compared to pediatric hospitals (20.4% vs. 33.0%,  $p < 0.01$ ). Open appendectomy occurred more often in adult hospitals compared to pediatric hospitals

(12.6% vs. 6.0%,  $p < 0.01$ ). Pediatric hospitals had higher rates of non-operative management (10% vs. 3.4%,  $p < 0.01$ ) and percutaneous drain placement (1.2% vs. 0.4%,  $p < 0.01$ ) compared to adult hospitals.

The length of time to procedure was shorter in adult hospitals ( $0.2 \pm 0.7$  vs.  $0.3 \pm 0.9$  days,  $p < 0.01$ ). Total hospital length of stay was also shorter at adult hospitals ( $2.3 \pm 2.1$  vs.  $2.7 \pm 2.7$  days,  $p < 0.01$ ). Pediatric hospitals had a higher rate of admission to the ICU compared to adult hospitals (4.1% vs. 2.9%,  $p = 0.02$ ). Postoperative complication rates did not significantly differ between adult and pediatric hospitals (1.3% vs. 0.8%,  $p = 0.09$ ).

## 3. Discussion

Appendicitis is a common surgical illness that is often treated by general surgeons, many of whom feel comfortable operating on children and adolescents [1,2]. Our study found that the large majority of appendectomies in teenagers are performed in adult centers and this is similar to previous findings [2,4,10]. A 2012 review of the KID database found that 82% of patients aged 2–18 years underwent appendectomy at non-children's hospitals [10]. A study utilizing a statewide hospital discharge database in Washington from 1987 to 2009 found that 22% of pediatric patients received treatment for appendicitis at pediatric hospitals, but that the proportion was increasing over time (from 17% in 1987 to 32% in 2009) [11].

Multiple studies comparing differences in treatment of appendicitis between pediatric and general surgeons have found that pediatric surgeons are more likely to manage complicated appendicitis; however, there are less data comparing disease severity between hospital types [1,3,12,13]. In general, specialty hospitals care for more complex patients than non-specialty hospitals, and this is concordant with our finding that pediatric hospitals had a greater proportion of patients with complicated appendicitis [6]. Studies performed in the United Kingdom have found that complicated appendicitis is more common in pediatric centers compared to general hospitals [4,14]. Cosper's review of the KID database attributed the longer LOS at specialty hospitals to higher patient acuity; however, the study did not provide adequate data to support that hypothesis [2].

We found that operative technique significantly varies between adult and pediatric hospitals. The increased rates of non-operative management and percutaneous drain placement seen at pediatric centers in our study are expected results of the higher incidence of complicated appendicitis. Rates of laparoscopy were not significantly different between hospital types; however, adult hospitals had significantly higher rates of open appendectomy. This trend is similar to the findings of a recent analysis of the KID database which found that open appendectomy was performed more often in non-children's hospitals compared to children's hospitals for simple (58.5% vs. 38.7%) and complicated (69.5% vs. 49%) appendicitis. [15]. Tian et al. found that children's hospitals had higher rates of laparoscopy compared to non-children's hospitals, and that significant variation exists both within and between children's and non-children's hospitals [10]. These findings represent an opportunity for quality improvement as open appendectomy in children is associated with a higher rate of wound infection and longer length of stay [16].

Table 1  
Perioperative outcomes by hospital type.

	Adult (n = 5585)	Pediatric (n = 1625)	* $p < 0.01$
Complicated appendicitis, n (%)	1138 (20.4)	536 (33.0)	*
Non-operative management, n (%)	188 (3.4)	162 (10)	*
Percutaneous drain placement, n (%)	23 (0.4)	20 (1.2)	*
Laparoscopic appendectomy, n (%)	4670 (83.6)	1346 (83.0)	0.45
Open appendectomy, n (%)	704 (12.6)	97 (6.0)	*
Time to procedure, (d)	$0.2 \pm 0.7$	$0.3 \pm 0.9$	*
Length of stay, (d)	$2.3 \pm 2.1$	$2.7 \pm 2.7$	*
Postop complications, n (%)	75 (1.3)	13 (0.8)	0.09

Perforation status is the most important determinant of length of stay after appendectomy, thus it is not unexpected that adult hospitals (which had the lowest rate of complicated appendicitis) were found to have a shorter length of stay [17]. However, we did not perform a separate analysis stratifying outcomes by disease severity. It is also possible that the length of stay at pediatric centers is longer because of transportation issues involved with transferring patients from their local community hospital to a specialized center; however, distance traveled was not assessed in this study. Nonetheless, the difference in length of stay between hospital types in our study was less than half a day and not likely clinically significant. A systematic review looking at the effect of specialty training, surgeon volume, hospital volume, and hospital type on outcomes after appendectomy found that results for length of stay were heterogeneous and differences were typically less than one day [17].

Our study found no significant difference in complications in older children treated at adult and pediatric hospitals and this is similar to the findings of other authors who have shown that the relationship between hospital type and outcomes following appendectomy is associated with patient age [9,11]. McAteer et al. found that the odds of complications and negative appendectomy were significantly lower at pediatric hospitals compared to non-pediatric hospitals for children younger than the age of five years; however, there was no significant difference observed in children aged 11–17 years [11]. Another recent study found that the protective effect of treatment at urban freestanding children's hospitals compared to rural hospitals for pediatric patients undergoing appendectomy was strongest among younger children. The author suggested that older children with non-perforated appendicitis may benefit from treatment by local adult surgeons by avoiding the costs and longer length of stay associated with transfer to a pediatric center, and this is consistent with the findings of our study [9].

There are several limitations to our study. First, the use of a state-specific database may limit the generalizability of the results. Second, the dataset only captures inpatient complications that occur during the index admission so the reported rate of postoperative complications is likely a low estimate. Third, there is a risk of miscoding of procedures with the use of an administrative database but this is likely a random effect across the database and should not impact our analysis. Regionalization literature in general has several deficiencies including a failure to account for the quality of individual hospitals, limited outcomes assessed, inherent differences in case mix between specialty and non-specialty hospitals, and a lack of data regarding parental preferences for treatment location [6].

#### 4. Conclusion

Most teenagers undergo appendectomy at adult hospitals; however, those treated at pediatric hospitals tend to be younger with higher rates of complicated appendicitis. Though pediatric hospitals have lower rates of open appendectomy, the lack of difference in complications suggests that older children with non-perforated appendicitis may be adequately treated by their local hospitals avoiding the burden associated with transfer. Opportunities may exist to standardize care across treating facilities to in order to optimize outcomes and resource use.

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