Journal of Pediatric Surgery 52 (2017) 1488–1491

Contents lists available at ScienceDirect

Journal of Pediatric Surgery

journal homepage: www.elsevier.com/locate/jpedsurg

Regional variation in rates of pediatric perforated appendicitis

Samir Sarda [a], Heather L. Short [b], Jason M. Hockenberry [a], Ian McCarthy [c], Mehul V. Raval [b,*]

[a] Department of Health Policy and Management, Rollins School of Public Health, Emory University, Atlanta, GA, USA
[b] Division of Pediatric Surgery, Department of Surgery, Emory University School of Medicine, Children's Healthcare of Atlanta, Atlanta, GA, USA
[c] Deparment of Economics, Emory University, Atlanta, GA, USA

ARTICLE INFO

Article history:
Received 13 September 2016
Received in revised form 9 February 2017
Accepted 11 February 2017

Key words:
Perforated appendicitis
Pediatric surgery
Pediatric quality indicators
Health outcomes
Kids' Inpatient Database (KID)

ABSTRACT

Background: While trends in perforated appendicitis (PA) rates have been studied, regional variability in pediatric admissions for PA remains unknown.
Methods: A retrospective, cross-sectional analysis of the 2006–2012 Kids' Inpatient Database was conducted to examine variation in PA admission rates by region of the United States and insurance status. PA rates were calculated and reported as per 1000 admissions in accordance with national quality measure specifications.
Results: National PA rates per 1000 admissions for 2006, 2009, and 2012 were 313.9, 279.2, and 309.1, respectively. Similarly, all regions demonstrated a statistically significant decrease in PA rates between 2006 and 2009 ($p < 0.001$), where the increase in rates between 2009 and 2012 was only statistically significant in the Midwest [Odds Ratio (OR) 1.07; 95% Confidence Interval (95%CI) 1.03–1.12] and West (OR 1.10; 95% CI 1.07–1.14). The Northeast consistently experienced the lowest PA rates. The odds of PA were highest among uninsured patients (OR 1.35; 95% CI 1.31–1.29). The South had the highest proportion of uninsured children, and these patients had the highest odds of perforation (OR 1.57; 95% CI 1.21–2.02).
Conclusions: For children with appendicitis, geographic region and insurance status appear to be associated with perforation upon presentation. Understanding regional variation in pediatric PA rates may inform health policymakers in the constantly evolving insurance coverage landscape.
Levels of evidence rating: Level III Treatment Study — Retrospective comparative study of appendicitis presentation in children by region of the country.

With the passage of the Affordable Care Act (ACA) in 2010, national health care policies have begun to focus on prevention and incentivizing the provision of coordinated value-based care. By establishing the Prevention and Public Health Fund [1], mandating health plans to cover certain preventive benefits free of cost-sharing [2,3] and enabling young adults to remain on the insurance plans of their parents until twenty-six years of age through the Dependent Coverage Provision (DCP) [4,5], efforts to expand access to care have become a vital prevention strategy. Nonetheless, initiatives to identify and track disparities in accessing care among various adult and pediatric populations had already been underway. In 2001, the Agency for Healthcare Research and Quality (AHRQ) developed a list of prevention quality indicators (PQIs) to drive improvements in quality metrics such as admissions for ambulatory care sensitive conditions [6]. Given the ability of both patients and providers in outpatient settings to prevent certain complications and minimize the severity of disease, the AHRQ, in 2006, devised a list of 24 hospital- and area-level pediatric quality indicators (PDIs), including perforated appendix admission rate as PDI-17 [7]. Improvements in access to timely surgical evaluations, patient education on the symptoms of appendicitis, and the number of misdiagnoses have all been cited as interventions that could substantially decrease the frequency of perforated appendix cases [6,8,9].

While much of the current literature on appendicitis care has centered on the effectiveness of various treatment options, such as comparisons between laparoscopic and open appendectomies [10–12], few studies have examined the preliminary effects of the post-ACA health care environment on admission rates for perforated appendices. The purpose of this study was to assess both regional variation in and the effect of insurance status on pediatric perforated appendix admission rates. We hypothesized that the passage of the ACA would result in a lower proportion of uninsured patients and therefore lower perforated appendicitis rates. Providing clinicians and health policy experts with an understanding of how region-specific rates have varied between 2006 and 2012 and whether they are associated with insurance status is imperative to later determining the effect of national policies, such as Medicaid expansion, on rates of pediatric admissions for perforated appendices.

Abbreviations: AHRQ, Agency for Healthcare Research and Quality; PQI, prevention quality indicator; PDI, pediatric quality indicator; KID, Kids' Inpatient Database.

* Corresponding author at: Division of Pediatric Surgery, Department of Surgery, Emory University School of Medicine, Children's Healthcare of Atlanta, 1405 Clifton Road NE, Atlanta, GA 30322. Tel.: +1 404 785 0781; fax: +1 404 785 0800.
E-mail address: mehulvraval@emory.edu (M.V. Raval).

http://dx.doi.org/10.1016/j.jpedsurg.2017.02.009
0022-3468/

1. Methods

1.1. Study design

A retrospective, cross-sectional analysis of the three most recent releases (2006, 2009 and 2012) of the Kids' Inpatient Database (KID) was performed to study the variation in perforated appendix admission rates by region of the United States. The KID, which was developed by the Agency of Healthcare Research and Quality (AHRQ) for the Healthcare Cost and Utilization Project (HCUP), is a national database of administrative, billing, and hospital discharge-level data for all patients less than the age of 21 [13]. The approximately 3 million pediatric discharge records per year stored in the KID are sampled from all community, nonrehabilitation hospitals of those states participating in HCUP. In 2012, that included a regionally diverse mix of 44 states, up from 27 states in the 2000 KID [13]. The increasing number of states represented in the KID's sampling frame has led to greater coverage of the national inpatient discharge population over time.

National estimates of discharges were generated using the discharge weights provided by HCUP [13–15]. These weights are determined based on poststratification of hospitals according to ownership status, bed size, teaching status, rural/urban classification, region of the U.S., and the designation as a freestanding children's hospital. Records from each hospital are randomly sampled to include 10% of uncomplicated births and 80% of complicated births alongside other pediatric cases [13]. Fewer uncomplicated births are sampled because less variation in outcomes is expected for this lower-risk population. Each discharge record in the KID is populated with more than 100 clinical and nonclinical data elements, ranging from patient demographics to hospital charges and diagnosis and procedure codes. The Children's Healthcare of Atlanta Institutional Review Board deemed this study to be exempt from ethical review owing to the deidentified nature of the KID.

1.2. Data analysis

Admission rates for perforated appendicitis were calculated and reported as per 1000 admissions in accordance with AHRQ specifications given the metric's designation as a pediatric quality indicator [15]. Specifically, discharges for patients between 1 and 17 years of age with International Classification of Diseases, Ninth Edition, Clinical Modification (ICD-9-CM) diagnosis codes for acute appendicitis with peritonitis (540.0) or an abscess of appendix (540.1) were included in the numerator. Obstetric admissions and transfers from outside facilities were excluded. All ICD-9-CM diagnosis codes for appendicitis in patients between 1 and 17 years old were included in the denominator (540.0, 540.1, 540.9, 541) [15]. Sample weights were used to generate national estimates of perforated appendix discharges prior to calculating perforated appendix rates per 1000 admissions. For trend analyses, discharge records with missing procedure data were excluded. National rates for each KID year studied as well as region-specific perforated appendix admission rates were determined.

To identify discharge- and hospital-level risk factors for perforated appendicitis, univariable followed by multivariable logistic regression analyses were performed using the following covariates: sex, race/ethnicity (White vs. Nonwhite), insurance status (uninsured vs. insured), hospital type (children's hospital vs. nonchildren's hospital), county classification (rural/micropolitan vs. urban/metropolitan), and median household income by zip code (high vs. low). For the purposes of this study, discharges coded as 'uninsured' were those classified as either self-pay or no charge while 'insured' signified inpatient visits covered by either Medicare, Medicaid, private or other insurance. County classification was grouped into 'rural/micropolitan' if neither micropolitan nor metropolitan designations were given or if the patients' residential counties were between 10,000 and 50,000 in size. 'Urban/metropolitan' status was defined as those patients living in counties with populations greater than 50,000. Patients residing in zip codes with median household incomes in the top two quartiles were considered to be living in a 'high-income area' and those in the two lowest quartiles were recognized as living in a 'low-income area' [5,13].

Binary logistic regression was also conducted to assess trends in perforated appendix admission rates between 2006 and 2012 and to compare such rates across years by region of the U.S. Since overall insurance coverage was greatest in the Northeast in 2012, the Northeast was chosen as the reference region. All statistical models were generated using IBM SPSS Statistics Version 23 in order to account for the KID's complex survey design. As with multiyear trend analyses and standard error calculations, all rates and discharge-level data that were scaled to acquire national weighted estimates were generated according to HCUP's validated approach [13,15]. Statistical significance was defined as $p \leq 0.05$ when interpreting the results of all regression analyses.

2. Results

2.1. Perforated appendix rates

National perforated appendix rates per 1000 admissions were 313.9 in 2006, 279.2 in 2009, and 309.1 in 2012. All regions experienced statistically significant declines in perforated appendix rates between 2006 and 2009, but the increase in rates between 2009 and 2012 was only significant in the Midwest (Odds Ratio (OR) 1.07, 95% Confidence Interval (CI) 1.03–1.12, $p < 0.001$) and West (OR 1.10, 95% CI 1.07–1.14, $p < 0.001$) (Fig. 1). While the perforated appendix rate in the Midwest was lower than the West and the South in 2006, it was highest in both 2009 and 2012, reaching 363.7 per 1000 pediatric admissions. The variations in all other regions were less dramatic and resulted in net declines in perforated appendix rates between 2006 and 2012. Relative to the Northeast, which has consistently exhibited the lowest perforated appendix admission rates, the Midwest saw significantly higher rates in 2012 while the West has experienced significantly higher rates in all three of the years studied ($p < 0.001$).

2.2. Insurance coverage

In the cumulative study period among all pediatric admissions, the South was responsible for the largest proportion of uninsured (5.3%) and publicly insured admissions (56.4%). The percent of pediatric patients who were uninsured in the region dropped from 6.8% to 4.7% after a 19.1% decline from 2006 to 2009 and a 13.6% decline from 2009 to 2012 (Fig. 2). During those two, three-year intervals, uninsured rates among hospitalized children dropped in the Midwest (−9.6% and −12.7%, respectively) and the Northeast (−20.6% and −41.7%, respectively) as well. However, a 15.1% increase to 4.0% uninsured was found in the West between 2009 and 2012. Though the proportion of all admissions covered by private insurance was greatest in the Northeast, the percentage of perforated appendix admissions covered by private insurance was largest in the Midwest (59.0%). Of those who presented with perforated appendicitis, as many as 6.6% were uninsured (South) and as many as 51.0% were publicly insured (West).

2.3. Risk factors associated with perforated appendix

Multivariable logistic regression analysis across the study period identified being male ($p < 0.001$) and nonwhite ($p < 0.001$) as significant predictors of being treated for a perforated appendix (Table 1). Moreover, the results suggest that patients with perforated appendicitis have more than 3 times the odds of being treated at a children's hospital than a nonchildren's hospital. On a national level, children and adolescents are more likely to present with perforated appendicitis if they are uninsured (OR 1.35, CI 1.31–1.39, $p < 0.001$). Region-specific models suggested that in the South uninsured patients have increased odds of presenting with a perforated appendix (OR 1.57, 95% CI 1.21–2.02, $p < 0.001$). Insurance status was not significantly associated with