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# Association of Health Care Utilization With Rates of Perforated Appendicitis in Children 18 Years or Younger

Katherine J. Baxter, MD, MS; Hannah T. M. H. Nguyen, MPH; Mark L. Wulkan, MD; Mehul V. Raval, MD, MS

Supplemental content

**IMPORTANCE** The pediatric perforated appendix rate is a quality metric measured by the Agency for Healthcare Research and Quality (AHRQ) that reflects access to care. The association of health care utilization prior to presentation with appendicitis is unknown.

**OBJECTIVE** To determine whether increased health care utilization prior to presentation with appendicitis is associated with lower perforated appendicitis rates in children.

**DESIGN, SETTING, AND PARTICIPANTS** Retrospective cohort study of privately insured children drawn from large employer and insurance company administrative data found in the Truven MarketScan national insurance claims database. Cases of appendicitis were identified among 38 348 children 18 years or younger from January 1, 2010, through December 31, 2013, with corresponding primary health care encounters from January 1, 2009, through December 31, 2012. In all, 19 109 eligible children were identified using *International Classification of Diseases, Ninth Revision* (*ICD-9*) diagnosis codes for appendicitis after excluding those patients who did not have continuous insurance coverage during the study period. Statistical analysis was performed from September 1, 2016, to October 15, 2017.

**EXPOSURES** Health care utilization was determined by the number of outpatient clinic encounters for each patient in the 1 to 12 months before presentation with appendicitis.

**MAIN OUTCOMES AND MEASURES** Perforated appendicitis was defined according to the AHRQ by using *ICD-9* codes for perforation and hospital length of stay of 3 or more days. Logistic regression models were used for perforated appendicitis after adjustment for age, sex, income, gastrointestinal comorbidities, geographic region, and insurance type.

**RESULTS** We identified 38 348 children 18 years or younger with *ICD-9* diagnosis codes for appendicitis, and 19 109 children remained for analysis after applying exclusion criteria. Of these, 11 422 were boys (59.8%); the mean (SD) age was 12.4 (3.9) years. Of the 19 109 children identified who underwent appendectomy, 5509 (28.8%) presented with perforated appendicitis. Children with perforation had lower outpatient health care utilization in the year before presentation compared with those diagnosed with acute appendicitis (4554 of 5509 children [82.7%] vs 11 937 of 13 600 [87.8%]; $P < .001$). In the adjusted model, outpatient health care utilization before presentation was associated with lower odds of perforated appendicitis (odds ratio [OR], 0.63; 95% CI, 0.58-0.69; $P < .001$). This association increased with visit frequency in the year before presentation (OR, 0.86; 95% CI, 0.77-0.95 for 1-2 visits, $P = .003$; OR, 0.61; 95% CI, 0.55-0.67 for 3-6 visits, $P < .001$; and OR, 0.43; 95% CI, 0.38-0.48 for ≥7 visits [5-18 years], $P < .001$). Covariates associated with perforation included younger age, geographic region, family income, and higher out-of-pocket insurance plans.

**CONCLUSIONS AND RELEVANCE** Among insured children 18 years or younger, increased health care utilization was associated with lower rates of perforated appendicitis. Primary health care relationships may facilitate timely presentation or serve as a marker for health-related self-efficacy, thereby contributing to outcomes for acute surgical conditions.

**Author Affiliations:** Division of Pediatric Surgery, Department of Surgery, Emory University School of Medicine, Atlanta, Georgia (Baxter, Nguyen, Wulkan, Raval); Division of Pediatric Surgery, Department of Surgery, Children's Healthcare of Atlanta, Atlanta, Georgia (Baxter, Nguyen, Wulkan, Raval).

**Corresponding Author:** Mehul V. Raval, MD, MS, Division of Pediatric Surgery, Department of Surgery, Children's Healthcare of Atlanta at Egleston, 1405 Clifton Rd NE, Atlanta, GA 30322 (mehulvraval@emory.edu).

Appendicitis represents the most common diagnosis for which children undergo emergency abdominal surgical procedures. Approximately 80 000 appendectomies are performed annually for children in the United States.[1] Appendicitis is considered a progressive disease that begins as acute inflammation secondary to blockage of the appendiceal orifice, leading to necrosis and possible perforation of the appendiceal wall. Any factor that delays treatment may lead to higher rates of perforated appendicitis. Compared with acute-onset appendicitis, perforated appendicitis is associated with higher costs, longer hospitalizations, and higher hospital readmission and complication rates. Prompt diagnosis and treatment of acute appendicitis has the potential to decrease its incidence, morbidity, and cost. Unfortunately, nearly 40% of children in the United States present with perforated appendicitis.[2]

The perforated appendix admission rate (pediatric quality indicator 17 [PDI 17]) is tracked by the Agency for Healthcare Research and Quality (AHRQ) as a community-level indicator of quality and access. It represents the only national quality indicator applicable to pediatric surgery. Although pediatricians and surgeons have long been concerned with accurate diagnosis and rapid treatment of appendicitis once the patient arrives at the hospital or emergency department, evidence shows that appendiceal perforation is determined by pre-hospital or patient factors.[3] Studies have demonstrated that perforated appendicitis rates are higher in the United States for racial and ethnic minority groups, Medicaid patients, uninsured patients, and patients living in regions other than the Northeast.[4,5] Conversely, short in-hospital delays prior to operation for children with appendicitis are not associated with increased risk of perforation.[6-9] We have little understanding of how a patient's individual pattern of interaction with the health care system (defined as health care utilization) may contribute to presentation with appendiceal perforation. Among groups of insured individuals, health care utilization (ie, visits to a primary care office or emergency department) can vary significantly. Variations in utilization have been demonstrated based on socioeconomic group, type of health care coverage, and disease.[10-12] Utilization may reflect a number of measurable social variables but also more nebulous factors, such as patient attitudes toward health care, health literacy, and self-efficacy. To our knowledge, the direct association between health care utilization and rate of perforated appendicitis has not been studied.

Health care utilization adds another layer to our understanding of health care costs, barriers to access, and patient-level dynamics in the health care system. The most routine example of health care utilization in pediatric care is the yearly well-child visit. Although primary care visits distant from an acute surgical diagnosis may seem unrelated on the surface, we wondered if families with an established relationship with their primary care clinician would more likely seek care promptly when signs and symptoms of an acute abdominal process appear. We hypothesized that, within a cohort of insured pediatric patients, outpatient health care utilization in the year preceding appendicitis would be associated with lower rates of appendiceal perforation.

## Key Points

**Question** What is the association between health care utilization of patients prior to presentation with appendicitis and subsequent rates of perforated appendicitis in children 18 years or younger?

**Findings** In this cohort study of 19 109 privately insured children with appendicitis, increased health care utilization was associated with a lower likelihood of presentation with perforated appendicitis after adjustment for income, geographic region, and insurance type.

**Meaning** The number of primary health care interactions may facilitate timely presentation of patients for acute surgical conditions or serve as a marker for health-related self-efficacy, thereby contributing to these outcomes.
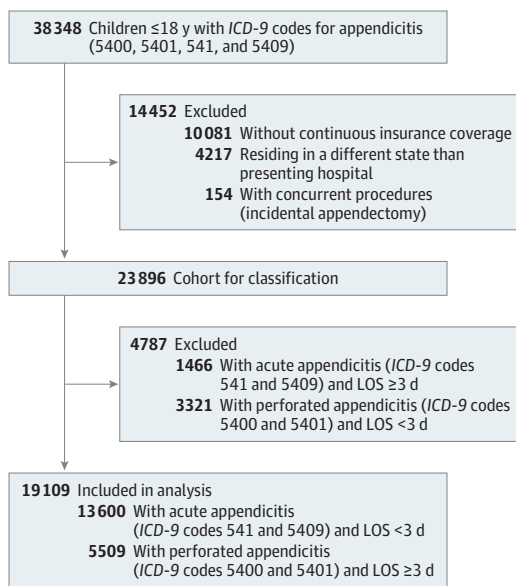
## Methods

### Study Population

We designed a retrospective cohort study of children with appendicitis using the Truven MarketScan Commercial national insurance claims database.[13] MarketScan represents administratively collected data from large employers, health insurance companies, and other health care payers. Limited data exist for patients insured by Medicare or Medicaid; thus, these data were not included in this study. MarketScan contains more than 7 million unique patients with longitudinal records of both inpatient and outpatient medical encounters. We identified cases of appendicitis in children 18 years or younger using *ICD-9* diagnosis codes 541, 5400, 5401, and 5409. Patients were included regardless of whether they underwent appendectomy at the initial encounter (ie, perforated appendicitis managed nonoperatively). Cases of appendicitis were identified from January 1, 2010, through December 31, 2013, with corresponding primary health care encounters from January 1, 2009, through December 31, 2012. Patients were excluded if not continuously enrolled in an accepted insurance plan during the study period. We identified patients who underwent concurrent procedures with appendectomy and excluded cases that suggested a primary diagnosis other than appendicitis. These procedures (identified using *ICD-9* procedure codes and *Current Procedural Terminology* [*CPT*] codes) included incidental appendectomy (*ICD-9*: 4711, 4719, and 4799), appendicostomy (*ICD-9*: 4791), Ladd procedure (*CPT*: 44055), cholecystectomy (*ICD-9*: 5123 and *CPT*: 47562, 47563, and 47600), salpingectomy or oopherectomy (*ICD-9*: 6549 and *CPT*: 58940, 58943, 58950, 58951, and 58952), removal of adnexal structures (*CPT*: 58661), and reduction of volvulus or intussusception (*CPT*: 44050). This study was considered exempt from full institutional review board at Emory University because of the deidentification of the data source. No additional patient-level waivers were required.

### Classification and Data Collection

Demographic information was collected including age, sex, gastrointestinal comorbidities, geographic region, metro-

## Figure. Cohort Selection Flowchart



**38 348** Children ≤18 y with *ICD-9* codes for appendicitis
(5400, 5401, 541, and 5409)

**14 452** Excluded
  **10 081** Without continuous insurance coverage
  **4217** Residing in a different state than
     presenting hospital
  **154** With concurrent procedures
     (incidental appendectomy)

**23 896** Cohort for classification

**4787** Excluded
  **1466** With acute appendicitis (*ICD-9* codes
     541 and 5409) and LOS ≥3 d
  **3321** With perforated appendicitis (*ICD-9* codes
     5400 and 5401) and LOS <3 d

**19 109** Included in analysis
  **13 600** With acute appendicitis
     (*ICD-9* codes 541 and 5409) and LOS <3 d
  **5509** With perforated appendicitis
     (*ICD-9* codes 5400 and 5401) and LOS ≥3 d

*ICD-9* indicates *International Classification of Diseases, Ninth Revision*;
LOS, length of stay.

politan statistical area, state of residence, and insurance type. Gastrointestinal comorbidities (*ICD-9* diagnosis codes) include congenital anomalies (750.3, 751.1-751.3, and 751.6-751.9), chronic liver diseases and cirrhosis (571.4-571.9), inflammatory bowel disease (555.0-556.9), irritable bowel disease (564.1), short-bowel disease (579.3), and celiac disease (579.0). Median annual household income was calculated based on metropolitan statistical area or state of residence using data from the Federal Financial Institution Examination Council.[14] Participant race and more granular location data were not available. As outlined by PDI 17 in the AHRQ,[15] patients were classified by definition (*ICD-9* diagnosis code) as having either perforated appendicitis or acute appendicitis. Perforated appendicitis included appendicitis with peritonitis (5400) and abscess of appendix (5401). Acute appendicitis included appendicitis not otherwise specified (541) and acute appendicitis not otherwise specified (5409). We validated this classification by excluding patients with codes for perforated appendicitis (5400 and 5401) and hospital length of stay fewer than 3 days, because hospital length of stay has been used as a primary criterion for clinically validating perforated appendicitis when using large administrative data sets.[16,17] Similarly, patients with acute appendicitis (541 and 5409) with hospital length of stay for 3 or more days were also excluded (**Figure**). Health care utilization was measured using data from the tables of outpatient visits described in the MarketScan database. Each outpatient record with a service date during the 1 to 12 months prior to the specific hospital admission was considered 1 encounter. We excluded outpatient visits within 1 month of hospital presentation because we sought to measure baseline health care utilization patterns (ie, routine primary care usage) and because outpatient visits within 1

month before hospital presentation may be related to the diagnosis of appendicitis. Types of insurance plans were stratified into the following 3 categories of increasing patient financial burden based on the methods of Simianu et al[18]: (1) health care maintenance organization and capitated point-of-service plans; (2) low out-of-pocket plans including exclusive provider, preferred provider, and noncapitated point-of-service organizations; and (3) high out-of-pocket plans, including consumer-driven and high-deductible plans.

### Statistical Analysis

Demographic data were compared between acute and perforated appendicitis groups using nonparametric tests, Pearson $\chi^2$ test of independence, and unpaired, 2-tailed *t* test. Logistic regression was performed to predict presentation with perforated appendicitis using health care utilization (stratified by number of visits) as the key independent variable and adjustment for age, sex, gastrointestinal comorbidities, geographic region, median annual household income, and insurance type. Effect modification on health care utilization was evaluated for all covariates and specifically for age at presentation with appendicitis. Limited missing data precluded the need for imputation or adjustment. All analyses were performed from September 1, 2016, to October 15, 2017, using SAS, version 9.4 (SAS Institute Inc), and 2-sided $P < .05$ indicated statistical significance. The analysis end date coincided with submission of the revised manuscript.

## Results

### Overall Cohort Characteristics

We identified 38 348 children with *ICD-9* diagnosis codes for appendicitis from January 1, 2010, to December 31, 2013. After exclusion criteria were applied, 19 109 children remained for analysis (Figure). Of these, 11 422 were boys (59.8%); the mean (SD) age was 12.39 (3.88) years. Of 19 109 children, 5509 (28.8%) had perforated appendicitis. Low out-of-pocket expenses was the most prevalent insurance plan category with 13 179 patients (69.0%) and the overall median annual household income was $65 100 (IQR, $57 100-$72 400). Of the entire cohort, 16 491 patients (86.3%) had an outpatient visit within 1 to 12 months prior to presentation with appendicitis. A small percentage of data was missing for insurance type (1292 patients [6.8%]), geographic region (58 [0.3%]), and income (47 [0.2%]) as shown in **Table 1**.

### Comparison of Patients With Perforated vs Acute Appendicitis

In the univariate comparison with acute appendicitis, children with perforated appendicitis were younger and more likely to be boys or male adolescents (Table 1). Children with perforated appendicitis were more likely to have an insurance plan with high out-of-pocket expenses (517 of 5509 patients [9.4%]). The Northeast region had the lowest unadjusted rate of

Table 1. Characteristics of Children 18 Years or Younger With Appendicitis[a]

| Characteristic | Acute Appendicitis (n = 13 600) | Perforated Appendicitis (n = 5509) | Total No. of Patients (N = 19 109) | P Value[b] |
|---|---|---|---|---|
| Age, mean (SD), y | 12.87 (3.7) | 11.22 (4.1) | 12.39 (3.9) | <.001[c] |
| Male, No. (%) | 8128 (59.8) | 3294 (59.8) | 11 422 (59.8) | .97 |
| Insurance plan, No. (%) | | | | |
| Low out-of-pocket plans[d] | 9407 (69.2) | 3772 (68.5) | 13 179 (69.0) | |
| High out-of-pocket plans[e] | 931 (6.8) | 517 (9.4) | 1448 (7.6) | <.001 |
| HMO or capitated POS | 2321 (17.1) | 869 (15.8) | 3190 (16.7) | |
| Unknown | 941 (6.9) | 351 (6.4) | 1292 (6.8) | |
| Geographic region, No. (%) | | | | |
| Northeast | 3123 (23.0) | 1048 (19.0) | 4171 (21.8) | |
| North Central | 2511 (18.5) | 1285 (23.3) | 3796 (19.9) | |
| South | 4137 (30.4) | 1755 (31.8) | 5892 (30.8) | <.001 |
| West | 3785 (27.8) | 1407 (25.5) | 5192 (27.2) | |
| Unknown | 44 (0.3) | 14 (0.2) | 58 (0.3) | |
| Median annual household income, No. (%), $ | | | | |
| <57 100 | 3487 (25.6) | 1304 (23.7) | 4791 (25.1) | |
| 57 100-65 100 | 3666 (27.0) | 1607 (29.2) | 5273 (27.6) | |
| 65 101-72 400 | 2937 (21.6) | 1415 (25.7) | 4352 (22.8) | <.001 |
| >72 400 | 3476 (25.6) | 1170 (21.2) | 4646 (24.3) | |
| Unknown | 34 (0.2) | 13 (0.2) | 47 (0.2) | |
| Gastrointestinal comorbidity | 263 (1.9) | 120 (2.2) | 383 (2.0) | .28 |
| Any outpatient visit, previous 1-12 mo, No. (%) | 11 937 (87.8) | 4554 (82.7) | 16 491 (86.3) | <.001 |
| Outpatient visits in preceding 1-12 mo, No. (%) | | | | |
| 0 | 1663 (12.2) | 955 (17.3) | 2618 (13.7) | |
| 1-2 | 3678 (27.0) | 1890 (34.3) | 5568 (29.1) | <.001 |
| 3-6 | 4521 (33.2) | 1687 (30.6) | 6208 (32.5) | |
| ≥7 | 3738 (27.5) | 977 (17.7) | 4715 (24.7) | |

Abbreviations: HMO, health maintenance organization; POS, point of service.

[a] Because of rounding, percentages may not total 100.

[b] Unless otherwise stated, P values are calculated using the Pearson $\chi^2$ test to compare the acute and perforated appendicitis groups.

[c] P value is calculated using the 2-sample Wilcoxon rank sum (Mann-Whitney) test for difference.

[d] Noncapitated plans with low out-of-pocket expenses include comprehensive plans, noncapitated POS plans, preferred provider organizations, and exclusive provider organizations.

[e] Noncapitated plans with high out-of-pocket expenses include consumer-driven health plans and high-deductible health plans.

perforated appendicitis (1048 of 4171 patients [25.1%]), whereas the North Central region had the highest unadjusted rate of perforation (1285 of 3796 [33.9%]).

Children with perforated appendicitis were less likely to have had an outpatient health care visit in the previous year when compared with patients with acute appendicitis (4554 of 5509 [82.7%] vs 11 937 of 13 600 [87.8%]; P < .001). Patients with 7 or more outpatient encounters in the 1 to 12 months prior to presentation with appendicitis were considered more frequent users of health care. A larger proportion of these patients had an outpatient encounter within the month preceding admission for appendicitis than less frequent users of health care (3258 [69.1%] vs 6362 [44.2%]; P < .001). On review of diagnosis codes for 4715 more frequent users, the most common diagnosis was asthma (839 patients [17.8%]), followed by attention-deficit/hyperactivity disorder (265 [5.6%]), gastroesophageal reflux (99 [2.1%]), obesity (94 [2.0%]), and depression (67 [1.4%]).

## Multivariable Regression Results

In the adjusted model, outpatient health care utilization prior to presentation was associated with lower odds of perforated appendicitis (odds ratio [OR], 0.63; 95% CI, 0.58-0.69;

P < .001). This negative association generally increased with visit frequency in the previous year to presentation (OR, 0.86; 95% CI, 0.77-0.95 for 1-2 visits, P = .003; OR, 0.61; 95% CI, 0.55-0.67 for 3-6 visits, P < .001; and OR, 0.43; 95% CI, 0.38-0.48 for ≥7 visits [5-18 years], P < .001) (Table 2). We found that age of 1 to 4 years was an effect modifier of health care utilization only when that term was set to 7 or more visits in the previous 1 to 12 months. When the interaction term was true (age 1-4 years and ≥7 visits), the odds of perforated appendicitis were not significantly different from the null (OR, 0.83; 95% CI, 0.56-1.24; P = .37). Younger age showed a stepwise increase in odds of appendiceal perforation. Odds of appendiceal perforation were increased for patients living in the North Central and Southern regions compared with the Northeast. Odds of perforation were higher for those in the second and third income quartiles compared with the lowest quartile. Compared with health maintenance organization and capitated point-of-service plans, patients with high out-of-pocket insurance plans had higher odds of perforation (OR, 1.40; 95% CI, 1.22-1.61; P < .001). The association of outpatient health care utilization remained significant with increased time intervals between the outpatient visit and presentation with appendicitis (eFigure in the Supplement).

Table 2. Multivariable Regression–Derived Predictors
of Perforated Appendicitis

| Predictor | Odds of Perforated Appendicitis[a] | |
|---|---|---|
| | OR (95% CI)[b] | P Value |
| **Age, y** | | |
| 1-4 (<7 Visits) | 6.08 (4.88-7.57) | <.001 |
| 1-4 (≥7 Visits)[c] | 11.76 (8.41-16.46) | <.001 |
| 5-9 | 2.26 (2.06-2.48) | <.001 |
| 10-14 | 1.76 (1.63-1.91) | <.001 |
| 15-18 | 1 [Reference] | |
| **Male** | 0.97 (0.90-1.03) | .31 |
| **Gastrointestinal comorbidity** | 1.62 (1.28-2.05) | <.001 |
| **Insurance plan** | | |
| HMO or capitated POS | 1 [Reference] | |
| Low out-of-pocket plans | 1.08 (0.98-1.18) | .12 |
| High out-of-pocket plans | 1.40 (1.22-1.61) | <.001 |
| **Geographic region** | | |
| Northeast | 1 [Reference] | |
| North Central | 1.40 (1.26-1.57) | <.001 |
| South | 1.15 (1.03-1.29) | .01 |
| West | 0.97 (0.87-1.09) | .62 |
| **Median annual household income, $** | | |
| <57 100 | 1 [Reference] | |
| 57 100-65 100 | 1.23 (1.12-1.36) | <.001 |
| 65 101-72 400 | 1.38 (1.25-1.52) | <.001 |
| >72 400 | 1.02 (0.92-1.14) | .001 |
| **Outpatient visits in preceding 1-12 mo** | | |
| 0 | 1 [Reference] | |
| 1-2 | 0.86 (0.77-0.95) | .003 |
| 3-6 | 0.61 (0.55-0.67) | <.001 |
| ≥7 (Patients aged 5-18 y) | 0.43 (0.38-0.48) | <.001 |
| ≥7 (Patients aged 1-4 y)[c] | 0.83 (0.56-1.24) | .37 |

Abbreviations: HMO, health maintenance organization; NA, not applicable;
OR, odds ratio; POS, point of service.

[a] Perforated appendicitis defined as *International Classification of Diseases,
Ninth Revision* (*ICD-9*) diagnosis codes 5400 or 5401 and length of hospital
stay for 3 or more days.

[b] Odds ratio for perforated appendicitis is reported after adjustment for all other
covariates.

[c] Odds ratios given interaction term for patients 1-4 years with 7 or more visits in
the preceding year equals 1.

## Discussion

In this study, we demonstrate a novel association between
health care utilization (eg, primary outpatient care) and re-
duced rates of perforated appendicitis. To our knowledge,
these results are the first to link acute-care surgical outcomes
typically managed within the emergency department and
inpatient hospital setting with the use of outpatient primary
care. The correlation between health care utilization and
decreased appendiceal perforation rates remained signifi-
cant after controlling for socioeconomic status (SES). These
results are even more striking since all patients were insured
and had relatively equivalent baseline health care access. These
findings have implications for health care reform by demon-

strating that health insurance coverage is not the only
area in which disparities exist. Larson et al[19] demonstrated
that recent legislation resulted in a marked decline in the
percentage of uninsured children, which translated into
significant preventative care gains. However, our research
shows that all insurance plans and physician-patient relation-
ships are not equal in encouraging families to seek prompt
care for acute conditions.

Among insured patients, use of health care resources may
be affected by family SES, increased out-of-pocket health care
costs, rural vs urban location, and individual understanding
of the health care system. Factors that may prevent a patient
from having a yearly well-child visit may also contribute to a
longer time to presentation when symptoms of appendicitis
develop. In an interesting parallel to our study, Bratu et al[20]
studied perforated appendicitis rates in the setting of univer-
sal health care in Canada. They found that, despite universal
health care coverage, those patients with lower SES were more
likely to present with perforation. Puka et al[10] showed that
lower SES in children with epilepsy was associated with fewer
outpatient visits and more emergency department visits. Simi-
lar results were seen for patients with inflammatory bowel
disease.[21] In our study, health care utilization remained inde-
pendently associated with lower odds of appendiceal perfo-
ration after adjustment for income and region, which sug-
gests that utilization is more than just a proxy for SES. It is
unclear why the second and third income quartiles had higher
odds of appendiceal perforation compared with the lowest
income quartile. We did note that the third income quartile had
the largest proportion of high out-of-pocket plans, although
type of plan was adjusted separately. There may be clustering
in each quartile of certain job types or industries that lean
toward more difficult access to health care, whether owing to
geography or employer support.

Our results confirmed an unexpectedly large number of
children 18 years or younger with 7 or more visits in the 1 to
12 months before presentation with appendicitis. This group
may represent a cohort of children with chronic conditions,
such as asthma and attention-deficit/hyperactivity disorder,
although their diagnostic codes were quite diverse. We
found that young age was an effect modifier of high utiliza-
tion; 7 or more visits was not significantly associated with
perforation at presentation in this particular group. We pos-
tulate that these young children, even with increased health
care use, remain difficult to diagnose in the early stages of
appendicitis because of their limited communication skills.
Early signs and symptoms of appendicitis may be inter-
preted as pertaining to another underlying illness in more
frequent users of health care resources.

Several US studies have shown that pediatric surgical
outcomes are linked to health care payer, demonstrating that
patients with Medicaid have increased complications com-
pared with those with private insurance.[22,23] Only privately
insured patients were included in our study because of the
information provided in the MarketScan Commercial data-
base. We found that patients with high out-of-pocket costs
(ie, high-deductible health plans) were more likely to
present with perforated appendicitis. Our findings are

supported by the work of Braveman et al,[4] which showed higher rates of perforated appendicitis in patients with fee-for-service plans compared with capitated insurance plans even after controlling for annual family income. This finding suggests that there are complex factors in determining health care utilization as opposed to a simple dichotomy of insured vs uninsured patients. These results demonstrate that, for patients with higher income levels, high out-of-pocket costs may be a deterrent to seeking medical attention in a timely fashion, leading to increased complications.

Penfold et al[24] found that, after controlling for SES and insurance type, patients who live in rural areas and must commute to urban centers for health care were more likely to present with perforated appendicitis, suggesting that travel distance contributes to delay in seeking care. Although we were not able to measure and control for travel distance to the hospital in this data set, a correlation is suggested by the association of geographic region with appendiceal perforation. Individual attitudes and behaviors with respect to health care still may not be explained even after demographic and economic factors are taken into account. A recent survey of adults and parents of children with appendicitis demonstrated that, despite having a similar SES, patients with delayed presentation had less social support and more self-reported willingness to "wait it out" when health conditions arise.[25] We suggest that primary care utilization serves as an indicator of these difficult-to-measure attitudes as well as general health-consciousness of the parent. Therefore, the associations seen in our study results cannot be entirely attributed to the primary care physician relationship.

Assessing quality in children's surgery is challenging.[26] Pediatric quality indicator 17, as described by the AHRQ, is used as a measure of community-level health quality and is consistent with evidence that perforation in appendicitis is determined primarily by outpatient, prehospital factors.[4-6] A previous study has shown that race and sociodemographic community characteristics contribute to overall hospital quality rankings for treating perforated appendicitis and should be adjusted for these factors.[27] The current study supplements this evidence, demonstrating that not only insurance status but also a patient's or family's ability and willingness to use health care services may be associated with presentation with perforated appendicitis. Striving to improve quality, access, and promotion of primary care should be a central goal. Although the magnitude of association is relatively small for routine use in this large cohort study (perforated appendicitis: OR, 0.86; 95% CI, 0.77-0.95

for 1-2 visits; $P = .003$), the high morbidity associated with perforated appendicitis vs acute appendicitis should be taken into account. If even a small percentage of patients have a shortened hospital length of stay by 2- to 3-fold and avoid a 5- to 6-fold higher risk of intraabdominal abscess, this translates to a large difference in quality and cost of care.[2,28]

## Limitations and Strengths

Limitations of this study include the inability to assess inpatient medications, including antibiotics. We were unable to further delineate the severity of perforation or peritoneal contamination, and some patients in the group with perforated appendicitis may behave similar to patients with acute appendicitis clinically. There is likely a degree of misclassification for both our exposure and outcome given the imperfect nature of coding data. Another major limitation is the lack of inclusion of publicly insured, self-insured, and uninsured patients in the MarketScan database given that its source is mostly large employers, limiting the generalizability of these results. This limitation may strengthen our ability to analyze utilization specifically in a setting where health care coverage and access is relatively constant. In addition, we were limited in our ability to further separate patients by area of residence (eg, at the state level) and exact income level because of the deidentified data available in MarketScan, which may lead to unmeasured confounding. Nevertheless, the strength of using this database is the ability to study a large, nationally derived cohort.

## Conclusions

In this study, we demonstrate that, among a cohort of commercially insured children, use of outpatient primary care services in the year before presentation with appendicitis is associated with a lower rate of appendiceal perforation. Although previous studies have shown the importance of SES, race, insurance status, and other demographic factors, this is the first study, to our knowledge, that links use of primary care services with surgical outcomes. This association may be explained by the guidance provided by a primary care physician relationship or by an overall predilection by some families to readily access health care. Although health care utilization also measures the less modifiable attributes of health literacy and trust in the medical system, these factors still argue for increased visibility and ease of access to primary care to improve children's health. This finding has implications for the assessment of surgical quality as well as broader US health care reform.

interpretation of the data; preparation, review, or approval of the manuscript; and decision to submit the manuscript for publication.

## REFERENCES

1. Barrett ML, Hines AL, Andrews RM. Trends in rates of perforated appendix, 2001-2010: Statistical Brief #159. In: *Healthcare Cost and Utilization Project (HCUP) Statistical Briefs [Internet]*. Rockville, MD: Agency for Healthcare Research & Quality; 2013: 1-14. https://www.hcup-us.ahrq.gov/reports/statbriefs /sb159.pdf. Accessed December 11, 2017.

2. Newman K, Ponsky T, Kittle K, et al. Appendicitis 2000: variability in practice, outcomes, and resource utilization at thirty pediatric hospitals. *J Pediatr Surg*. 2003;38(3):372-379.

3. Ponsky TA, Huang ZJ, Kittle K, et al. Hospital- and patient-level characteristics and the risk of appendiceal rupture and negative appendectomy in children. *JAMA*. 2004;292(16):1977-1982.

4. Braveman P, Schaaf VM, Egerter S, Bennett T, Schecter W. Insurance-related differences in the risk of ruptured appendix. *N Engl J Med*. 1994; 331(7):444-449.

5. Bratton SL, Haberkern CM, Waldhausen JH. Acute appendicitis risks of complications: age and Medicaid insurance. *Pediatrics*. 2000;106(1, pt 1): 75-78.

6. Drake FT, Mottey NE, Farrokhi ET, et al. Time to appendectomy and risk of perforation in acute appendicitis. *JAMA Surg*. 2014;149(8):837-844.

7. Bhangu A; UK National Surgical Research Collaborative. Safety of short, in-hospital delays before surgery for acute appendicitis: multicentre cohort study, systematic review, and meta-analysis. *Ann Surg*. 2014;259(5):894-903.

8. Bonadio W, Brazg J, Telt N, et al. Impact of in-hospital timing to appendectomy on perforation rates in children with appendicitis. *J Emerg Med*. 2015;49(5):597-604.

9. Serres SK, Cameron DB, Glass CC, et al. Time to appendectomy and risk of complicated appendicitis and adverse outcomes in children. *JAMA Pediatr*. 2017;171(8):740-746.

10. Puka K, Smith ML, Moineddin R, Snead OC, Widjaja E. The influence of socioeconomic status on

health resource utilization in pediatric epilepsy in a universal health insurance system. *Epilepsia*. 2016;57(3):455-463.

11. Mueller EL, Hall M, Carroll AE, Shah SS, Macy ML. Frequent emergency department utilizers among children with cancer. *Pediatr Blood Cancer*. 2016;63(5):859-864.

12. Duquette S, Soleimani T, Hartman B, Tahiri Y, Sood R, Tholpady S. Does payer type influence pediatric burn outcomes? A national study using the Healthcare Cost and Utilization Project Kids' Inpatient Database. *J Burn Care Res*. 2016;37(5): 314-320.

13. Truven MarketScan Commercial national insurance claims database. https://truvenhealth .com/markets/life-sciences/products/datatools /marketscan-databases. Accessed December 2, 2017.

14. Federal Financial Institution Examination Council. Home page. https://www.ffiec.gov/. Accessed December 2, 2017.

15. Perforated appendix admission rate. Technical specifications. Pediatric Quality Indicators #17 (PDI#17). AHRQ Quality Indicators™, version 4.5. https://www.qualityindicators.ahrq.gov/Downloads /Modules/PDI/V45/TechSpecs/PDI%2017 %20Perforated%20Appendix%20Admission %20Rate.pdf. Published May 2013. Accessed December 2, 2017.

16. Rice-Townsend S, Hall M, Barnes JN, Baxter JK, Rangel SJ. Hospital readmission after management of appendicitis at freestanding children's hospitals: contemporary trends and financial implications. *J Pediatr Surg*. 2012;47(6):1170-1176.

17. Rice-Townsend S, Gawande A, Lipsitz S, Rangel SJ. Relationship between unplanned readmission and total treatment-related hospital days following management of complicated appendicitis at 31 children's hospitals. *J Pediatr Surg*. 2013;48(6): 1389-1394.

18. Simianu VV, Fichera A, Bastawrous AL, et al. Number of diverticulitis episodes before resection and factors associated with earlier interventions. *JAMA Surg*. 2016;151(7):604-610.

19. Larson K, Cull WL, Racine AD, Olson LM. Trends in access to health care services for US children:

2000-2014. *Pediatrics*. 2016;138(6):e20162176. doi:10.1542/peds.2016-2176

20. Bratu I, Martens PJ, Leslie WD, Dik N, Chateau D, Katz A. Pediatric appendicitis rupture rate: disparities despite universal health care. *J Pediatr Surg*. 2008;43(11):1964-1969.

21. Benchimol EI, To T, Griffiths AM, Rabeneck L, Guttmann A. Outcomes of pediatric inflammatory bowel disease: socioeconomic status disparity in a universal-access healthcare system. *J Pediatr*. 2011; 158(6):960-967.e1-e4. doi:10.1016/j.jpeds.2010.11 .039

22. Stone ML, LaPar DJ, Mulloy DP, et al. Primary payer status is significantly associated with postoperative mortality, morbidity, and hospital resource utilization in pediatric surgical patients within the United States. *J Pediatr Surg*. 2013;48(1): 81-87.

23. Sutton TL, Pracht EE, Ciesla DJ. Acute appendicitis: variation in outcomes by insurance status. *J Surg Res*. 2016;201(1):118-125.

24. Penfold RB, Chisolm DJ, Nwomeh BC, Kelleher KJ. Geographic disparities in the risk of perforated appendicitis among children in Ohio: 2001-2003. *Int J Health Geogr*. 2008;7:56. doi:10.1186/1476 -072X-7-56

25. Comparative Effectiveness Research Translation Network's Collaborative for Healthcare Research in Behavioral Economics and Decision Sciences (CERTAIN-CHOICES). Factors influencing delayed hospital presentation in patients with appendicitis: the APPE survey. *J Surg Res*. 2017; 207:123-130.

26. Raval MV, Deans KJ, Rangel SJ, et al. Assessing quality in pediatric surgery—the limited role of appendectomy as the optimal target. *J Pediatr Surg*. 2013;48(11):2313-2319.

27. Tian Y, Heiss KF, Wulkan ML, Raval MV. Assessment of variation in care and outcomes for pediatric appendicitis at children's and non-children's hospitals. *J Pediatr Surg*. 2015;50(11): 1885-1892.

28. Luo CC, Chien WK, Huang CS, et al. National trends in therapeutic approaches and outcomes for pediatric appendicitis: a Taiwanese nationwide cohort study. *Pediatr Surg Int*. 2015;31(7):647-651.