Ruptured Appendicitis Among Children as an Indicator of Access to Care

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Objective. To determine factors associated with ruptured appendicitis among children, using administrative databases. Insurance-related differences in the risk of ruptured appendix among adults in California have previously been described (Braveman, Schaaf, Egerter, et al. 1994).

Data Sources/Study Setting. State of Maryland Medicaid claims data for children ≤ 18 years of age from 1989 to 1993 and hospital discharge data for children ≤ 19 years of age from 1989 to 1994 were analyzed.

Study Design. Administrative data analysis pre- and post-implementation of a Medicaid managed care program called Maryland Access to Care.

Data Collection/Extraction Methods. Medicaid claims and hospital discharge ICD-9-CM codes were used to define hospitalization for ruptured and nonruptured appendicitis. Linear regression was used to model trends. Logistic regression was used to model the probability of ruptured appendicitis.

Principal Findings. Among the 374 Medicaid inpatient claims for appendicitis, 37 percent were for ruptured appendicitis. Among the 5,141 hospital discharges for appendicitis, 30 percent were for ruptured appendicitis. Using Medicaid claims data, the probability of ruptured appendicitis was inversely related to age (OR = 0.86, 95% CI 0.81–0.91), white race (OR = 0.35, 95% CI 0.17–0.71) and preventive care visits (OR = 0.19, 95% CI 0.05–0.77). Using hospital discharge data, age (OR = 0.91, 95% CI 0.90–0.93) and female gender (OR = 0.87, 95% CI 0.77–0.99) were significant covariates. Insurance-related covariates were not significant in multivariate models addressing the probability of ruptured appendicitis.

Conclusions. During a period of rapid managed care growth, insurance type was not associated with an increased risk of ruptured appendicitis among children in this geographic area. Age, female gender, and the number of preventive care visits are inversely related to the risk of ruptured appendix among children. The protective effect of preventive care visits suggests that a primary care relationship facilitates access to care, thus reducing delay in the management of appendicitis.

Key Words. Ruptured appendicitis, appendicitis, children, Medicaid managed care, health insurance

Ruptured appendicitis leads to longer hospital stays and increased risk of postoperative complications, morbidity, and mortality. Earlier diagnosis and management of acute appendicitis may prevent perforation. Because delay in treatment is a major determinant of rupture, the occurrence of ruptured appendicitis may be a sentinel event reflecting problems in access to health care. For example, ruptured appendicitis has been used as an indicator of avoidable hospitalization attributable to problems with access to ambulatory care (Weisman, Gatsonis, and Epstein 1992; Pappas et al. 1997). Among adults, the risk of ruptured appendicitis increased among Medicaid and uninsured patients, compared to patients with private capitated coverage (Braveman, Schaaf, Egerter, et al. 1994), a finding the authors attributed to decreased access among Medicaid and the uninsured. Another study of adults demonstrated that the time between the onset of symptoms and presentation to a physician was 2.3 days for ruptured appendicitis, compared to 1.7 days for simple appendicitis (Eldar, Nash, Sabo, et al. 1997). These findings support the notion that ruptured appendicitis may be an indicator of access to health care, health care–seeking behavior, or both.

Studies of ruptured appendicitis among children have also suggested that it may be a useful marker for access to care, quality of care, or both. Although prior studies have demonstrated that the biological risk factors for ruptured appendicitis include male gender and young age (Addiss et al. 1990; Luckman 1989), subsequent studies have implied that health service factors also contribute to the incidence of ruptured appendicitis. Delay in treatment due to parental delay in seeking care and initial misdiagnosis caused by associated illnesses are strongly associated with ruptured appendicitis among children, as documented by several hospital case series (Brender et al. 1985; Golladay and Sarrett 1988; Rappaport, Peterson, and Stanton 1989; Young and Moss 1997; Korner, Sondenaa, Soreide, et al. 1997; Horwitz et al. 1997; Williams and Bello 1998). Univariate analyses of appendiceal rupture have demonstrated an association with young age (< 2 years old), duration of symptoms (> 24 hours), referral from an emergency room, and Medicaid

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insurance (Harrison et al. 1984; O'Toole, Karamanoukian, Allen, et al. 1996). However, a multivariate analysis was not done in these case series.

A study comparing the management of pediatric appendicitis in the late 1970s to the late 1980s (Linz et al. 1993) documented delayed surgical referrals and increasing proportions of children evaluated in an emergency department setting. This retrospective review of 226 cases at one children's hospital describes a ten-year trend in increasing time from onset of symptoms to seeing a surgeon (41 hours in the 1970s versus 56 hours in the 1980s), but no change in time from seeing a surgeon to having the operation. The authors attribute this delay to problems at the "initial physician-contact" level and to misdiagnosis. A recent study has shown that primary care involvement decreases the risk of ruptured appendicitis among children because involvement of the primary care provider appears to expedite care and referral to a surgeon (Chande and Kinnane 1996).

While the incidence of ruptured appendicitis may vary by age, gender, and such health service factors as insurance type and primary care involvement, pediatric appendectomy rates have been fairly stable. Appendicitis has been described as a nondiscretionary condition due, in part, to how stable the rates for appendectomy (7–9 per 10,000 per year) were among children in the three-city study conducted by Perrin and colleagues (Perrin, Homer, Berwick, et al. 1989; Perrin 1994). Significant variation in this surgical procedure by geographic area does not occur among children and thus does not confound the use of ruptured appendicitis as a possible indicator of access to health care.

The objective of this study was to determine whether specific health service variables were associated with ruptured appendicitis among children, after adjustment for previously described biological determinants. Using Medicaid claims databases, we evaluated the impact of a fee-for-service Medicaid managed care program, Maryland Access to Care (MAC), on the occurrence of ruptured appendicitis. We also evaluated whether preventive care visits were related to the incidence of ruptured appendicitis. Using hospital discharge databases, we also investigated whether a child's health insurance was an important predictor of ruptured appendicitis.

METHODS

Populations and Study Setting

This study included children and adolescents in the state of Maryland who were eligible for the MAC program, who were hospitalized during the study

period, or both. MAC, instituted in December 1991, was designed to maintain access, strengthen primary care ties, increase preventive services, and decrease emergency visits. This program was a fee-for-service primary care case management program, with mandatory enrollment and an assigned primary care provider who was required to provide gatekeeping and early periodic screening, diagnosis, and treatment (EPSDT) services. The current study is an extension of a more comprehensive evaluation of the impact of the MAC program and preventive care that is described in detail elsewhere (Gadomski, Nichols, and Jenkins 1998).

Data Sources

The following two administrative databases were analyzed: (1) Maryland Medicaid claims data for children $\leq$ 18 years of age eligible for MAC for three years pre- and two years post-implementation of MAC, 1989 to 1993, and (2) Maryland hospital discharge data from the Health Services and Cost Review Commission (HSCRC) for children $\leq$ 19 years of age for three years pre- and post-MAC, 1989 to 1994, all payers included. For these databases, Medicaid inpatient claims or hospital discharge ICD-9-CM codes were used to define hospitalization for ruptured (540.0, 540.1) and nonruptured (540.9) appendicitis.

The construction of the analytical file for Medicaid claims is described elsewhere (Gadomski, Nichols, and Jenkins 1998). Briefly, the Medicaid claims and eligibility databases were used to construct a child-quarter analysis file. This file consisted of person-level data for the 20 analysis quarters defined around the December 1991 MAC implementation date, resulting in 12 pre- and eight post-MAC quarters. If a recipient was eligible for MAC at any time during one of these analysis quarters, she or he had an observation for that quarter in the file. If a child had been eligible for MAC during a given quarter, yet had no utilization of a particular type of service during that quarter, the child was assigned a zero for that service in that quarter. Eligibility files and inpatient, outpatient, and physician claims were combined to construct a child-quarter analysis file.

Statistical Analysis

Trends in Ruptured Appendicitis: Pre- Versus Post-MAC Quarter Comparisons. The percent of ruptured appendicitis cases was calculated for each quarter using both the Medicaid claims (five years) and the hospital discharge database (six years). Linear regression was used to model the trend in these rates,

controlling for seasonal variables (winter, spring, summer) and trend (quarter − 1). Linear regression compared later quarters with earlier quarters and pre- to post-MAC quarters to establish whether the percent of ruptured appendicitis cases changed significantly during the study period.

Incidence of Ruptured Appendicitis. In order to estimate incidence, the number of appendicitis and ruptured appendicitis hospital discharges in 1990 was divided by 1990 U. S. Census population estimates for children ages 0–18 years residing in the state of Maryland.

Length of Stay. The mean length of stay (LOS) in hospital in days for ruptured versus nonruptured appendicitis was calculated using both databases. Using hospital discharge data, LOS was compared by insurance group using analysis of variance. Scatterplots were constructed to confirm that linear relationships existed between LOS and study quarter. Simple correlation analysis of LOS and quarter was performed. Linear regressions were performed to test the strength of the relationship between LOS and quarter by insurance type, controlling for seasonal variables (winter, spring, summer) and trend (quarter − 1). Analysis of covariance was performed to address age as a potential confounding variable in the relationship between LOS and insurance type.

Prediction of Ruptured Appendicitis: Medicaid Claim. Among all children hospitalized for appendicitis, logistic regression was used to model the probability of ruptured appendicitis, controlling for several covariates for each administrative database. The dependent variable for all logistic regressions was ruptured appendicitis (ICD-9-CM = 540.0 or 540.1). The child quarter was the unit of analysis. Independent variables from the Medicaid eligibility file were included to adjust for known correlates of hospitalization (Homer et al. 1995; Goodman, Fisher, Gittelsohn, et al. 1994); these were Medicaid recipients' age, gender, race, county of residence (ordered by population size), and eligibility group. The Medicaid eligibility group was included to account for the chronic illness present among the Supplemental Security Income (SSI) recipients. Referent groups for gender, race, and eligibility group were female, races other than Caucasian or African American, and the Medical Assistance eligibility group, respectively.

Utilization measures, such as number of preventive care visits, were created using Maryland Medicaid codes, current procedural terminology (CPT) codes, and ICD-9-CM codes. Preventive care includes well-child care, EPSDT, and immunization visits, whereas acute care visits are visits for acute illnesses in a primary care setting. We were able to differentiate between primary care visits for preventive care and those for acute care using a variety of codes from a variety of files. For example, Maryland local codes discriminate

between EPSDT visits (W9075–W9077) and office visits (M0005–M0009). Visits that included ICD-9-CM codes for well-child care (V20.2) or EPSDT screening (V79.3) as the primary or secondary diagnosis were classified as preventive care because the reason for the visit most likely was well-child care or EPSDT and the illness code was incidental. Although both types of visits are considered primary care, the longer preventive care visits with one's primary care provider are more likely to accomplish the goals of primary care than a 5–10-minute visit for acute complaint. CPT codes also include consultative visits, which we defined as specialty care visits. In addition, our computer algorithm verified consultative visits as specialty care visits based on the type of provider code listed in the physician claims file. The number of preventive care visits was included as an indicator for access to and quality of primary care. The number of acute care visits in a primary care setting and specialty care visits were also included, as well as a temporal variable, the study quarter.

Prediction of Ruptured Appendicitis: Hospital Discharge Data. For the hospital discharge database, the independent variables used were age, gender, county of residence (ordered by population size), primary insurance (Medicaid, private insurance, self-pay), race, number of pediatric beds, and quarter. Individual MAC enrollment status and ambulatory care use variables were not available in this database. Because it was not possible to discriminate between MAC and non-MAC Medicaid recipients in the hospital discharge database, it was not possible to examine this variable in the hospital discharge database model. Thus, the Medicaid insurance designation in the hospital discharge database includes all Medicaid recipients and therefore is not comparable to the Medicaid claims analysis of MAC-eligible children in this study.

All analyses were performed using the Statistical Analysis System (SAS) program, version 6.12, running on an alpha VMS computer.

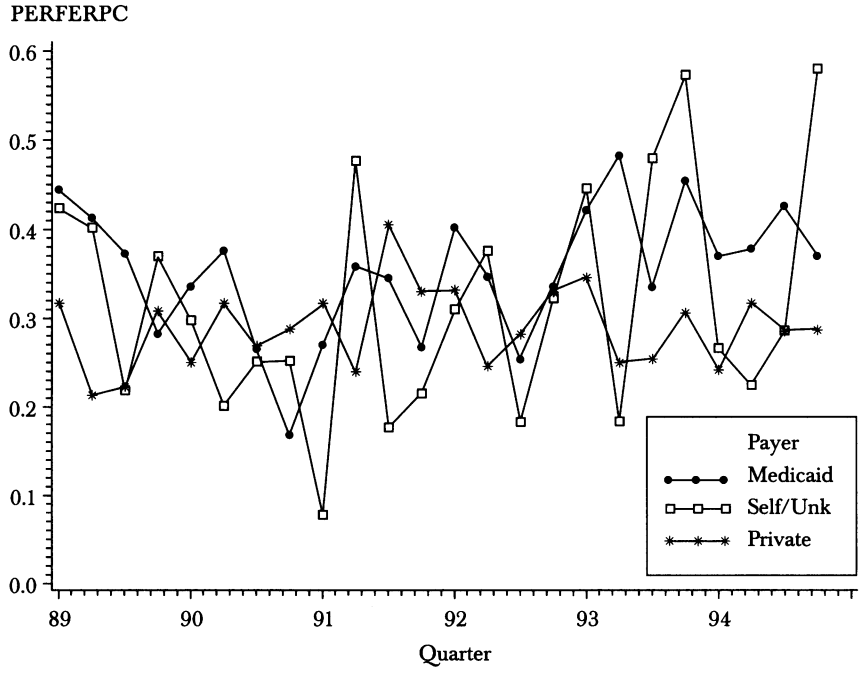
RESULTS

Trends in Ruptured Appendicitis Using Hospital Discharge Data. Analysis of hospital discharge data yielded 3,614 hospitalizations for appendicitis during the six-year study period, of which 30 percent were for ruptured appendicitis. Significant univariate differences by payer were noted (Medicaid, 36 percent; self-pay, 32 percent; private, 29 percent; $p = .001$) in hospital discharge data. A higher proportion of ruptured appendicitis occurred among Medicaid recipients (35.6 percent), compared to those privately insured (28.8 percent,

$p < .0001$). This higher percentage among Medicaid insured is consistent with what has been reported in other studies (Harrison et al. 1984; O'Toole, Karamanoukian, Allen, et al. 1996).

Seasonal fluctuations in the percent of ruptured appendicitis cases did occur for both Medicaid and non-Medicaid hospitalizations, as shown in Figure 1. However, linear regression analyses failed to demonstrate a significant overall trend in total appendicitis or ruptured appendicitis during this six-year period. Thus, the total number of hospitalizations for ruptured and nonruptured appendicitis remained stable during the six-year period. As a reference point, it is noteworthy that the 1990 hospital discharge rate estimates for ruptured appendicitis (2/10,000) or appendicitis (7/10,000) are similar to estimates published elsewhere (Addiss et al. 1990; Perrin 1994).

Figure 1: Percent Ruptured Appendicitis Among Children in Maryland, 1989–94

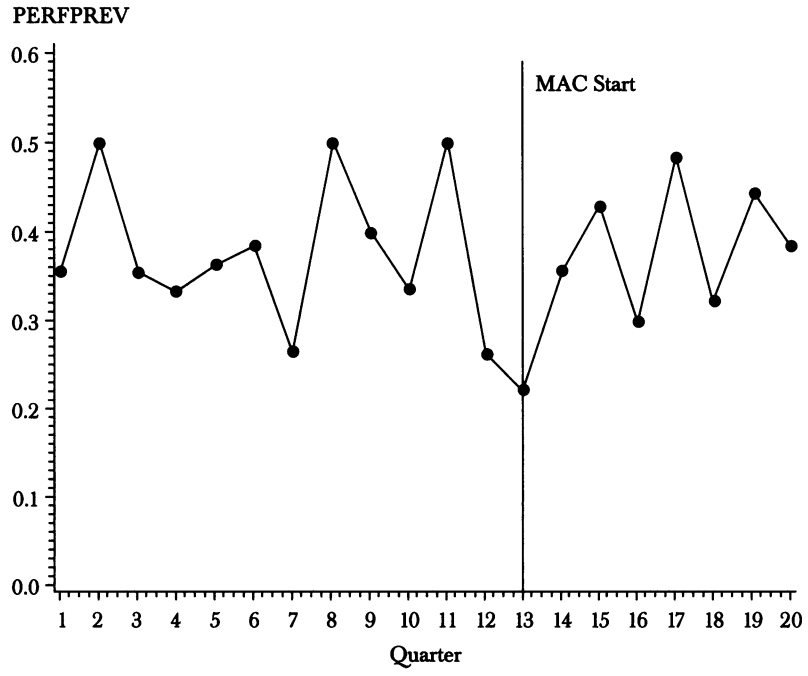


Note: There was no significant trend for season, MAC quarter, or quarter.

Trends in Ruptured Appendicitis Using Medicaid Inpatient Claims Data. Analysis of the Medicaid inpatient claims yielded 374 cases of appendicitis, of which 37 percent were ruptured. Figure 2 demonstrates the percent of ruptured appendicitis, calculated for each quarter using these Medicaid claims. Linear regression analysis on these data did not show a significant difference between pre- and post-MAC quarters. Thus, the percent of ruptured appendicitis did not change significantly during the study period.

Length of Stay. Table 1 shows the mean LOS for ruptured and nonruptured appendicitis for both of these databases. The Medicaid claims and hospital discharge data for Medicaid LOS are not comparable because (1) Medicaid hospital discharges in the HSCRC database include both MAC-eligible as well as -ineligible Medicaid recipients; and (2) the hospital discharge data contain one more year of data (i.e., children 19 years of age and

Figure 2: Percent Ruptured Appendicitis Among MAC-Eligible Child Medicaid Recipients, 1989–93



Note: There was no significant trend for season, MAC quarter, or quarter.

Table 1: Mean LOS in Days for Children with Appendicitis by Insurance Type and by Administrative Database Used for Analysis

	Ruptured	*Nonruptured*
Medicaid claims for MAC-eligible children	7.98 ($n = 140$)	3.25 ($n = 238$)
Hospital discharge data		
Medicaid	7.60 ($n = 221$)	3.11 ($n = 399$)
Self/Unknown	6.44 ($n = 142$)	2.83 ($n = 298$)
Private	6.49 ($n = 1{,}183$) p = n.s.	2.74 ($n = 2{,}917$) $F = 0.86$, p = n.s.*

*Using analysis of covariance controlling for age.

the calendar year 1994). However, the mean LOS for ruptured appendicitis is significantly longer than for nonruptured appendicitis in both databases, as expected (Table 1). Examination of hospital discharge data shows that the LOS for Medicaid recipients was significantly longer than for private insurance ($p < .004$) for nonruptured appendicitis, but not for ruptured appendicitis. However, when analysis of covariance is used to control for age, this difference is no longer significant ($F = .86$). Because Medicaid recipients are usually younger and because younger children may have required a longer observation period to make the diagnosis, age is a confounding variable in the comparison of LOS by insurance type.

Simple correlation analysis of LOS by study quarter demonstrated a significant reduction in LOS during the study period for all payers for nonruptured appendicitis ($p > .001$ for all Pearson correlation coefficients). However, reduction in LOS by quarter for ruptured appendicitis occurred in the private insurance group (Pearson correlation coefficient = $-.117$, $p = .0001$) and the Medicaid group (Pearson correlation coefficient = $-.15$, $p = .02$), but not the self-pay group (Pearson correlation coefficient = $-.12$, p-value was not significant). No seasonal differences in LOS were observed in the linear regressions.

Prediction of Ruptured Appendicits. Among all children hospitalized for appendicitis, the Medicaid claims database demonstrated a significant inverse relationship between the number of preventive care visits and the occurrence of ruptured appendicitis (OR for one additional preventive care visit = 0.19) (Table 2). The quarterly rate of preventive care visits among those with

Table 2: Predicting Ruptured Appendix Among All MAC-Eligible Children Hospitalized for Appendicitis. Results of Logistic Regression Using Medicaid Claims

	Probability of Ruptured Appendix (n = 374) OR with 95%CI	p
Age	0.86 (0.81–0.91)	.001
Female	0.84 (0.53–1.32)	
Urban	1.00 (0.96–1.04)	
AFDC	0.72 (0.42–1.24)	
SSI	1.35 (0.38–4.75)	
White	0.35 (0.17–0.71)	.004
African American	0.84 (0.41–1.74)	
MAC enrolled	0.57 (0.84–1.16)	
Quarter	1.04 (0.98–1.09)	
PREV	0.19 (0.05–0.77)	0.019
PRIM	1.01 (0.82–1.23)	
SPEC	0.86 (0.60–1.24)	

Note: PREV = number of preventive care visits; PRIM = number of acute visits to primary care provider; SPEC = number of visits to a specialist.

ruptured appendicitis is 21/1,000, compared to 55/1,000 among those with nonruptured appendicitis. Other visit types (acute or specialty care) were not significant predictors. Individual MAC enrollment was not associated with ruptured appendicitis (OR = 0.57, but the 95% CI crosses 1.0). Among demographic variables, age and white race were inversely related to ruptured appendicitis.

For the hospital discharge database, the only significant covariates were age (OR = 0.91, CI 0.90–0.93) and gender (OR = 0.87, CI 0.77–0.99) (Table 3). Health service variables, such as primary insurance, the number of pediatric beds, and the MAC quarter, were not significantly associated with ruptured appendix.

It should be noted that the hospital discharge data set (n = 5,141) has almost 14 times the number of subjects as the Medicaid claims data set (n = 374). Because of the resulting differences in statistical power and the inherent differences between the populations included in these data sets, direct comparisons of any statistical outcomes are not appropriate. The smaller sample size in the Medicaid database yields less power to address Type II error. However, even this smaller data set provided adequate power (.80) to detect a 15 percent difference in ruptured versus nonruptured appendicitis

Table 3: Predicting Ruptured Appendix Among All Children Admitted for Appendicitis in the State of Maryland, 1989–92. Logistic Regression Results Using Hospital Discharge Data (Includes All Payers and All Medicaid Recipients)

	Probability of Ruptured Appendix (n = *5,141*) *OR with 95%CI*	p
Age	0.91 (0.90–0.93)	.0001
Female	0.87 (0.77–0.99)	.038
Urban	0.90 (0.73–1.11)	
Medicaid	1.01 (0.83–1.23)	
Self-pay	1.11 (0.89–1.39)	
White	0.81 (0.60–1.09)	
African American	1.18 (0.85–1.63)	
Pediatric beds	1.01 (1.00–1.01)	
MAC quarters	0.94 (0.74–1.20)	
Quarter	1.01 (0.99–1.02)	

between boys and girls (.48 and .33, respectively). A difference half this size (7 percent) was actually observed (.40 and .33, respectively).

DISCUSSION

The incidence of appendicitis and ruptured appendicitis among children did not change during a period of rapid growth in managed care in Maryland. Common concerns about managed care include delayed presentation (due to decreased access and increased barriers), decreased physician access or delayed surgical referral (due to gatekeeping), or delayed diagnosis (due to provider or health system factors). All of these factors have been shown to be associated with an increased incidence in ruptured appendicitis. Because we did not observe an increase in this outcome during the study period, it would be logical to assume that the above contributing factors also did not increase in prevalence. Thus, the stability of the incidence of ruptured appendicitis in this study is reassuring.

The protective effect of preventive care visits in the Medicaid claims multivariate model supports the importance of primary care in modifying the odds of ruptured appendicitis among children. It may also reflect a relationship with a regular primary care provider who can facilitate access and expedite referral. Because preventive care itself cannot prevent appendicitis,

the number of preventive care visits may be a proxy for the existence of a primary care relationship. Another possibility is that it may be a reflection of parental attentiveness to health care issues. Parents who bring their children in for regular preventive care visits may be more attuned to health as well as to signs of illness. As a result, these parents may have or may acquire a higher level of health literacy. Familiarity with the "medical home" as well as greater health literacy may enable these parents in turn to convey urgency to the primary care provider when appendicitis signs and symptoms occur. This primary care relationship may facilitate timely entry into emergency care when these conditions arise.

To a certain extent, the type of primary care provider available is determined by insurance coverage; therefore, insurance type and access to and quality of primary care may be related. Because the hospital discharge database used in this study does not include information on the primary care provider, we were unable to address this relationship. Although others have demonstrated that Medicaid insurance and lack of insurance increased the risk of ruptured appendicitis among adults (Braveman, Schaaf, Egerter, et al. 1994), our study did not demonstrate this same effect in children. Using the 1984–89 California hospital discharge database, the study by Braveman and colleagues utilized similar covariates, appropriate risk adjustors for adults, and multivariate analysis, but did not include children.

Technical aspects of care, such as the use of diagnostic imaging (computed tomography or ultrasound) in making the diagnosis of appendicitis, were not examined in this study but were unlikely to have changed significantly during the period studied. Although diagnostic imaging has been shown recently to improve the diagnosis and management of appendicitis (Rao, Rhea, Novelline, et al. 1998; Balthazar, Rofsky, and Zucker 1998), these technologies would not be expected to affect access to care or health care–seeking behavior.

A number of caveats must be noted. This is a study of associations, not cause and effect, and the limitations of administrative databases apply. Hospital discharge data can be used to identify distributions and intensity of care but cannot provide direct information on appropriateness or preceding ambulatory care. This study is limited to one state. Thus, these findings may not be generalizable to other regions that differ in the degree of managed care penetration, the type of Medicaid managed care offered, and the ease of access to primary care. Also, these results may not be generalizable to areas with different levels of access to surgical care because reduced access to surgical care may, in and of itself, act to delay surgical intervention and therefore contribute to subsequent rupture.

Clearly, the complexity of the clinical presentation of an individual child could in no way be captured by this data. In addition, given the low rate of appendicitis or appendectomies performed by individual surgeons, it is unlikely that the proportion of ruptured appendicitis cases would be a valid measure of individual physician performance.

What, then, does ruptured appendicitis tell us as an indicator? The strong inverse relationship between the number of preventive care visits and the incidence of ruptured appendicitis strongly implies that it is a good macro-level indicator of access to care in this setting. The generalizability of this indicator in other settings, such as areas of higher managed care penetration, decreased access, and health systems of differing quality, should be an area for further inquiry.

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