Little Effect of Insurance Status or Socioeconomic Condition on Disparities in Minority Appendicitis Perforation Rates

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Objective: To estimate how much of the gap in appendicitis perforation rates between minority and white children is explained by differences in socioeconomic and insurance factors.

Design: Observational analysis of hospital discharge information.

Setting: The Healthcare Cost and Utilization Project database.

Participants: Appendicitis perforation rates determined from the Healthcare Cost and Utilization Project database of hospital discharges from 2001 to 2008.

Main Outcome Measures: The proportion of the gap between perforation rates explained by various patient- and hospital-level variables.

Results: There were no disparities observed in adult appendicitis perforation rates. The perforation rate for white children was 26.7%; black children, 35.5%; and Latino children, 36.5%. Gap analysis showed that only 12.0% of the difference in perforation rates between black and white children was explained by insurance status and only 12.7% of the difference between Latino and white children was explained. Income level only accounted for 7.2% of the gap for black children and 6.1% for Latino children. Age explained one-third of the gap for Latino children and one-third was not accounted for by measurable variables. Two-thirds of the difference between appendicitis perforation rates between black and white children was not explained by measurable factors.

Conclusions: A very small amount of the gap between minority and white children's appendicitis rates is explained by the proxy factors for health insurance and poverty status that might relate to health care access. Appendicitis perforation rates are not an appropriate indicator of health care access.

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One of the great medical discoveries of the late 19th century was that appendiceal rupture caused many cases of lethal pelvic infection. Carefully studying a large series of autopsies, Reginald Fitz[1] postulated that the appendix became inflamed and eventually gangrenous, with subsequent perforation causing pelvic sepsis. In this earlier time before antibiotics and fluid resuscitation were available, pelvic sepsis was usually lethal.[2] The lethality of perforated appendicitis led surgeons to advocate emergency appendectomy once a diagnosis of appendicitis was suspected.[3] Prevention of appendiceal rupture is believed to be a race against time, with appendectomy performed immediately once a diagnosis of appendicitis is established.

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Assuming perforation is the inevitable fate for untreated appendicitis,[4] perforation rates are considered a reliable marker for access to health care systems. Numerous reports of minority patients, the impoverished, and those who are underinsured have concluded that patients from these groups with inadequate health care access have higher appendicitis perforation rates.[5-14] These analyses have relied on descriptive statistics or regression analyses without quantifying how much of an effect any individual factor has on perforation rates. More recent epidemiological studies have questioned the inevitability of perforation when appendicitis is present.[15,16] A growing body of literature suggests that appendicitis does not need emergent treatment because perforation rates are not impacted by delayed treatment.[17,18]

If perforation is not an inevitable consequence of delayed treatment, there must be an explanation for why several large-scale investigations concluded that there was an association between race, ethnicity, and socioeconomic factors and appendicitis perforation rates. We hypothesize that this apparent relationship results from not considering the relative magnitude of socioeconomic and health care access factors to perforation rates above and beyond simple statistical significance. We further hypothesize that gap analysis will show that the reason there was an apparent socioeconomic effect on perforation rates resulted from incomplete consideration of uncontrolled residual confounding variables. To fully evaluate the potential for racial, ethnic, and socioeconomic disparities to influence appendicitis perforation rates, we used gap decomposition techniques to quantify how much these factors contribute to perforated appendicitis outcomes. This analysis will also quantify the degree to which unmeasured confounding factors contribute to appendicitis perforation rates.

METHODS

The Healthcare Cost and Utilization Project (HCUP) databases for 2001 to 2008 were combined. The HCUP database is composed of administrative state-level discharge records that account for 20% of all US nongovernment hospital admissions. A subset of this database was created by inclusion of records that had *International Classification of Diseases, Ninth Revision* diagnostic codes of 540.0 to 543.9 (appendicitis) in any of the 15 diagnosis entries or if any of the 15 procedure codes ranged from 47.0 to 47.99 (operations on the appendix). Perforated appendicitis was considered present if any diagnostic code was 540.0 (rupture of the appendix) or 540.1 (appendicitis with peritoneal abscess). Nonperforated appendicitis was considered present if any diagnostic code ranged from 540.0 to 543.9 exclusive of the 2 earlier-cited perforation codes.

Race/ethnicity was obtained from the HCUP database core elements file and encoded as white, black, and Latino. Because of relatively small numbers, other racial ethnic categories were not considered for more detailed analysis. The HCUP database is missing race data in its entirety in records from Georgia, Illinois, Kentucky, Maine, Minnesota, Nevada, Ohio, Oregon, Washington, and West Virginia. Race information is missing from some California records. A combination variable of white, black, and Latino was created to test the distribution of perforation rates as a function of various demographic features between the missing data and the combination variable. This was done to determine if the population of patients with missing race information was similar to that for which race was designated in HCUP. As a sensitivity analysis, records with missing values were randomly assigned race designations in proportions equivalent to the known race population. The randomly assigned variables were studied alone and also following combination with the records from patients with known race.

Because the spectrum of appendicitis perforation rates differs greatly between adults and children, the analytic data set was segregated into an adult population (≥18 years old) and children (<18 years old). The HCUP database also contains medical insurance information. Socioeconomic status was estimated from the average income for the zip code region where the patient lived. Poor was defined as income less than \$36 000 to \$39 000 per year for 2001 to 2008 (the exact threshold changes annually in the HCUP core data elements file); lower middle-class incomes were \$36 000 to \$39 000 to \$46 000 to \$49 000 annually; upper middle class, \$46 000 to \$49 000 to \$62 000 to \$64 000; and "rich" if the annual salary exceeded \$62 000 to \$64 000.

Patient insurance status and hospital-specific characteristics were obtained from the HCUP database. Hospital size was obtained from the variable Hosp_Bedsize in the HCUP hospital file data elements (http://www.hcup-us.ahrq.gov/db/vars/hosp_bedsize/nisnote.jsp). The definitions used for small, medium, and large bed size are presented in eTable 1 (http://www.archsurg.com). The variable Hosp_Control was assessed to determine the relationship of hospital ownership to appendicitis perforation rates. Teaching status and hospital environment were obtained from the hospital file variables Hosp_Teach and Hosp_Location, respectively. The number of appendectomies performed in each hospital per year was calculated.

Multivariate logistic regression was used to assess the impact race, ethnicity, poverty, and insurance status had on pediatric appendicitis perforation rates. Regressions were nested to examine the effect addition of variables had on each other.

Factors that contribute to the differing appendiceal perforation rates between white and minority patients were assessed by gap decomposition. The differences in perforation rates are composed of measured factors that contribute to some portion of the difference and an unmeasured component that is unexplained by the information available for analysis. Patient- and hospital-level factors were assessed to quantify how much they contribute to the higher perforation rates observed in minority patients.

$$\bar{Y}^W - \bar{Y}^B = \left[\sum_{i=1}^{N^W} \frac{F(X_i^W \hat{\beta}^W)}{N^W} - \sum_{i=1}^{N^B} \frac{F(X_i^B \hat{\beta}^W)}{N^B}\right] + \left[\sum_{i=1}^{N^B} \frac{F(X_i^B \hat{\beta}^W)}{N^B} - \sum_{i=1}^{N^B} \frac{F(X_i^B \hat{\beta}^B)}{N^B}\right], \quad (4.2)$$

$$\bar{Y}^W$$

represents the mean perforation rate for white patients. For binary data, the mean value is the same as the perforation rate. Similarly,

$$\bar{Y}^B$$

is the appendicitis perforation rate for black (or any other minority) patients.

$$\bar{Y}^W - \bar{Y}^B$$

is the gap between white and minority patient appendicitis rates. The first term in brackets on the right side of the equation determines the explained portion of the group difference (ie, gap). The second term determines the proportion of the gap that is unexplained by the variables used in the analysis. This second term is not reported in this article. For logistic regression, the following definitions are used:

$$\sum_{i=1}^{N^W} \frac{F(X_i^W \hat{\beta}^W)}{N^W}$$

represents the average probability for perforation in the white cohort as determined by summation of each patient's predicted probability for perforation (determined by solution of the logistic regression equation) for appendicitis perforation divided by the number of white patients.

$$X_i^W$$

is a vector of individual values for the explanatory variables for white patients (eg, age, sex, and insurance type). Substituting the distribution of individual values for black patients

$$X_i^B$$

into the regression equation using the estimated regression coefficients for white patients

$$\hat{\beta}^W$$

facilitates estimation of the amount of the overall difference in appendicitis perforation rates attributable to the factors entered

Table 1. Race, Ethnicity, Socioeconomic and Insurance Status, and Hospital Characteristics and Pediatric Appendicitis Perforation Rates

	%			
	White	Black	Latino	Other
Perforation rate	26.7	35.5	36.5	29.7
Insurance				
Medicaid insurance	30.5	38.7	40.1	34.7
Private insurance	25.2	33.1	31.4	27.5
Self-pay	26.7	30.7	35.4	32.8
Income				
Poor	28.1	37.8	38.1	32.5
Lower middle class	27.8	34.5	37.9	31.2
Upper middle class	27.4	34.4	35.5	30.6
Rich	25.0	32.9	33.3	27.4
Region				
Northeast	24.1	32.8	27.9	29.1
Midwest	28.4	36.2	35.2	28.6
South	26.9	36.3	36.0	32.9
West	29.0	38.5	40.5	30.1
Hospital size				
Small	27.6	33.0	36.5	29.0
Medium	25.6	32.9	37.0	30.1
Large	26.8	37.0	36.3	30.5
Hospital type				
Nonfederal government	27.5	30.8	36.3	26.5
Private, nonprofit	25.1	34.7	36.1	28.6
Private, investor owned	24.1	27.2	34.5	29.6
Hospital location				
Rural	20.5	31.6	29.6	27.2
Urban	27.0	35.8	36.9	30.9
Teaching status				
Teaching	29.6	38.3	38.3	33.5
Nonteaching	24.5	30.7	34.4	27.3
Hospital volume				
Low quartile (<103/y)	25.3	30.3	31.5	28.3
Midquartile 1 (103-199/y)	25.7	32.9	34.5	29.8
Midquartile 2 (200-323/y)	27.6	37.4	37.8	30.6
High quartile (>323/y)	28.4	40.0	38.6	33.0

as independent variables in the regression equation.[19] Greater detail regarding gap decomposition and the R and SAS codes used to perform this analysis is presented in the eAppendix.

Briefly, a logistic regression equation was estimated for all potential racial, ethnic, and patient- and hospital-level explanatory variables. An individual white patient's estimated risk for perforation was calculated by entering the explanatory variables into the regression equation. This individual was paired with a black patient whose explanatory variables were entered into the same regression equation that used the same estimated coefficients. This was done 1 variable at a time, and on subtracting the estimated probability for the black patient from the white patient, an estimate of the explained portion of the perforation rate gap was obtained. This process was repeated for all the explanatory variables, resulting in a set of gap estimates for each variable. Because there were more white patients than minority patients in the sample, they were randomly matched 1:1 with a minority patient in each iteration of the estimation process. One thousand iterations were performed with rerandomization of the white patient–matching cohort and the mean contribution to the gap for each variable was calculated. During this analysis, variables were grouped together into similar categories. For example, all variables indicating a patient's type of insurance were grouped into a single "insurance" category such that the amount of the perforation rate gap that can be explained by any difference in medical insurance status was reflected in this single variable.

The variables were assembled into 11 groups: (1) sex, (2) age and age × age, (3) income level derived from zip code information, (4) region of the country, (5) insurance type, (6) elective or emergent hospital admission status, (7) hospital size (see HCUP definition in the eTables), (8) hospital ownership and teaching status, (9) urban or rural location of the hospital, (10) total hospital volume and annual appendectomy volume and the square of these variables, and (11) year of the surgery.

RESULTS

The study cohort included 526 925 cases of appendicitis contained in the HCUP database between 2001 and 2008. When we evaluated perforation rates for the entire population, there were no clinically important differences between racial categories. Adult appendicitis perforation rates were very similar among white, black, and Latino patients (eTable 2). Disparities were evident between children, with white patients having a 26.7% perforation rate. The pediatric appendicitis perforation rate was 35.5% for black children and the perforation rate was highest in Latino children at 36.5%. The racial, ethnic, and socioeconomic and insurance status for children with

Table 2. Nested Multivariate Logistic Regression[a]

Group	OR (95% CI) Race	Poverty	Medicaid
All		1.37 (1.33-1.42)	
All			1.44 (1.40-1.47)
Black vs white	1.53 (1.43-1.60)		
Black vs white	1.42 (1.34-1.50)		1.26 (1.21-1.31)
Black vs white	1.53 (1.42-1.65)	1.18 (1.12-1.24)	
Black vs white	1.46 (1.35-1.58)	1.09 (1.03-1.16)	1.24 (1.16-1.33)
Latino vs white	1.58 (1.54-1.63)		
Latino vs white	1.54 (1.47-1.61)		1.19 (1.14-1.25)
Latino vs white	1.54 (1.47-1.61)	1.19 (1.14-1.25)	
Latino vs white	1.44 (1.37-1.51)	1.09 (1.04-1.15)	1.30 (1.23-1.37)

Abbreviations: CI, confidence interval; OR, odds ratio.

[a] Race/ethnicity was evaluated by comparing black with white patients or Latino with white patients while excluding all other patients from the analysis. Poverty (income <$25 000/y) was compared with the highest income level (>$45 000/y). Medicaid insurance was compared with any insurance that was not classified as Medicaid.

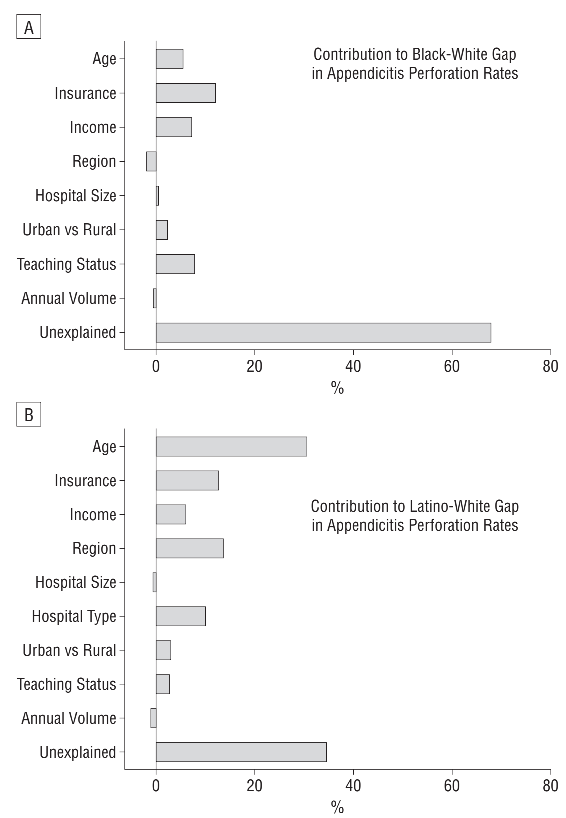

Figure. Decomposition analysis for pediatric perforated appendicitis rates in black patients (A) and Latino patients (B) compared with white patients. The horizontal bars represent the percentage of the difference in perforation rates between black (A) or Latino (B) and white children explained by racial differences in the listed factor. Bars to the right of the zero line contribute to the higher perforation rate observed in minority children. Those to the left of the line are associated with a reduced risk of perforation in minority children.

perforated appendicitis is presented in **Table 1**. Approximately one-third of all records either did not have racial or ethnic information or those patients were categorized as belonging to a group other than white, black, or Latino. Because many states contributing to HCUP do not supply race information, we compared the patient- and hospital-level appendicitis perforation rates for data with missing race information with a combination variable of white, black, and Latino. The distribution is very similar, suggesting that race information is missing in a way that is equivalent to being random and that exclusion of data with missing race information from subsequent analysis should not impact our results.

In general, children with Medicaid insurance had higher perforation rates than those with private insurance or those who were classified as "self-pay." Too few minority children had Medicare insurance to include in this analysis. Similarly, children in families with lower incomes had higher appendicitis perforation rates than their counterparts in higher-income families.

Regional differences in pediatric appendicitis perforation rates were small for white and black children. In contrast, there was a 27.9% perforation rate for Latino children living in the Northeast and a 40.5% perforation rate for those living in the western United States. Differences in hospital size had little effect on perforation rates. Pediatric appendicitis perforation rates were lower (27.2%) for black children in private, investor-owned facilities as compared with the 34.7% rate in private nonprofit hospitals. Perforations were more common in urban environments and were more common in teaching hospitals. This may be related to differences in racial and ethnic compositions at these facilities. Teaching hospitals are enriched with black patients, with 6.7% of all appendicitis cases being black in teaching hospitals compared with 3.6% in nonteaching facilities. The same is true for Hispanic patients, with 23.7% of appendicitis cases being Hispanic in teaching facilities compared with 18.4% in nonteaching hospitals. Similarly, more black individuals were treated in urban than rural facilities (5.4% vs 2.7%) and substantially more Hispanic individuals were treated at urban hospitals (23.2% vs 7.1%). Perforation rates were higher in high-volume hospitals.

Nested logistic regression analysis reported in **Table 2** showed independent effects of black race or Latino ethnicity compared with white race, poverty, and the use of Medicaid insurance on pediatric appendicitis perforation rates. Each variable remained significant after addition of the other variables into the regression equation, suggesting that race, ethnicity, poverty, and Medicaid insurance status each had independent effects on perforated appendicitis rates. Further exploration of the contribution of each factor on perforation rates was performed by decomposition analysis. eTable 3 shows the mean values for all variables entered into the regression used for decomposition analysis. eTable 4 presents the results of the regression. Decomposition analysis for the black-white gap in pediatric perforated appendicitis rates is shown in the **Figure**, A. Because black children's perforated appendicitis rate was 0.355 and for white children, it was 0.267, the difference to be explained was 0.088. Of this, only 7.2% of the 0.088 difference was explained by difference in income groups among these children. Twelve percent of the difference was explained by insurance status, 7.8% by teaching status, and 5.5% by age differences. Approximately two-thirds of the 0.088 difference in perforated appendicitis rates was not

Table 3. Prior Studies of Perforated Appendicitis in Children That Examined Racial, Ethnic, Insurance, and Income Effects on Perforation Rates

	Source (Year), Perforated Appendicitis Rate									
	Luckmann and Davis[22] (1991)	O'Toole et al[12] (1996)	Bratton et al[7] (2000)	Gadomski and Jenkins[8] (2001)	Guagliardo et al[9] (2003)	Guagliardo et al[9] (2003)	Ponsky et al[13] (2004)	Smink et al[14] (2005)	Nwomeh et al[11] (2006)	Jablonski and Guagliardo[10] (2005)
White	22.0	a	a	a	27.0	27.5	35.2	29.7	23.7	29.0
Black	27.0	a	a	a	30.0	37.5	40.5	36.8	30.1	36.0
Latino	31.0	a	a	a	38.6	33.0	a	39.5	a	36.0
Commercial or private	a	23.0	23.0	29.0	28.6	28.8	31.7	29.7	24.1	a
HMO	a	27.0	23.0	a	a	a	a	a	a	a
Medicaid or self-pay		37.0	28.0	36.0	38.7	30.0	45.0	39.9	30.3	a
Income										
>$45 000	a	a	a	a	29.2	26.4	a	31.2	25.8	29.0
<$25 000	a	a	a	a	44.0	33.1	a	34.3 (2%)	28.6 (1%)	38.0
Data source	OSHPD	Buffalo Children's Hospital	Washington state	Maryland state discharges for children	OSHPD	New York	36 US children's hospitals	KID	Columbus Children's Hospital	KID
Ages, y	5-29	0-16	0-17	0-19	4-18	4-18	5-17	0-18	2-10	4-18
Dates	1983-1986	1990-1993	1987-1996	1989-1992	1997	1995	1997-2002	1997	2001-2003	2000
Sample size	102 546	294	13 532	3614	9077	3245	24	33 184	788	32 784

Abbreviations: HMO, health maintenance organization; KID, Kids' Inpatient Database; OSHPD, Office of Statewide Health Planning and Development.
[a] The study did not look at this parameter.

explained by any of the patient- or hospital-level factors we studied. Higher appendicitis case volume was associated with a lower perforation rate but volume only explained 2.3% of the gap.

Age explained nearly one-third of the 0.099 difference in perforated appendicitis rates between Latino and white children (Figure, B). This difference was driven largely by Latino children at risk of perforation being younger than white children at risk. Only 6.1% of the perforation rate difference between Latino and white children was accounted for by income level; 13.6%, by regional differences; 12.7%, by insurance type; and 2.7%, by hospital teaching status. One-third of the 0.099 difference in appendicitis perforation rate between Latino and white children could not be accounted for by the factors assessed in this analysis. Being in the northeastern United States was associated with a higher risk of perforation for black children but less for Latino children. Large hospital size was associated with higher perforation rates in black children relative to white children but only explained 0.7% of the gap, whereas large hospitals were associated with few perforations for Latino children but hospital size only explained 0.2% of the observed white-Latino gap in perforation rates.

COMMENT

Logistic regression analysis is one of the most common statistical methods used to assess the contribution of factors to a dichotomous outcome variable in observational studies. Results are reported as odds ratios that are interpreted as the odds of an event occurring relative to the odds of it not occurring if the factor is present or absent. Using logistic regression, we found an odds ratio of approximately 1.50 for appendicitis perforation rates for black children relative to white children. This means that the odds of a black child having perforated appendicitis are 50% higher than for a white child. When Medicaid insurance status was entered into the regression equation, the odds ratio for insurance status was approximately 1.25, suggesting that Medicaid insurance status accounts for a 25% increased risk for perforation in black children independent of their race. Expression of the results as a percentage of increased risk in odds ratio makes the impact of the risk factor on an outcome appear larger than is merited by the actual, raw numbers.

Analysis by simple logistic regression can also overestimate the effect a variable has on an outcome. Unmeasured or nonincluded factors (confounders) affecting an outcome that are correlated with a variable included in the regression equation cause the appearance of a larger effect on the outcome than really exists. For example, obesity and diabetes mellitus are highly correlated. If one examined the relationship between obesity and mortality without inclusion of diabetes in the regression, a very strong association between obesity and mortality might be found that would be lessened if diabetes had been controlled for.[20] This situation is known as having residual, unmeasured confounders. Another problem with logistic regression is that if the prevalence of some factor is small, it will only contribute a small amount to the explained variance of an effect, yet it, by itself, may have a strong association manifested by a large odds ratio.[21]

Numerous studies have reported that minority children have higher appendicitis perforation rates than do white children (**Table 3**). In many of these studies, logistic regression was performed to determine the contribution of insurance and socioeconomic factors to the higher perforation rates observed in minority children (**Table 4**). The proportions of patients with perforation and the results from regression analysis in most of these studies are very similar in magnitude to those we obtained by similar

Table 4. Prior Studies Using Regression Analysis to Examine the Impact Socioeconomic Factors Have on Appendicitis Perforation Rates in Children

Source (Year)	Group	OR (95% CI)
Guagliardo et al,[9] CA (2003)	Black vs white	0.90 (0.07-1.16)
Guagliardo et al,[9] NY (2003)	Black vs white	1.44 (1.07-1.95)
Jablonski and Guagliardo[10] (2005)	Black vs white	1.40 (1.27-1.55)
Nwomeh et al[11] (2006)	Black vs white	1.35 (0.082-2.20)
Smink et al[14] (2005)	Black vs white	1.23 (1.10-1.39)
Gadomski and Jenkins[8] (2001)	Black vs nonblack	1.18 (0.85-1.63)
Ponsky et al[13] (2004)	Black vs white	1.13 (1.01-1.30)
Smink et al[14] (2005)	Latino vs white	1.20 (1.10-1.30)
Guagliardo et al,[9] CA (2003)	Latino vs white	1.30 (1.14-1.48)
Guagliardo et al,[9] NY (2003)	Latino vs white	1.22 (0.92-1.62)
Jablonski and Guagliardo[10] (2005)	Latino vs white	1.36 (1.28-1.44)
Guagliardo et al,[9] CA (2003)	Low vs high income	1.22 (1.03-1.45)
Guagliardo et al,[9] NY (2003)	Low vs high income	1.02 (0.72-1.44)
Jablonski and Guagliardo[10] (2005)	Low vs high income	1.15 (1.05-1.27)
Smink et al[14] (2005)	Low vs high income	1.06 (0.98-1.15)
Bratton et al[7] (2000)	Medicaid vs commercial	1.30 (1.20-1.40)
Gadomski and Jenkins[8] (2001)	Medicaid vs non-Medicaid	1.01 (0.83-1.23)
Smink et al[14] (2005)	Medicaid vs private	1.27 (1.18-1.37)
Weissman et al[23] (1992)	Medicaid vs private	1.89 (1.53-1.96)
Weissman et al[23] (1992)	Medicaid vs private	2.22 (1.85-2.78)
Guagliardo et al,[9] CA (2003)	Public vs private insurance	1.29 (1.14-1.46)
Guagliardo et al,[9] NY (2003)	Public vs private insurance	0.99 (0.79-1.24)
Ponsky et al[13] (2004)	Public vs private Insurance	1.48 (1.34-1.64)
Weissman et al[23] (1992)	Public vs private insurance	1.14 (0.93-1.34)
Weissman et al[23] (1992)	Public vs private Insurance	1.20 (0.80-1.60)
Ponsky et al[13] (2004)	Self-insured vs private insurance	1.36 (1.22-1.53)

Abbreviations: CA, California; CI, confidence interval; NY, New York; OR, odds ratio.

analysis of the HCUP database. Analyses in this manner led the investigators of the prior published studies to conclude that socioeconomic factors independently contributed to appendiceal perforation rates. This was first observed for adults whose insurance status was shown to be an independent risk factor for appendiceal perforation independent of race and socioeconomic status, leading to the conclusions that insurance-related delays in treatment were a significant health policy issue.[5,24] Subsequent studies focused on children, with a number of them highlighting apparent racial disparities in perforation rates that might be related to inadequate health care access.[9-11,13,14] All of these studies relied on logistic regression analysis as outlined earlier and arrived at the same conclusion.

We also performed a similar logistic regression analysis and obtained virtually identical results of prior published studies (Table 4). Further exploration of the regression models by gap decomposition suggested different interpretations than may be obtained from simple logistic regression. Decomposition of the difference between minority and white patients' perforated appendicitis rates demonstrated that insurance and socioeconomic factors account for a small fraction of the disparity. Using logistic regression, we found that the adjusted odds ratio for appendiceal perforation for black children was 1.24 for Medicaid insurance and 1.30 for Latino children. Black and Latino children had an approximately 9% higher perforation rate than white children and decomposition analysis showed that insurance status only accounted for 12% of this difference. The finding that insurance type accounts for only 12% of the increased perforation rate between minority and white children demonstrates that insurance status contributes only minimally to appendiceal perforation in children, a fact that is not evident from consideration of odds ratios alone.

Minority children have higher appendicitis perforation rates than white children. Why this occurs is unknown, but in general, minority patients are in lower socioeconomic categories and have less access to health care insurance, factors that might contribute to perforated appendicitis because of delayed treatment. In our analysis of a large database that incorporates 20% of all US hospital admissions, we found no differences in perforation rates for adult white, black, or Latino patients. In an analysis of similar data from 1979 to 1984, Addiss et al[25] observed that the appendicitis perforation rate for nonwhite patients was 21.8% compared with 18.2% for white patients. Our more contemporary data showed that the perforation rates for white and nonwhite adults were about the same at 25% to 29%. Racial and ethnic differences in appendicitis perforation rates seem to be limited to the pediatric population.[24,26]

Higher appendicitis perforation rates were observed for black and Latino children compared with white children. Consistent with prior observations, these minority patients had, on average, lower socioeconomic status and were more frequently underinsured or uninsured.[5] Most of the gap between perforation rates in black and white children was not explained by the factors we studied, demonstrating the large effect of residual confounding in these sorts of analyses. Age accounted for nearly one-third of the gap between Latino and white children but socioeconomic or hospital-level factors explained little of the gap in perforation rates. Given the minimal contribution of insurance status to the gap, we conclude that any delays in treatment that might accompany inadequate health insurance coverage do not substantively contribute to appendicitis perforation rates. This conclusion is consistent with our prior epidemiological studies that suggest a disconnect between acute appendicitis and perforated disease.[15,16] If perforation is an inevitable consequence of biological factors and not related to the duration of acute appendicitis, there would be minimal impact of socioeconomic factors on perforation rates, as we found in the current study. Indeed, there is biological evidence that immunological factors such as interleukin 6 activation determine the propensity to perforate.[27,28] If this is the case and biologically driven differences could determine appendicitis perforation, exogenous factors such as poverty or inadequate insurance would not substantially contribute to the racial/ethnic gap in perforation rates. However, the large amount of unexplained gap could result from residual confounding that is not accounted for by the variables available in an administrative database. Thus, one cannot definitively conclude that any biological, patient, or hospital characteristic accounts for the disparity in childhood appendicitis perforation rates.

In addition to the substantial amount of unexplained confounding in this study, it is also limited by the large number of patients who did not have racial or ethnic information designated in HCUP. The HCUP database is created by collating hospital discharge information that is collected by individual states. Each state has different reporting requirements such that several of them either do not collect or transmit race or ethnic information to HCUP. Since this occurs in a systematic way that is independent of the outcome, it is likely that these missing data are missing in a way that is equivalent to being random and should not affect our analysis or conclusions.[29] We found the distribution of patient and hospital factors in the missing data to be similar to that for the aggregated data in which race/ethnicity was present, supporting the notion that this is the case.

As is the case with most analyses from administrative data sets, we used zip code–level approximations for income level. It is conceivable that there is significant heterogeneity of income levels within a zip code region that could contribute to error in our analysis. This error might understate the contribution from racial gaps in income levels.

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