

# Racial and Ethnic Disparities in Pediatric Appendicitis Rupture Rate

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## Abstract

**Objectives:** To determine if there are racial/ethnic differences in the rates of appendiceal rupture among the children of two large states. Because rupture is primarily due to delayed diagnosis, differences would suggest disparities in timely access to quality emergency care. **Methods:** This was an observational, cross-sectional analysis of full-year samples of acute appendicitis cases from California and New York children 4 to 18 years old. Racial/ethnic groups were compared for risk of appendiceal rupture adjusted for biological factors both before and after adjustment for the following socioeconomic, hospital, and admission characteristics: income, insurance, hospital type, and admission source. Results were interpreted in light of census data on the proportion of immigrants in each racial/ethnic group. **Results:** Compared with white children with acute appen-

ditis, Hispanic and Asian children have higher odds of rupture in California, whereas Asian and black/African American children have higher odds in New York. These differences roughly parallel the within-state proportion of immigrant children in these groups. Adjustments for family, socioeconomic, and hospital characteristics attenuate but do not eliminate disparities. **Conclusions:** The authors found evidence of significant racial/ethnic disparities in rate of appendiceal rupture, an important and preventable outcome, in two large but dissimilar states. Immigrant groups may be most at risk for delayed emergency care. Future research should focus on immigration and acculturation as risk factors for appendicitis rupture in children. **Key words:** appendicitis; race; disparity; children; emergencies. *ACA-DEMIG EMERGENCY MEDICINE* 2003; 10:1218-1227.

There is keen interest in the persistence of disparities in health and health care<sup>1</sup> and abundant evidence that health disparities exist over a broad range of medical conditions and services.<sup>2-7</sup> Among medical conditions that have been used to study access to care, acute appendicitis (AA) has unique characteristics that have provided insight into problems of access to emergency care.<sup>8</sup> These include a consistent natural history with a readily identifiable negative outcome (rupture), a single definitive intervention (appendectomy), and lack of behavioral, social, economic, or health

history effects on onset.<sup>9-13</sup> Three statewide studies and one single-county study have used the appendicitis rupture (AR) rate to improve our understanding of delayed access to emergency care.<sup>14-17</sup> However, the studies found little evidence of racial/ethnic disparities in AR rates.

Therefore, it must be asked whether racial/ethnic disparities in AR rates are truly small to nonexistent and whether AR rates are insensitive to racial/ethnic disparities in timely access to emergency care. To answer these questions, it is important to conduct analyses of large and representative databases that include different minority populations. In addition, such analyses would be strengthened by the proper consideration of multiple factors that potentially mediate the relationship between race/ethnicity and AA outcome. We focus on the following patient/family, provider/facility, and system factors as suggested by others in reviewing this issue<sup>18</sup>: income, hospital type, insurance, and source of admission. Previous studies have included as many of these effects as possible in statistical models and have seemingly provided rigorous estimates of the independent relationship between race/ethnicity and AR. However, it is likely that these and similar factors mediate the relationship of race to AR. Therefore, including such mediating factors in a regression model could give misleading results by diminishing the observed association between race/ethnicity. This is a well-described methodologic hazard known as

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overcontrolling.<sup>19</sup> Overcontrolling may have caused other studies to miss disparities in AR rates.

The primary purpose of this study was to determine if there is racial/ethnic disparity in AR rates and emergency care access among children and how serious such disparity may be. Therefore, for all pediatric cases in two large states, we examined estimates of the relationship between race/ethnicity and AR that were first adjusted only for biological factors and then maximally adjusted for multiple covariates. By so doing, we can describe the existence of any disparities in AR rates and appreciate what factors may mediate or moderate their effects on AR.

A secondary purpose of the study was to explore a possible contributor to the revealed disparities. Preliminary results suggested that interstate differences in the patterns of racial/ethnic disparity paralleled interstate differences in patterns of immigration. It is well known that immigrant families face greater barriers to health care<sup>20</sup> compared with native-born Americans. Therefore, we analyzed U.S. Census 2000 data to explore the possible relationship of immigration status to AR rates.

## METHODS

**Study Design.** This was an observational, cross-sectional study of hospital admissions and Census 2000 data from two states, stratified by state. Each state served as an independent sample for investigating disparities in emergency care access using AR rates. Our institutional review board granted an exemption from informed consent for this study of anonymous administrative hospitalization records and Census data.

**Study Setting and Population.** Hospital discharge records were analyzed from the 1997 Californian Office of Statewide Health Planning and Development (OSHPD) dataset and the 1995 New York Statewide Planning and Research Cooperative System (SPARCS). The data were obtained for other research projects, but as in previous studies, they are suitable for illustrating the value of statewide hospital discharge datasets for answering the present questions. Cases were limited to children 4 to 18 years old because AA is rarely diagnosed in a timely manner for very young children, regardless of race/ethnicity or access to care. For example, a rupture rate as high as 100% has been reported among children less than 4 years old.<sup>21</sup>

**Study Protocol.** Cases were limited to any child with a primary, secondary, or tertiary ICD-9 CM diagnosis of 540.X, acute appendicitis. Cases were excluded if they had incidental appendectomy (47.1X) or comorbid conditions likely to interfere with the timely diagnosis of acute appendicitis. Examples included

injuries to the gastrointestinal (GI) tract, GI neoplasms, and inflammatory bowel disease. The comorbid exclusions are available from the authors on request.

**Measurements and Outcomes.** The dichotomous outcome was acute appendicitis with or without complication. ICD-9 CM codes in the "with complication" category were 540.0 (acute appendicitis with generalized peritonitis), 540.1 (acute appendicitis with peritoneal abscess), 567.2 (other suppurative peritonitis), 569.5 (abscess of intestine), 614.3 (acute parametritis and pelvic cellulitis), 614.4 (chronic or unspecified parametritis and pelvic cellulitis), 682.2 (other cellulitis and abscess—trunk), and 998.59 (other postoperative infection). "Without complication" included the remaining cases with ICD-9 CM code 540.9 (acute appendicitis without mention of peritonitis). To keep terminology consistent with previous publications,<sup>17</sup> we refer to all complicated cases as "ruptures."

The independent variable of primary interest was race/ethnicity as recorded on the hospital abstract. Cases were limited to four groups: white, black,\* Hispanic, and Asian. The discharge abstract records do not recognize multiracial categories. Records without a racial identifier were excluded.

As with any study, we were able to quantify a limited subset of all potentially relevant confounding factors. Fortunately, we were able to draw covariables from the major domains of factors affecting access to care, including patient/family factors (e.g., income), provider/facility factors (e.g., hospital type), and system factors (e.g., source of admission). Some of the identified factors were used to screen our sample (see Study Protocol, above), some were used as covariates, and some were found not to require adjustment in our samples.

The independent covariates included biologic factors (age and gender), a patient/family factor (income), system factors (insurance type and source of admission), and provider/facility factors (hospital ownership and hospital teaching status). Age and gender have been related to AA outcome in previous studies,<sup>14-17,22</sup> and insurance type has well-known effects on access to health care.<sup>23</sup> ZIP code median income was used as a proxy for family income; it has been shown useful as a proxy in hospital utilization studies.<sup>15,24</sup> ZIP code median income was categorized by the HCUP Nationwide Inpatient Sample (NIS) scheme<sup>25</sup>: \$0-\$24,999; \$25,000-\$34,999; \$35,000-\$44,000; and  $\geq$ \$45,000. Source of admission ("emergency department" versus "other sources") was used

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\*While we usually use the term "African American," it is misleading in the context of this paper, where we must distinguish between two groups of black Americans—those descended from slaves and those who are recent immigrants.

as a covariate because several studies have shown it to be a significant risk factor for AR.<sup>14-16</sup>

Studies of the associations of hospital ownership (public vs. private) and teaching status with health outcomes have provided mixed results.<sup>15,26</sup> We included them as covariates because interest in these factors remains high.<sup>27-29</sup> Hospital characteristics were obtained by linking discharge records to the American Hospital Association Annual Survey.

Higher volume of admissions within a hospital is associated with better outcomes for many procedures, including appendectomy.<sup>30</sup> However, the significance of this effect for AR rate studies has not been explored. To determine if higher volume was associated with lower rupture rate, we plotted AR rate by decile of pediatric admission volume. Mean rupture rates and 95% confidence intervals for the top eight deciles (>40 pediatric admissions for the year) indicated that hospitals with more than 40 admissions were indistinguishable for rupture rate. The lower two deciles (<40 admissions) appeared to have elevated rates. Thus we experimented with a dichotomous variable for high-low volume (40-admission cutoff) in bivariate and multivariate regression models. The volume variable never approached statistical significance and therefore was not included as a covariate.

**Data Analysis.** Basic AA rates by race/ethnicity, age group, and gender were computed using Census 2000 counts<sup>31</sup> as denominators. Percentages of rupture were computed for all categories of each variable, and intergroup differences were tested for statistical significance using the chi-square test.

The odds of rupture were modeled with logistic regression using PROC GENMOD from SAS version 8.12 (SAS Institute, Inc.; Cary, NC). Two models of the effect of race/ethnicity on rupture were tested. One used only the biologic variables, age group, and gender as covariates to avoid the hazard of overcontrolling.<sup>19</sup> The more complete model included all family, provider, and system factors available in these data sets. A basic assumption of regression is independence of observations. However, AA cases seen at the same hospital cannot be considered independent observations. Thus, all logistic regression models reported here were based on generalized estimating equations (GEE),<sup>32</sup> a feature of PROC GENMOD. The GEEs allowed adjustment for the effect of case clustering by hospital of admission. This approach is referred to as multilevel analysis, or hierarchical modeling. See Diez-Roux<sup>33</sup> or Duncan et al.<sup>34</sup> for in-depth discussions of the need for multilevel analysis for these types of data.

Preliminary results suggested that state differences in the patterns of racial/ethnic disparity might be attributable to different patterns of immigration. Unfortunately, data suitable for studying AR rate on a large scale, such as hospital discharge databases, do not record immigrant status. Therefore, in lieu of

a direct analysis of the effect of appendicitis patient immigrant status on odds of rupture, we compared the odds of rupture within each racial/ethnic group with the odds of being an immigrant within that group. The latter odds were based on Census 2000 data downloaded from American Factfinder<sup>31</sup> and were computed for the following categories: "white alone, non-Hispanic", "black alone, non-Hispanic", "Asian alone non-Hispanic", and "Hispanic, any race." The denominator for each group was total number of children aged 4 to 18. The numerator was total number of children aged 4 to 18 who were either foreign-born or had a foreign-born parent. The percentages so obtained were converted to odds ratios (ORs) by dividing them by percentage of immigrants in the reference group, whites. There are no confidence intervals associated with these ORs because they are not derived from samples but from the universe of children.

## RESULTS

The AA incidence rates are reported in Table 1. White and Hispanic children have higher AA rates than black and Asian children, although the differences are more dramatic for the California sample. Rates peak

**TABLE 1. Hospitalization Rates for Acute Appendicitis among Children 4-18 Years Old**

	Hospitalizations	Population (Census 2000)	Rate per 1,000
California 1997			
discharges			
Race/ethnicity			
White, non-Hispanic	4,017	2,781,131	1.44
Black, non-Hispanic	297	561,115	0.53
Hispanic, all races	4,304	3,311,483	1.30
Asian, non-Hispanic	459	742,272	0.62
Age group			
4-8 yr	2,256	2,552,437	0.88
9-11 yr	2,153	1,549,744	1.39
12-14 yr	2,067	1,427,794	1.45
15-18 yr	2,593	1,866,026	1.39
Gender			
Female	3,521	3,594,270	0.98
Male	5,548	3,801,731	1.50
New York 1995			
discharges			
Race/ethnicity			
White, non-Hispanic	2,379	2,187,123	1.09
Black, non-Hispanic	342	711,420	0.48
Hispanic, all races	444	739,616	0.60
Asian, non-Hispanic	80	197,286	0.41
Age group			
4-8 yr	884	1,329,678	0.66
9-11 yr	902	831,483	1.08
12-14 yr	1,009	781,707	1.29
15-18 yr	948	1,023,822	0.93
Gender			
Female	2,283	1,933,647	0.76
Male	1,460	2,003,043	1.12

**TABLE 2. Appendicitis Ruptures among Children by Patient and Hospital Characteristics**

	No. of Ruptures	No. of Cases	% with Ruptures
California 1997			
discharges			
Race/ethnicity*			
White, non-Hispanic	1,080	4,014	26.9
Black, non-Hispanic	89	297	30.0
Hispanic, all races	1,661	4,299	38.6
Asian, non-Hispanic	156	459	34.0
Insurance type*			
Private	1,457	5,095	28.6
Public	1,311	3,392	38.7
Self-pay	218	582	37.5
Age group*			
4–8 yr	1,030	2,256	45.7
9–11 yr	717	2,153	33.3
12–14 yr	601	2,067	29.1
15–18 yr	638	2,593	24.6
Gender			
Female	1,183	3,521	33.6
Male	1,803	5,548	32.5
ZIP code median annual income*			
\$0–\$24,999	292	657	44.4
\$25,000–\$34,999	681	1,896	35.9
\$35,000–\$44,999	830	2,485	33.4
≥\$45,000	1,102	3,771	29.2
Admission source			
Emergency department	2,169	6,651	32.6
Other	816	2,415	33.8
Hospital ownership*			
Private	1,916	6,056	31.6
Public	693	1,858	37.3
Residency program*			
Yes	1,226	3,270	37.5
No	1,383	4,644	29.8
New York 1995			
discharges			
Race/ethnicity*			
White, non-Hispanic	655	2,379	27.5
Black, non-Hispanic	122	342	35.7
Hispanic, all races	148	444	33.3
Asian, non-Hispanic	37	80	46.3
Insurance type			
Private	610	2,121	28.8
Public	228	711	32.1
Self-pay	124	413	30.0
Age group*			
4–8 yr	299	748	40.0
9–11 yr	219	797	27.5
12–14 yr	235	882	26.6
15–18 yr	209	818	25.6
Gender			
Female	396	1,267	31.3
Male	566	1,978	28.6

*continued***TABLE 2. (cont.)**

	No. of Ruptures	No. of Cases	% with Ruptures
ZIP code median annual income*			
\$0–\$24,999	101	305	33.1
\$25,000–\$34,999	217	710	30.6
\$35,000–\$44,999	288	889	32.8
≥\$45,000	328	1,245	26.4
Admission source*			
Emergency department	701	2,481	28.5
Other	252	745	33.8
Hospital ownership			
Private	82	296	27.7
Public	880	2,949	29.8
Residency program*			
Yes	587	1,782	32.9
No	375	1,462	25.7

\*Chi square,  $p < 0.0001$ .

in midadolescence, and the rate is approximately 50% higher for boys than girls.

Table 2 presents the unadjusted rates of complication. To our knowledge, such rates have not been published for children. We will describe them briefly, although final interpretation of the importance of these factors is best evaluated in the multivariate analyses of Table 3. There are rate differences by race/ethnicity, age, income, and hospital teaching status. No gender differences are apparent. The states show inconsistent findings for insurance type, admission source, and hospital ownership.

Table 3 presents ORs of rupture obtained from all regressions. All values are adjusted for patient clustering within a hospital. The ORs in the first column are otherwise unadjusted. ORs in the middle column are adjusted for race/ethnicity, age, and gender and are the main focus of this study. In California, Hispanics and Asians have elevated odds of AR, whereas the AR rates of blacks and whites are virtually indistinguishable. A different picture emerges for New York. Here, Asians have the highest odds of rupture—more than twice that of whites. Black children are also more likely to experience rupture. Hispanic children have higher odds than white children, although the difference is not statistically significant. As expected, odds of rupture decrease with age in both states. Boys and girls do not have significantly different odds of rupture in either state.

In the last column of Table 3, all available potential mediating factors have been added as covariates to the regression models. These additional adjustments ameliorate but do not eliminate racial/ethnic differences. In California, Hispanics still have elevated adjusted odds of rupture, as do Asians, although the Asian–white differences are not statistically

**TABLE 3. Odds Ratios for Appendicitis Ruptures among Children**

	OR	OR Adjusted for Biologic Factors	OR Adjusted for All Factors
California 1997 discharges			
Race/ethnicity			
White, non-Hispanic	ref	ref	ref
Black, non-Hispanic	1.02 (0.80–1.32)	1.04 (0.81–1.34)	0.90 (0.70–1.16)
Hispanic, all races	1.56 (1.37–1.77)	1.45 (1.28–1.64)	1.30 (1.14–1.48)
Asian, non-Hispanic	1.29 (0.99–1.68)	1.30 (1.00–1.70)	1.21 (0.92–1.58)
Age group			
4–8 yr	2.34 (2.05–2.68)	2.25 (1.96–2.58)	2.18 (1.91–2.50)
9–11 yr	1.40 (1.24–1.57)	1.37 (1.22–1.55)	1.35 (1.20–1.52)
12–14 yr	1.24 (1.09–1.42)	1.24 (1.08–1.41)	1.23 (1.08–1.40)
15–18 yr	ref	ref	ref
Gender			
Female	ref	ref	ref
Male	1.07 (0.96–1.19)	1.05 (0.95–1.17)	1.05 (0.94–1.17)
Insurance type			
Private	ref		ref
Public	1.46 (1.30–1.63)		1.29 (1.14–1.46)
Self-pay	1.42 (1.10–1.84)		1.36 (1.07–1.74)
ZIP code median annual income			
\$0–\$24,999	1.46 (1.24–1.72)		1.22 (1.03–1.45)
\$25,000–\$34,999	1.22 (1.04–1.42)		1.05 (0.91–1.23)
\$35,000–\$44,999	1.17 (1.02–1.33)		1.05 (0.92–1.19)
≥\$45,000	ref		ref
Admission source			
Emergency department	ref		ref
Other	1.13 (1.05–1.27)		1.15 (1.02–1.30)
Hospital ownership			
Private	ref		ref
Public	1.24 (1.03–1.48)		1.12 (0.94–1.34)
Residency program			
Yes	ref		ref
No	0.80 (0.67–0.94)		0.88 (0.75–1.03)
New York 1995 discharges			
Race/ethnicity			
White, non-Hispanic	ref	ref	ref
Black, non-Hispanic	1.49 (1.12–1.98)	1.47 (1.11–1.96)	1.44 (1.07–1.95)
Hispanic, all races	1.32 (1.02–1.71)	1.27 (0.97–1.67)	1.22 (0.92–1.62)
Asian, non-Hispanic	2.28 (1.48–3.49)	2.16 (1.42–3.29)	2.09 (1.36–3.21)
Age group			
4–8 yr	1.91 (1.53–2.37)	1.87 (1.50–2.32)	1.85 (1.48–2.30)
9–11 yr	1.10 (0.88–1.37)	1.11 (0.89–1.39)	1.10 (0.88–1.38)
12–14 yr	1.05 (0.83–1.32)	1.13 (0.84–1.34)	1.04 (0.82–1.31)
15–18 yr	ref	ref	ref
Gender			
Female	ref	ref	ref
Male	0.87 (0.75–1.02)	0.88 (0.75–1.02)	0.89 (0.76–1.04)
Insurance type			
Private	ref		ref
Public	1.09 (0.85–1.40)		0.99 (0.79–1.24)
Self-pay	1.18 (0.98–1.44)		1.02 (0.79–1.30)
ZIP code median annual income			
\$0–\$24,999	1.28 (0.92–1.77)		1.02 (0.72–1.44)
\$25,000–\$34,999	1.22 (0.98–1.52)		1.20 (0.96–1.51)
\$35,000–\$44,999	1.32 (1.10–1.59)		1.38 (1.14–1.67)
≥\$45,000	ref		ref
Admission source			
Emergency department	ref		ref
Other	1.28 (1.04–1.55)		1.28 (1.05–1.57)
Hospital ownership			
Private	ref		ref
Public	0.93 (0.69–1.24)		0.81 (0.60–1.10)
Residency program			
Yes	ref		ref
No	0.71 (0.59–0.84)		0.77 (0.64–0.93)

All values are adjusted for clustering of cases within a hospital.  
OR = odds ratio; ref = reference.

significant. In New York, Asians and blacks still have significantly higher odds of rupture compared with whites.

Income and insurance effects differ between the states. In California, adjusted odds of rupture for publicly insured and self-pay children were significantly higher than for privately insured children, whereas in New York the groups were indistinguishable. In California, the lowest income group had elevated odds compared with the highest income group, whereas in New York only the second highest income group, \$35,000–\$44,999, was distinguishable from the highest income group.

Patients admitted from the discharging hospital's emergency department (ED) tended to fare better than those admitted from other sources, and hospital ownership was not a statistically significant factor in either state. Children discharged from hospitals lacking residency programs also fared better, although this protective effect was not statistically significant in California.

Table 4 compares the odds of AR with odds of immigrant status by racial/ethnic group. In both states the odds of being an immigrant varied across racial/ethnic groups in a fashion that roughly paralleled odds of AR. In California, Hispanics and Asians had elevated odds of being immigrants, and blacks had lower odds. For New York the immigration and AR findings were also similar: Asians and blacks had elevated odds of recent immigration and of AR. One group did not follow the pattern: New York Hispanics had elevated odds of recent immigration but their odds of AR were not quite statistically significant with 95% confidence intervals (OR, 1.27; 95% CI = 0.97 to 1.67).

**TABLE 4. Odds Ratios (ORs) for Appendicitis Rupture (AR) and Immigrant Status by Race/Ethnicity among Children**

	OR of AR*	OR of Immigrant Status†
California		
White, non-Hispanic	ref	ref
Black, non-Hispanic	n.s.	0.65
Hispanic, all races	1.45	5.72
Asian, non-Hispanic	1.30	8.75
New York		
White, non-Hispanic	ref	ref
Black, non-Hispanic	1.47	2.72
Hispanic, all races	n.s.	4.48
Asian, non-Hispanic	2.16	8.53

\*Adjusted for biologic factors. See Table 3.

†Child is foreign-born or has a foreign-born parent. Confidence intervals are not applicable because ORs are population-based.

ref = reference; n.s. = not significant; OR = odds ratio; ref = reference.

## DISCUSSION

It has been suggested that appendiceal rupture and its risk factors may serve as a sentinel marker for the quality of health care for acute time-dependent diseases.<sup>35</sup> With this in mind, four previous studies have examined appendicitis rupture rates in administrative databases.<sup>14–17</sup> Taken together, these studies suggest that method of payment or access to primary care, rather than race per se, may be related to AR rates. Braveman and colleagues used AR rate to determine if insurance type was a factor for timely access to emergency care among California adults.<sup>15</sup> After adjusting for numerous social, economic, and medical system covariates, they found progressively increasing AR rates, from private capitated insurance (lowest rupture rate), to private fee-for-service, to Medicaid, to uninsured (highest rupture rate). They suggested that both concern over the ability to pay medical bills and lack of a stable relationship with a primary care provider delayed diagnosis and lead to AR. Similarly, a study by Bratton et al. of children from Washington State (1987–1996) found that Medicaid patients were 30% more likely than privately insured patients to experience rupture.<sup>14</sup> An analysis of 1993 San Diego County discharges failed to detect insurance effects but found that admission from an ED reduced AR rates.<sup>16</sup> In a pediatric study of a small sample of Maryland Medicaid managed care children ( $n = 374$ ), Gadowski and Jenkins found that a pattern of regular primary care visits was associated with lower AR rates.<sup>17</sup> The only racial/ethnic differences observed in these studies were moderately higher rates of AR (14%) among African American adults in California,<sup>15</sup> with similar findings more specifically observed among children in San Diego County.<sup>16</sup>

The AA rates in Table 1 are consistent with published reports.<sup>9–11</sup> This is reassuring, because it suggests that the administrative data we used will provide a reliable basis for subsequent analyses. Three themes emerge from our other findings: 1) racial/ethnic disparity in AR rates is apparent, 2) factors related to recency of immigration may contribute to the disparities, and 3) admission from the ED is a protective factor.

**Basic Disparity.** The primary purpose of this study was to test for disparities in AR while avoiding the hazards of overcontrolling for mediating factors. Therefore, the racial/ethnic differences reported in the middle column of Table 3 are our central findings. Compared with white children, children of minority groups are at elevated risk of AR. These disparities are attenuated but not eliminated when intermediary factors are added to the regression models.

We agree with others that AR is a marker for access to emergency care for time-dependent conditions,<sup>18,35</sup>

yet this is the first report to call attention to significant racial/ethnic disparities in such access, at least for children. Although recognition of the problem is an important first step, understanding the causes and development of solutions will depend on future studies with access to variables not available in the administrative data used here.

**Immigration and Acculturation.** The inconsistent findings between states regarding which minority groups had elevated risk of rupture suggest one cause for the disparities. Comparing the two states (Table 4), the within-race/ethnicity odds of a child experiencing AR roughly, albeit imperfectly, parallel the within-race/ethnicity odds of being foreign-born or having a foreign-born parent. We hypothesize that recent immigration is a marker for significant barriers to access to emergency care, just as it is for reduced number of annual physician contacts.<sup>36</sup>

Risk of AR among immigrants may be elevated through multiple mechanisms that have been identified as barriers for immigrant access to a broad range of health care services. Beyond the insurance and income barriers for which we controlled, additional barriers include lack of familiarity with the medical system,<sup>36,37</sup> preference for traditional healing and sources of advice,<sup>38,39</sup> provider disrespect or indifference toward traditional health beliefs,<sup>40,41</sup> provider ignorance of community and social context,<sup>42</sup> shortage of providers of like race/ethnicity,<sup>42-44</sup> legal barriers,<sup>45-47</sup> and mistrust of the system,<sup>38,45,47</sup> exacerbated by language barriers<sup>37,38,40,41</sup> and poorer quality of care in terms of rates of preventive services, screening, and treatment.<sup>39</sup>

Over 77% of California Hispanics are of Mexican origin. Many are fairly recent arrivals with limited English skills. Furthermore, Hispanic communities are more likely than white communities to be medically underserved and are disproportionately reliant on relatively smaller numbers of Hispanic physicians.<sup>43</sup> The state's population is 32.4% Hispanic, but only 4.5% of recent U.S. medical school graduates are Hispanic.<sup>48</sup> Many Hispanics, particularly in California, are undocumented and may fear engagement with U.S. institutions, including the health care system. This could be the basis for potentially dangerous delay in seeking health care for abdominal pain.

California Asians are a more complex group than California Hispanics. Half are of Chinese origin, but the rest are from 14 different Census-enumerated cultures. "Asian-only" is the fastest growing racial/ethnic group in the state, increasing by 51.9% between 1990 and 2000.<sup>49</sup> More than half of this increase is through immigration, and there is a trend toward increasing residential segregation for these recent arrivals.<sup>50</sup> The more recent arrivals, particularly those from Southeast Asia, suffer persistent poverty and

cultural isolation that impacts health and health care utilization.<sup>49,51,52</sup>

The immigration profile for the major racial/ethnic groups is very different in New York, as is the state's AR profile. Unlike California, many New York blacks are recent African or black Caribbean immigrants.<sup>31</sup> This is consistent with our immigration hypothesis for AR rates, and may partially explain why black non-Hispanic children in New York are at significantly higher risk of AR compared with white non-Hispanic children. New York Asians have the highest odds of AR reported in this study. Though a very diverse group, they also have a very high proportion of recent immigrants. New York Hispanics are an exception to the immigrant-AR rate pattern, because they have a high proportion of immigrants, but their AR rate is not quite statistically different from whites (OR, 1.27; 95% CI = 0.97 to 1.67).

Our attribution of AR risk to recency of immigration is a data-driven hypothesis, not a conclusion. Careful consideration of interstate difference in countries of origin, proportions of undocumented aliens, rates of acculturation, and indigent care health policies may be required to fully appreciate the patterns of interstate variations in AR rate by race/ethnicity. If the hypothesis is proven correct, it might be possible to reduce disparities in timely access to quality emergency services for children by improving the cultural competency of primary and emergency care providers, improving the availability of translation services, and educating immigrant communities regarding available emergency care services.

**Protective Effect of Emergency Department Admission.** We included five nonbiological covariates in the full models of Table 3 to determine if racial/ethnic disparities would still be apparent in spite of their attenuating effects and to report results that are as comparable as possible to four previous studies.<sup>14-17</sup> Few patterns emerge for these covariates from the combined body of administrative data analyses. Better insurance and higher income are usually but not always protective against AR, and findings are mixed regarding hospital characteristics.

The most consistent pattern emerging from all large-scale studies is that acute appendicitis cases admitted from the hospital ED have significantly lower odds of rupture than admissions from other sources (both states in present study, Bratton et al.,<sup>14</sup> Braveman et al.,<sup>15</sup> Buckley et al.<sup>16</sup>). "Other sources" are primarily referrals from physicians' offices and other freestanding outpatient facilities, but they also include inpatients who were in observation status and referrals from other short-term acute care facilities. Buckley et al. speculate that going to an outpatient provider before the hospital delays the inevitable surgical intervention and raises risk of AR.<sup>16</sup> This reasonable assumption is consistent with the acute

myocardial infarction and stroke literature,<sup>35,53–55</sup> yet it contrasts with Gadomski and Jenkins's equally reasonable conclusion that a good "primary care relationship facilitates access to care, thus reducing delay in the management of appendicitis."<sup>17</sup> It is possible that both conclusions are correct. For patients at similar stages of AA, those who go directly to the ED rather than an outpatient facility will have less delay before intervention. Among the subset of patients who visit an outpatient facility at symptom onset, however, those with a good primary care provider relationship will have less tendency to delay the initial visit, will have less difficulty being seen by the provider, and will be more quickly referred to the hospital. To date no large-scale study has had access to all the variables needed to explore these scenarios.

## LIMITATIONS

Administrative data are currently the only available source for broad-scale estimates of the level of disparity in emergency care services. However, these data have recognized limitations. For example, hospitals are not required to follow a uniform method of assigning inpatients to racial/ethnic categories, and there is no quality assurance for these assignments. Some hospitals record self-reported race/ethnicity, whereas others record the admitting staff's impression of the patient's race/ethnicity. Furthermore, the coding of race/ethnicity does not allow distinctions to be made among diverse subgroups within the four broad categories analyzed here. For instance, access to the health care system may be quite different for Cuban Americans than Mexican Americans. Insofar as such coding practices introduce random misclassifications, they would attenuate rather than inflate disparities in AR rates. The administrative discharge records also notably lack an immigrant status indicator. We have suggested an effect of immigrant status and degree of acculturation based on state-level census statistics. However, patient-level measures of acculturation, English language skills, and comfort with the health care system are required to definitively test this hypothesis. In the meantime, support for the hypothesis may be found if similar results are obtained from analyses of discharge data and census statistics in other states and for other years.

Approximately 3% of children from our two states were multiracial in the 2000 Census and were not used in the denominators of AA incidence rates reported in Table 1. This slightly inflated the computed rates, and population increases between our study years and 2000 modestly deflated the rates. Nonetheless, given the paucity of published data on pediatric AA incidence rates, we deemed it useful to report the values.

Future studies of this type should also consider geographic barriers to access, such as local provider

availability and distance. A single-county study found no geographic effects.<sup>16</sup> However, more sophisticated measures of geospatial access for larger areas should be applied to the question.<sup>56</sup>

Auble<sup>35</sup> has suggested that studies to develop AR rate as a sentinel marker of health care system performance should be modeled after research on delay of care for acute myocardial infarction. The National Heart, Lung, and Blood Institute has identified and organized a multitude of measures related to delay of emergency care into a conceptual framework that could advance AR research. Because it would require patient consent and prospective data collection of event and time interval variables, sample sizes will not approach those obtainable from administrative data such as that used here. However, a more detailed and nuanced understanding of the factors, processes, and pathways to AR will be an invaluable complement to the broad-scale monitoring of disparities that is possible with administrative data analyses. Together they may eventually qualify AR rate as an indicator for the National Healthcare Disparities Report Card now under development by the Agency for Healthcare Research and Quality.<sup>57</sup>

## CONCLUSIONS

The racial/ethnic disparities in AR rate reported here are original findings in both the appendicitis and disparity literature. They suggest that AR rate, at least among children, is a useful indicator of racial/ethnic disparities in access to timely, high-quality emergency care. Admission from the ED is emerging as a significant protective factor against rupture in all age groups, yet there are residual racial/ethnic disparities even after controlling for source of admission and a host of other patient, provider, and health system factors. Studies that consider factors other than those traditionally analyzed in AR studies will be required to understand the reasons for these residual disparities. It might be especially fruitful to investigate factors related to immigration and acculturation.

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