

Original Contribution

Disparities Between Black and White Children in Hospitalizations Associated With Acute Respiratory Illness and Laboratory-confirmed Influenza and Respiratory Syncytial Virus in 3 US Counties—2002–2009

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Few US studies have assessed racial disparities in viral respiratory hospitalizations among children. This study enrolled black and white children under 5 years of age who were hospitalized for acute respiratory illness (ARI) in 3 US counties during October–May 2002–2009. Population-based rates of hospitalization were calculated by race for ARI and laboratory-confirmed influenza and respiratory syncytial virus (RSV), using US Census denominators. Relative rates of hospitalization between racial groups were estimated. Of 1,415 hospitalized black children and 1,824 hospitalized white children with ARI enrolled in the study, 108 (8%) black children and 111 (6%) white children had influenza and 230 (19%) black children and 441 (29%) white children had RSV. Hospitalization rates were higher among black children than among white children for ARI (relative rate (RR) = 1.7, 95% confidence interval (CI): 1.6, 1.8) and influenza (RR = 2.1, 95% CI: 1.6, 2.9). For RSV, rates were similar among black and white children under age 12 months but higher for black children aged 12 months or more (for ages 12–23 months, RR = 1.7, 95% CI: 1.1, 2.5; for ages 24–59 months, RR = 2.2, 95% CI: 1.3, 3.6). Black children versus white children were significantly more likely to have public insurance or no insurance (85% vs. 43%) and a history of asthma/wheezing (28% vs. 18%) but not more severe illness. The observed racial disparities require further study.

child; continental population groups; hospitalization; influenza; respiratory syncytial virus; respiratory tract infections

Abbreviations: ARI, acute respiratory illness; NVSN, New Vaccine Surveillance Network; RR, relative rate; RSV, respiratory syncytial virus; RT-PCR, reverse-transcription polymerase chain reaction.

Racial/ethnic health disparities in the United States have long been recognized for many diseases, both chronic and infectious (1). Identifying populations and targeting interventions for specific diseases is an important step towards reducing such disparities. Few studies of racial/ethnic disparities among US children have focused on acute respiratory illness (ARI) in general or on specific respiratory viruses such as influenza and respiratory syncytial virus (RSV), pathogens with a high burden of severe illness (2–4). Recent US studies

of 2009 pandemic influenza A(H1N1) in the United States found higher rates of hospitalization with the virus among black children and those in other minority groups than among whites (5–8). A California study using administrative data did not find higher rates of RSV-coded infant hospitalizations for black children compared with white children by insurance type (9). Higher rates of RSV-coded hospitalizations among American Indian/Alaska Native infants (10) and laboratory-confirmed RSV hospitalizations of Alaska Native infants (11)

compared with the US infant population have also been reported.

The primary goal of this prospective, population-based study was to determine whether racial disparities existed between black and white children under 5 years of age for hospitalizations associated with community-acquired ARI and laboratory-confirmed seasonal influenza and RSV illness in 3 large US counties. Secondly, we assessed racial differences in access to care, influenza vaccination, and other characteristics that may affect racial disparities in hospitalization rates.

MATERIALS AND METHODS

Study population

The New Vaccine Surveillance Network (NVSN) prospectively enrolled children under 5 years of age admitted to network hospitals with an admission diagnosis of ARI or fever ("ARI"). ARI admission diagnoses included ARI, apnea, asthma exacerbation, bronchiolitis, croup, cystic fibrosis exacerbation, febrile neonate, febrile seizure, fever without localizing signs, hypothermia, influenza, otitis media, paroxysmal cough, pharyngitis, pneumonia, respiratory distress, RSV, rule-out sepsis, sinusitis, tonsillitis, upper respiratory illness, wheezing, and other respiratory infection. Admissions for fever without localizing signs were included because pediatric respiratory infections can be associated with high fever without respiratory symptoms. Children had to be enrolled in the NVSN within 48 hours of admission. Children were excluded if they had a known nonrespiratory cause for the hospitalization, had been previously hospitalized during the prior 4 days, had remained hospitalized since birth, or had fever and neutropenia related to oncological treatment. This study excluded Hispanic/Latino children of any race because of low numbers and because a lack of Spanish translators in some study years resulted in incomplete ascertainment of Hispanic/Latino children. Children of races other than black or white, including multiracial children, were also excluded because of low numbers.

Surveillance was population-based, with participating hospitals accounting for more than 95% of the pediatric hospitalizations of resident children in each county. The 3 surveillance counties, located in the states of Tennessee, New York, and Ohio, are among the 100 largest counties in the United States and encompass the cities of Nashville, Rochester, and Cincinnati, respectively, with combined urban/suburban populations of more than 142,000 children under 5 years of age.

This study included children enrolled during the months of October through May between 2002–2003 and 2008–2009 and excluded the influenza pandemic period after April 14, 2009. During October 2002–April 2005, hospital surveillance was conducted 4 days per week, except for the 2004–2005 influenza season, in which it was conducted 7 days per week. During the remaining seasons, surveillance was conducted 5 days per week. The Ohio county site contributed 3 seasons of data (2003–2004, 2004–2005, and 2008–2009), because NVSN surveillance began at the Ohio site in 2003, and a protocol deviation pertaining to

70% of eligible children at the site from 2005–2006 through 2007–2008 resulted in the exclusion of those years from this study for that site.

The NVSN study design and methods of ARI surveillance have been described previously (3, 4). The study was approved by the institutional review boards at each site and the Centers for Disease Control and Prevention. Informed consent was obtained from each parent/guardian before enrollment.

Data collection and laboratory testing

After obtaining informed consent, study personnel collected nasal and throat swabs for research purposes only, which were tested for influenza A and B viruses and RSV by reverse-transcription polymerase chain reaction (RT-PCR). Viral culture for influenza and RSV was also performed during some years, and specimens found to be positive by RT-PCR or viral culture were considered positive. All influenza and RSV cases in this report were laboratory-confirmed by means of these methods. Study laboratories did not test for RSV during the 2008–2009 season because of study budget constraints; therefore, that season was excluded from RSV-specific analyses.

Study personnel conducted parent/guardian interviews to obtain information on demographic factors (race/ethnicity, maternal education), access to care, exposures, medical history, use of influenza antiviral medication, palivizumab prophylaxis against RSV, and number of days the child had been ill at admission. Medical record review was also conducted to obtain additional data on medical history, demographic characteristics (date of birth, sex), use of influenza antiviral medication, and clinical course. Influenza vaccination data were obtained from vaccination providers from 2003–2004 through 2008–2009.

Race/ethnicity

Parents/guardians were asked 2 questions about race/ethnicity during study interviews: 1) whether the child was Hispanic or Latino and 2) whether the child's race was white, black/African-American, American Indian/Alaska Native, Asian, Native Hawaiian/other Pacific Islander, or other; additional choices included none, unknown, and refused/no response. Study personnel recorded all responses that were indicated by the parent/guardian.

For this study, a non-Hispanic/Latino child was classified as white if the parent/guardian specified the child to be white and of no other race. A non-Hispanic/Latino child was classified as black if the parent/guardian specified the child to be black or African-American and of no other race. The questions, categories, and terminology were chosen for consistency with those of the US Census (12).

Other data definitions

We assessed other demographic and health-related factors that may affect ARI hospitalizations or that have been associated with racial/ethnic disparities in health care. A preexisting high-risk medical condition was considered

present if it was noted in the medical record or if the parent/guardian responded that s/he had been told by a health-care provider that the child had the condition. High-risk medical conditions, corresponding to those considered by the Advisory Committee on Immunization Practices to increase the risk for serious complications of influenza (13), included: heart disease, chronic pulmonary disease, kidney disease, cancer, diabetes, immunodeficiency, sickle cell anemia, and neurological/neuromuscular conditions. History of asthma/wheezing included a diagnosis of asthma, reactive airway disease, or recurrent or chronic wheezing. Up to 10 discharge diagnoses were collected; asthma discharge diagnoses included all those with *International Classification of Diseases, Ninth Revision*, code 493.xx (<http://www.cdc.gov/nchs/icd/icd9cm.htm>).

Influenza vaccination data verified from providers' records were included if children were at least 6 months of age (i.e., age-eligible for vaccine) on or after November 1 each season and had received vaccine at least 14 days before illness onset (to allow time for an adequate immunological response). Children were considered fully vaccinated against influenza if they received 2 vaccine doses at least 24 days apart for the season, or 1 dose for the season plus a dose in a previous season. Children were considered partially vaccinated if they received only 1 dose for the season without a dose in a prior season and unvaccinated if they did not receive vaccine for the season.

Statistical methods

Three different outcomes were assessed: any ARI, laboratory-confirmed influenza, and laboratory-confirmed RSV. Rates of hospitalization (per 1,000 children) associated with each of the 3 outcomes and 95% confidence intervals were calculated for black and white children as the bootstrapped weighted number of hospitalizations divided by the census population for the counties, multiplied by 1,000, applying the percentile method (14). A total of 2,000 bootstrap samples were selected, stratified by county and study year. The weights accounted for the nonsurveillance days per week and the nonparticipation rates by site, quarter-year, and age. The census denominators were the post-2000 annual bridged race estimates of the number of resident children under 5 years of age for each county during 2003–2009, by single year of age, from the US Census (12).

We calculated hospitalization rates for black and white children overall and by age group. Age-specific relative rates (the black:white ratio of rates) and 95% confidence intervals were obtained using bootstrap methods. We also calculated rates by county and study year to assess descriptively whether trends varied according to these factors. Comparisons of other characteristics (i.e., sociodemographic factors, access to care, clinical characteristics) were considered exploratory. All comparisons and age groups were specified a priori. Median values and interquartile ranges were used to describe continuous data. Wilcoxon rank-sum tests were used to compare durations of hospitalization. Pearson chi-square or Fisher's exact tests were used for categorical data. A 2-sided 5% α level was applied for all statistical tests without adjustment for multiple

comparisons. SAS statistical software was used for all analyses (version 9.2; SAS Institute Inc., Cary, North Carolina).

The unit of analysis for this study was a hospitalization, and all enrolled hospitalizations were included in rates to capture the entire burden. Counts and percentages were also based on the number of hospitalizations. A small percentage of children were enrolled more than once within a season. To assess the impact of multiple hospitalizations, we also compared sociodemographic and clinical characteristics based on unique children using their last hospitalization for the season; results (data not shown) were similar to those based on all hospitalizations.

RESULTS

Study population

Of the 4,329 ARI hospitalizations included in the study seasons during October through May, 1,415 (33%) were among 1,361 black children and 1,824 (42%) were among 1,776 white children (Figure 1). Hospitalizations of Hispanic/Latino children (16%), children of multiple/other races (8%), and children with missing race/ethnicity data (0.8%) were excluded from this analysis. Four percent of black children and 3% of white children had more than 1 hospitalization. Enrollment rates among eligible black and white children were 82% and 84%, respectively, and did not differ significantly between the two racial groups by age (0–5, 6–11, 12–23, or 24–59 months), sex, study year, or insurance status. The main reason for nonenrollment was parental refusal or unavailability among black (84%) and white (83%) children.

The number of ARI hospitalizations that were influenza-positive was 108 (8%) for black children and 111 (6%) for white children. The number that were RSV-positive was 230 (19%) for black children and 441 (29%) for white children (Table 1).

Demographic factors, access to care, and exposure characteristics

The distribution of several socioeconomic characteristics differed between black and white children hospitalized for ARI (Table 1). In particular, a lower proportion of black children had private insurance (14% vs. 57%) or received routine sick care in a private physician's office (49% vs. 86%). In addition, a higher proportion of black children than of white children had mothers with lower educational levels (32% vs. 18% were not high school graduates) and had a school-age sibling (53% vs. 39%). Similar racial trends were seen for influenza and RSV-associated hospitalizations.

Influenza vaccination and treatment

Among influenza-negative children who were at least 6 months of age, similar proportions of black and white children were fully vaccinated, but a lower proportion of black children received 1 or more doses of influenza vaccine (34% vs. 48%) (Table 1). Among influenza-positive children, 12%

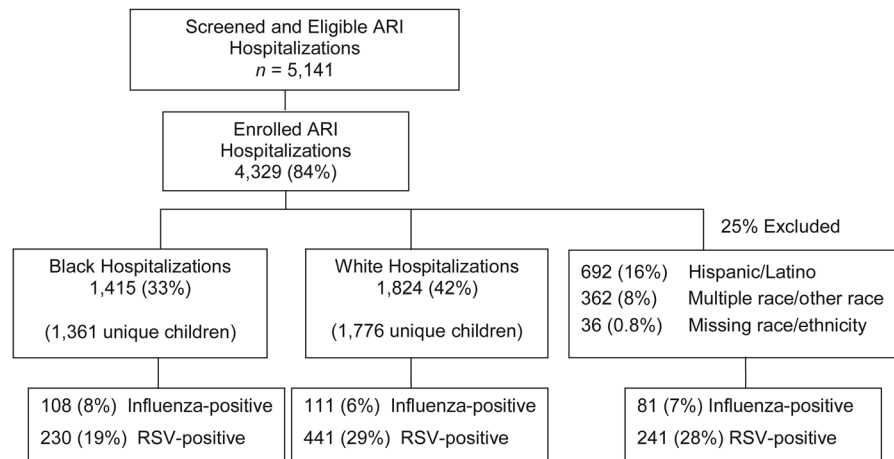


Figure 1. Hospitalizations for acute respiratory illness (ARI) by race/ethnicity during October–May in 3 US counties, 2002–2009. Percentages are based on the number of hospitalizations. The black and white groups exclude Hispanics/Latinos, multiple races, and other races. Of the 1,361 unique black children enrolled, 1,311 (96%) had 1 hospitalization, 48 (3.5%) had 2 hospitalizations, 1 (0.07%) had 3 hospitalizations, and 1 (0.07%) had 5 hospitalizations. Of the 1,776 unique white children enrolled, 1,731 (97%) had 1 hospitalization, 42 (2.4%) had 2 hospitalizations, and 3 (0.17%) had 3 hospitalizations. Results for respiratory syncytial virus (RSV) exclude the 2008–2009 season, when RSV testing was not done. Influenza and RSV were laboratory-confirmed by the study investigators.

of black children and 42% of white children received 1 or more doses of influenza vaccine.

Use of antiviral agents for influenza was rarely noted by the parent or in the hospital record for either race (<1%). Parental reporting of palivizumab prophylaxis for RSV among premature children younger than age 2 years was not significantly different between black and white children (38% vs. 30%; $P = 0.13$).

Population-based rates of ARI hospitalization

ARI hospitalization rates were significantly higher for black children than for white children (14.1 per 1,000 vs. 8.3 per 1,000 overall; relative rate (RR) = 1.7) (Table 2). For both black and white children, rates were highest among children under 6 months of age and decreased with increasing age. The age-specific relative rates of hospitalization for black children versus white children ranged from 1.5 to 2.0, and all were significantly greater than 1 (Table 2).

In all 3 counties, higher ARI hospitalization rates were observed for black children than for white children in the age groups 0–5 months and 6–59 months (Figure 2). Figure 3 shows ARI rates over all study years for black and white children stratified by age group (0–5 and 6–59 months); ARI hospitalization rates were higher for black children for all years in both age groups.

Population-based rates of laboratory-confirmed influenza hospitalization

Black children were more likely to be hospitalized for influenza-related ARI than white children. The age-specific relative rates of influenza-associated hospitalization for

black children versus white children ranged from 1.9 to 2.5 (Table 2). Similarly, hospitalization rates were higher for black children than for white children by county (Figure 2) and across years (Figure 3), except for 2 seasons with low overall incidence of influenza-associated hospitalization (2002–2003 and 2006–2007).

Population-based rates of laboratory-confirmed RSV hospitalization

Black children were slightly more likely to be hospitalized with RSV than white children (RR = 1.2; Table 2). Among children aged 12–23 months and 24–59 months, the relative rates were 1.7 and 2.2, respectively, but no significant differences existed among those under 12 months of age. Similar trends were seen in each county and study year (Figures 2 and 3). In addition, because RSV-associated hospitalizations are most common during the first few months of life (more than 20 per 1,000 children under 3 months of age in each racial group), we calculated relative rates for children aged 0–2 months and 3–5 months, and they were not statistically different for black children compared with white children (for age 0–2 months, RR = 1.1, 95% confidence interval: 0.8, 1.4; for age 3–5 months, RR = 0.7, 95% confidence interval: 0.4, 1.2).

Clinical characteristics

ARI hospitalizations. Several clinical characteristics differed between racial groups (Table 3). A history of a high-risk condition, particularly asthma/wheezing, and premature birth were more common among black children than among white children. However, a lower proportion of black children than of white children received supplemental

Table 1. Characteristics (%) of Hospitalized Children Under Age 5 Years With Acute Respiratory Illness, Laboratory-confirmed Influenza, and Laboratory-confirmed Respiratory Syncytial Virus, by Race, in 3 US Counties, 2002–2009

Characteristic	ARI		Influenza		RSV	
	Black (n = 1,415)	White (n = 1,824)	Black (n = 108)	White (n = 111)	Black (n = 230)	White (n = 441)
Study site						
Tennessee county	42**	37	40	47	37**	33
New York county	26	33	31	23	37	49
Ohio county	33	30	30	30	26	17
Age, months						
0–5	44*	49	45	48	51*	61
6–11	15	13	15	14	15	16
12–23	21	18	19	19	20	15
24–59	21	20	21	20	14	8
Male sex	59*	56	55	53	60	53
Access to health care						
Health insurance						
Any insurance	94**	96	95	98	97	96
Privately insured	14**	57	7**	55	15**	61
Had a regular health-care provider ^a	96**	99	97	96	98	99
Usual place of care when sick						
Private physician's office	49**	86	47**	84	43**	88
Emergency department/urgent-care center	12	3	11	6	7	1
Public health clinic	15	5	19	8	7	4
Maternal education						
Less than high school	32**	18	39**	22	32**	19
Completion of high school	36	23	37	22	40	18
More than high school	28	56	23	57	27	62
Exposure to other children						
Day care/preschool	31*	27	24	24	32	26
School-age sibling	53**	39	59**	40	52**	34
Living with a smoker	42	39	43	40	43	39
Influenza vaccination ^b						
Unvaccinated	67**	52	88**	57		
Partially vaccinated	14	28	4	20		
Fully vaccinated	20	20	8	22		

Abbreviations: ARI, acute respiratory illness; RSV, respiratory syncytial virus.

* $P < 0.05$; ** $P < 0.01$ (P value for the association between the selected characteristic and racial group; calculated separately for ARI, influenza, and RSV).^a Regular health-care provider: $n = 816$ for black children, $n = 1,208$ for white children.^b Percentages shown are for the subset of enrolled children who were more than 6 months of age on or after November 1 each season. The denominators used to calculate ARI percentages for influenza-negative children included 653 hospitalizations among black children and 653 hospitalizations among white children, and the denominators for influenza-positive children included 51 hospitalizations among black children and 54 hospitalizations among white children. Vaccination rates based on unique children (i.e., the last hospitalization for each child) were very similar (within 1 percentage point).

oxygen or were hospitalized for 3 days or more. A lower proportion of black children than of white children had discharge diagnoses of pneumonia or bronchiolitis, but higher proportions of black children had diagnoses of asthma, both overall and by age group. Black and white children did not differ significantly with respect to other clinical

characteristics such as admission to an intensive care unit or receipt of mechanical ventilation. Two children (1 black and 1 white) died.

Influenza and RSV-associated hospitalizations. For influenza hospitalizations, only a history of a high-risk condition, including asthma/wheezing, was more commonly

Table 2. Age-specific Population-based Rates of Hospitalization (per 1,000 Children) for Acute Respiratory Illness, Laboratory-confirmed Influenza, and Laboratory-confirmed Respiratory Syncytial Virus Among Children Under Age 5 Years, by Race, in 3 US Counties, 2002–2009

Infection and Age Group, months	Weighted No. of Cases		Black Children		White Children		Relative Rate	
	Black Children	White Children	Rate	95% CI	Rate	95% CI	Black:White Ratio	95% CI ^a
ARI or fever								
0–5	1,275	1,796	58.7	54.1, 63.3	39.7	37.3, 42.2	1.5	1.3, 1.7
6–11	426	477	19.7	17.0, 22.5	10.6	9.2, 12.0	1.9	1.5, 2.3
12–23	611	652	14.3	12.6, 16.2	7.2	6.4, 8.1	2.0	1.7, 2.4
24–59	652	786	5.3	4.6, 5.9	2.9	2.6, 3.2	1.8	1.5, 2.1
Total	2,965	3,712	14.1	13.5, 14.8	8.3	8.0, 8.6	1.7	1.6, 1.8
Influenza								
0–5	88	92	4.0	2.9, 5.2	2.0	1.5, 2.6	2.0	1.3, 3.0
6–11	31	26	1.4	0.8, 2.2	0.6	0.3, 0.9	2.5	1.2, 5.6
12–23	34	37	0.8	0.5, 1.2	0.4	0.2, 0.6	1.9	1.0 ^b , 3.8
24–59	46	42	0.4	0.2, 0.5	0.2	0.1, 0.2	2.3	1.3, 4.5
Total	198	198	0.9	0.8, 1.1	0.4	0.4, 0.5	2.1	1.6, 2.9
RSV								
0–5	258	543	14.8	12.1, 17.4	14.7	12.9, 16.5	1.0	0.8, 1.3
6–11	65	147	3.7	2.5, 5.1	4.0	3.0, 4.9	0.9	0.6, 1.4
12–23	96	125	2.8	2.0, 3.7	1.7	1.3, 2.1	1.7	1.1, 2.5
24–59	83	84	0.8	0.5, 1.2	0.4	0.3, 0.5	2.2	1.3, 3.6
Total	502	899	3.0	2.6, 3.4	2.4	2.2, 2.7	1.2	1.0 ^b , 1.4

Abbreviations: ARI, acute respiratory illness; CI, confidence interval; RSV, respiratory syncytial virus.

^a Ninety-five percent confidence intervals that exclude 1 are considered to represent statistically significant results.

^b Rounded down to 1.0.

reported among black children than among white children. For RSV-associated hospitalizations, the characteristics that were significantly different between black and white children were generally the same as for all ARI hospitalizations.

DISCUSSION

Our findings indicated that a racial disparity existed in hospitalizations for ARI among black children compared with white children. ARI hospitalization rates were higher for black children than for white children, with age-specific relative rates ranging from 1.5 to 2.0. The county-specific and yearly rates by age group were also higher for black children, providing further support for a racial disparity. However, our finding that black children were not more severely ill than white children might suggest that other factors, such as access to care, may possibly affect hospitalization rates.

We also found influenza-associated hospitalization rates to be significantly higher for black children than for white children (RR = 2.1). These disparities, however, were absent or less discernible during the mild influenza seasons. Our findings were consistent with 3 US studies of laboratory-confirmed influenza hospitalization during the 2009 influenza A(H1N1) pandemic (5–7). Specifically, age-adjusted pandemic influenza hospitalization rates were higher among minorities and among African Americans

versus white persons in 10 states (10.9 per 100,000 population vs. 2.0 per 100,000 in the spring/summer of 2009 and 29.7 per 100,000 population vs. 16.3 per 100,000 in the fall/winter of 2009–2010) (5), in New Mexico (RR = 1.7) (6), and in Chicago, Illinois (9 per 100,000 population vs. 2 per 100,000) (7); investigators in the latter study noted that disparities persisted among children under 15 years of age. In a review of US pneumonia and influenza mortality during the past century, Hutchins et al. (8) noted higher rates among African Americans and other minorities in comparison with white persons. Our study did not assess racial disparities in mortality because fatal cases were rare in our population.

Unlike ARI and influenza rates, RSV-associated hospitalization rates were not higher among black infants than among white infants, but they were higher among older black children aged 12–59 months. Our results are consistent with a retrospective study of California hospital discharge data, which did not find higher RSV-coded hospitalization rates per 1,000 livebirths among black infants compared with white infants for the MediCal-insured (27.9 vs. 34.9) or the non-MediCal-insured (12.1 vs. 11.9) (9).

The reasons for these racial disparities in ARI hospitalization rates, for both a potentially vaccine-preventable disease (influenza) and other ARIs for which vaccines are not available, are unclear. One possibility is that severity of illness might be greater among black children. However,

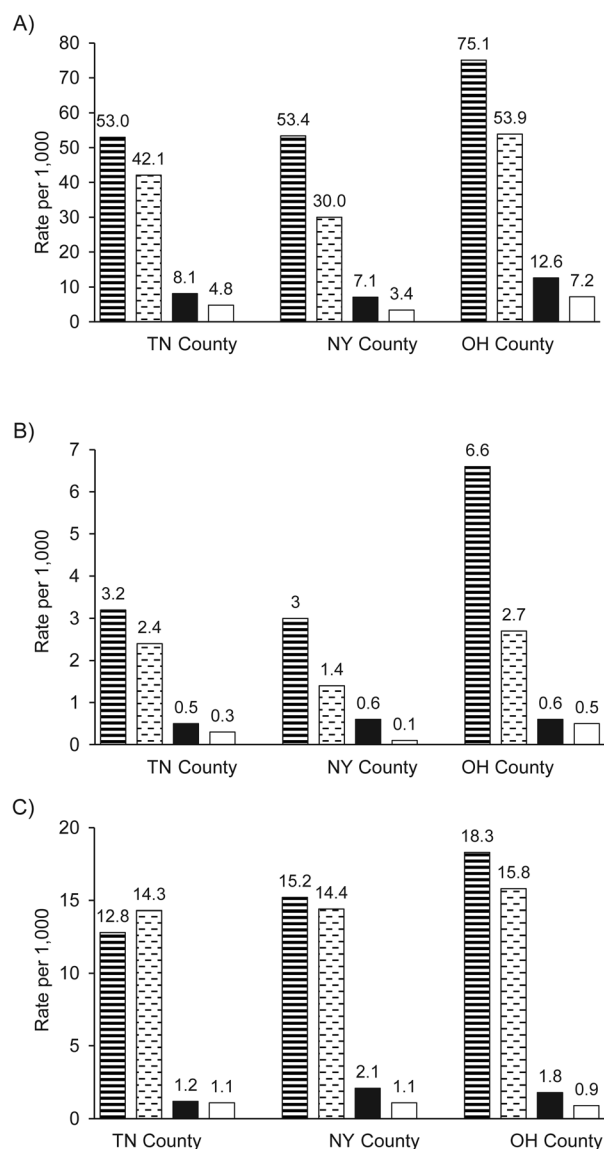


Figure 2. Rates of hospitalization for acute respiratory illness (ARI) and laboratory-confirmed influenza and respiratory syncytial virus (RSV) per 1,000 children by county, age, and race, in 3 US counties during 2002–2009. A) ARI; B) laboratory-confirmed influenza; C) laboratory-confirmed RSV. Striped bars, black children aged 0–5 months; dashed bars, white children aged 0–5 months; black bars, black children aged 6–59 months; white bars, white children aged 6–59 months. TN, Tennessee; NY, New York; OH, Ohio.

we did not find black children to be more severely ill than white children based on their admission to an intensive care unit or receipt of mechanical ventilation. Lower vaccination rates among black children might potentially explain these findings, but the proportion fully vaccinated among children with ARI was similar for the two races. Other factors might influence hospitalization rates, such as poorer access to health care and less effective use of preventive measures.

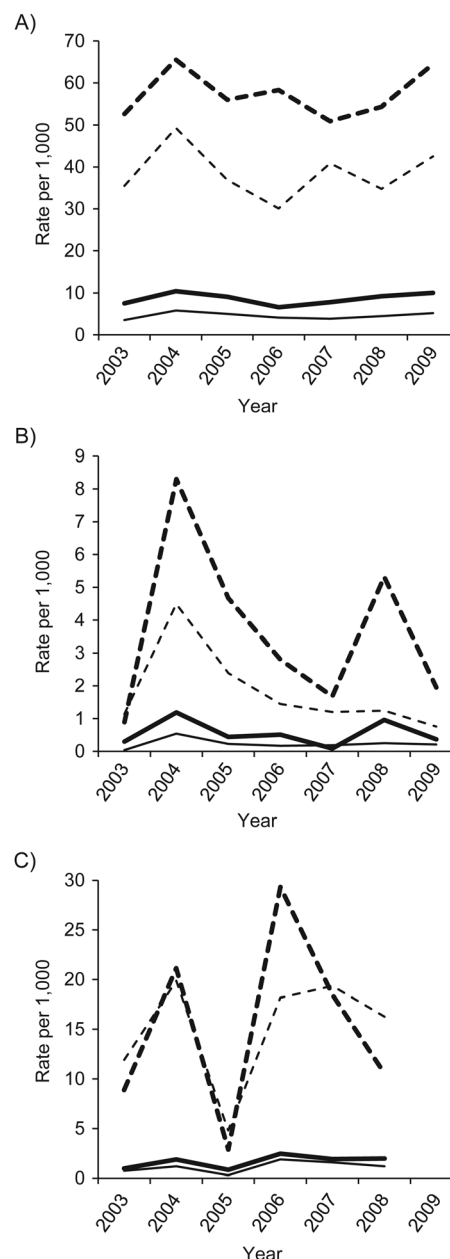


Figure 3. Annual rates of hospitalization for acute respiratory illness (ARI) and laboratory-confirmed influenza and respiratory syncytial virus (RSV) per 1,000 children, by age and race, in 3 US counties during 2002–2009. A) ARI; B) laboratory-confirmed influenza; C) laboratory-confirmed RSV. The ending year of each season is denoted on the x-axis (e.g., 2003 represents the end of the 2002–2003 season). Thick dashed line, black children aged 0–5 months; thin dashed line, white children aged 0–5 months; thick solid line, black children aged 6–59 months; thin solid line, white children aged 6–59 months.

For example, a substantially higher proportion of black children in our study were publicly insured and were more likely to receive their usual sick care outside of a private physician's office compared with white children. Other

Table 3. Medical History and Clinical Characteristics of Hospitalized Children Under Age 5 Years With Acute Respiratory Illness, Laboratory-confirmed Influenza, and Laboratory-confirmed Respiratory Syncytial Virus, by Race, in 3 US Counties, 2002–2009

Characteristic	ARI				Influenza				RSV			
	Black (n = 1,415)		White (n = 1,824)		Black (n = 108)		White (n = 111)		Black (n = 230)		White (n = 441)	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
History of a high-risk condition	557**	39	513	28	35*	32	23	21	74**	32	89	20
Asthma/wheezing by child's age, months	399**	28	331	18	20	19	12	11	58**	25	51	12
<6	19*	3	11	1	1	2	0	0	5*	4	3	1
6–11	61*	29	46	19	4	25	4	27	8	24	16	16
12–24	133**	46	92	28	6	30	4	19	22*	48	19	29
24–59	186**	63	182	49	9	39	4	18	23	70	18	50
Chronic lung disease	115	8	126	7	5	5	6	5	15	7	26	6
Neurological disorder	74	5	119	7	4	4	6	5	14	6	22	5
Premature birth (born >1 month early)	268**	19	266	15	17	16	12	11	48**	21	58	13
Median no. of days ill at admission (IQR ^a)	3 (2–5)		3 (2–5)		3 (1–4)		2 (1–5)		4 (2–5)		4 (3–5)	
Median length of stay, days (IQR)	2 (1–3)		2 (1–3)		2 (1–2)		2 (1–3)		2* (1–3)		2 (1–4)	
Length of stay >3 days	381**	27	570	31	26	24	29	26	80*	35	196	44
Admission to intensive care unit	88	6	122	7	8	7	10	9	10	4	27	6
Mechanical ventilation	29	2	48	3	3	3	6	5	4	2	10	2
Supplemental oxygen	441**	31	748	41	29	27	22	20	99**	43	274	62
Discharge diagnosis of pneumonia or bronchiolitis by child's age, months	695**	49	1,010	55	42	39	40	36	181**	79	390	88
<6	306*	49	500	56	12	24	15	28	103	88	251	93
6–23	275	55	331	59	19	53	16	44	56**	70	115	85
24–59	114*	39	179	49	11	48	9	41	22	67	24	67
Asthma diagnosis by child's age, months	453**	32	399	22	20	19	14	13	64**	28	66	15
12–23	160**	55	128	39	7	35	5	24	25*	54	22	33
24–59	197**	67	192	52	9	39	5	23	23	70	20	56
Chest radiography												
Radiograph taken	970	69	1,284	70	66	61	59	53	184	80	342	78
Abnormal radiograph	794	82	1,025	80	54	82	44	75	160	87	296	87

Abbreviations: ARI, acute respiratory illness; IQR, interquartile range; RSV, respiratory syncytial virus.

* $P < 0.05$, ** $P < 0.01$ (P value for the association between the selected characteristic and racial group; calculated separately for ARI, influenza, and RSV).^a 25th–75th percentiles.

studies that have evaluated geographic disparities in pediatric hospitalizations have noted that lower hospitalization rates existed in areas that had a higher quality of primary care (15). Further, Rinderknecht et al. (16) noted that children referred to a pediatric emergency department by a health-care provider tended to be white and more severely ill. In our study, black children were more likely to have a history of asthma/wheezing and asthma discharge diagnoses, and their mothers were less educated. Respiratory viruses have been associated with asthma exacerbation (17). Studies have noted higher hospitalization rates for asthma among black children compared with white children (18), and hospitalizations for asthma exacerbations may be associated with poorer asthma management, which has been associated with lower socioeconomic status (19–21). In this study, we could not distinguish the factors that most

likely resulted in the racial disparities in hospitalization rates. Further study is needed to elucidate these factors, especially those which can potentially be modified, such as the quality of primary care.

Our study had several limitations. Not all eligible children were enrolled, and this may have biased our results. However, the proportions enrolled were similar for black children and white children. Another limitation was that the Ohio site did not contribute data for 4 of the 7 study years because of a later start and a protocol deviation, which might have affected our estimated rates for the Ohio county. Although our study counties are geographically diverse, they may not be representative of the entire United States, and all of the participating hospitals were academic institutions, which may differ from nonacademic hospitals. The proportion of black children was higher and the

proportion of Hispanic/Latino children was lower in our study than in the overall US population. Additionally, smaller percentages of black (6%) and white (4%) children in our study were uninsured, as compared with national estimates of 18% for black children and 9% for white children (22). Another limitation was the lack of study data on asthma medications, asthma classification, and host and environmental risk factors for asthma. In addition, we relied on parental reports to assess palivizumab use and did not have enough detailed data on risk factors to identify accurately those children for whom palivizumab was indicated. Furthermore, we did not examine the potential contribution of bacterial coinfections or collect data on antibiotic use. Finally, our study was based on a comparison of rates, which required county denominators that were not available for many characteristics such as medical history and access to care. For this reason, our study and other studies with a similar approach can identify a racial disparity but cannot determine the reasons for the disparity.

In conclusion, compared with white children, black children in this study had significantly higher rates of hospitalization for ARI, influenza and, among children aged 12 months or more, RSV illness. Although our data suggest that less access to and effective use of health care and preventive measures by black children may have contributed to the racial differences in hospitalization rates, additional studies are needed to determine what factors affect racial disparities. Identifying these factors, especially those that are potentially modifiable, such as the quality and availability of primary care, higher rates of influenza vaccination, and improved asthma management, are important steps in reducing existing racial disparities and the burden of respiratory disease hospitalizations.

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REFERENCES

- Centers for Disease Control and Prevention. CDC health disparities and inequalities report—United States, 2011. *MMWR Morb Mortal Wkly Rep.* 2011;60(suppl): 1–109.
- Dawood FS, Fiore A, Kamimoto L, et al. Burden of seasonal influenza hospitalization in children, United States, 2003–2008. *J Pediatr.* 2010;157(5):808–814.
- Poehling KA, Edwards KM, Weinberg GA, et al. The underrecognized burden of influenza in young children. *N Engl J Med.* 2006;355(1):31–40.
- Hall CB, Weinberg GA, Iwane MK, et al. The burden of respiratory syncytial virus infection in young children. *N Engl J Med.* 2009;360(6):588–598.
- Dee DL, Bensyl DM, Gindler J, et al. Racial and ethnic disparities in hospitalizations and deaths associated with 2009 pandemic influenza A (H1N1) virus infections in the United States. *Ann Epidemiol.* 2011;21(8):623–630.
- Thompson DL, Jungk J, Hancock E, et al. Risk factors for 2009 pandemic influenza A (H1N1)-related hospitalization and death among racial/ethnic groups in New Mexico. *Am J Public Health.* 2011;101(9):1776–1784.
- Centers for Disease Control and Prevention. 2009 pandemic influenza A (H1N1) virus infections—Chicago, Illinois, April–July 2009. *MMWR Morb Mortal Wkly Rep.* 2009; 58(33):913–918.
- Hutchins SS, Fiscella K, Levine RS, et al. Protection of racial/ethnic minority populations during an influenza pandemic. *Am J Public Health.* 2009;99(suppl 2): S261–S270.

9. Sangaré L, Curtis MP, Ahmad S. Hospitalization for respiratory syncytial virus among California infants: disparities related to race, insurance, and geography. *J Pediatr*. 2006;149(3):373–377.
10. Holman RC, Curns AT, Cheek JE, et al. Respiratory syncytial virus hospitalizations among American Indian and Alaska Native infants and the general United States infant population. *Pediatrics*. 2004;114(4):e437–e444.
11. Singleton RJ, Bulkow LR, Miernyk K, et al. Viral respiratory infections in hospitalized and community control children in Alaska. *J Med Virol*. 2010;82(7):1282–1290.
12. National Center for Health Statistics. *Vintage 2009 Bridged-Race Postcensal Population Estimates* [data files]. Hyattsville, MD: National Center for Health Statistics; 2010. (http://www.cdc.gov/nchs/nvss/bridged_race/data_documentation.htm#vintage2009). (Accessed May 30, 2012).
13. Centers for Disease Control and Prevention. Prevention and control of influenza with vaccines: recommendation of the advisory committee on immunization practices (ACIP). *MMWR Recomm Rep*. 2010;59(RR-8):1–62.
14. Efron B, Tibshirani RJ. *An Introduction to the Bootstrap*. New York, NY: Chapman & Hall, Inc; 1993:168–177.
15. Homer CJ, Szilagyi P, Rodewald L, et al. Does quality of care affect rates of hospitalization for childhood asthma? *Pediatrics*. 1996;98(1):18–23.
16. Rinderknecht AS, Ho M, Matykiewicz P, et al. Referral to the emergency department by a primary care provider predicts severity of illness. *Pediatrics*. 2010;126(5):917–924.
17. Jackson DJ, Lemanske RG. The role of respiratory virus infections in childhood asthma inception. *Immunol Allergy Clin N Am*. 2010;30(4):513–522.
18. Berdahl T, Owens PL, Dougherty D, et al. Annual report on health care for children and youth in the United States: racial/ethnic and socioeconomic disparities in children's health care quality. *Acad Pediatr*. 2010;10(2):95–118.
19. Law HZ, Oraka E, Mannino DM. The role of income in reducing racial and ethnic disparities in emergency room and urgent care center visits for asthma—United States, 2001–2009. *J Asthma*. 2011;48(4):405–413.
20. Smith LA, Hatcher-Ross JL, Wertheimer R, et al. Rethinking race/ethnicity, income, and childhood asthma: racial/ethnic disparities concentrated among the very poor. *Public Health Rep*. 2005;120(2):109–116.
21. Akinbami LJ, Rhodes JC, Lara M. Racial and ethnic differences in asthma diagnosis among children who wheeze. *Pediatrics*. 2005;115(5):1254–1260.
22. Flores G, Olson L, Tomany-Korman SC. Racial and ethnic disparities in early childhood health and health care. *Pediatrics*. 2005;115(2):e183–e193.