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Running title: Asthma and influenza vaccination

Association between asthma and influenza vaccine uptake among US adolescents: a retrospective survey study

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ABSTRACT

Objective: Despite longstanding recommendations for children with asthma to receive the influenza vaccine, vaccine uptake in this population remains low. We used the nationally representative National Immunization Survey-Teen to analyze the impact of asthma on adolescent influenza vaccination rates.

Methods: Adolescents ages 13-17 years with provider-reported data on vaccine coverage were included in the analysis. The primary outcome was being up-to-date on influenza vaccination, defined as receiving the seasonal influenza vaccine in at least one of the past 3 years, and was analyzed using logistic regression. Asthma was defined by parent report of whether the adolescent has ever been told by a health professional that he or she has asthma. Data were collected in 2016-2017 and analyzed in 2020.

Results: Of 36,655 adolescents in the analytic sample (mean age 15 years, 49% female), 55% were up-to-date on influenza vaccination, and 21% had been diagnosed with asthma. On bivariate analysis, vaccination was more common among adolescents who had been diagnosed with asthma compared to those who were not (60% vs. 53%, $P < 0.001$). On multivariable analysis, asthma diagnosis was associated with greater likelihood of being up-to-date on seasonal influenza vaccination (adjusted odds ratio: 1.29; 95% confidence interval: 1.22, 1.36; $P < 0.001$).

Conclusion: Seasonal influenza vaccination rates remain low among adolescents. Despite concerns about vaccine effectiveness in children with asthma, this diagnosis was associated with increased likelihood of influenza vaccination, possibly in relation to increased health care use (and exposure to vaccine encouragement) among adolescents with asthma.

Key words: Vaccination; asthma; influenza; adolescent health

INTRODUCTION

Seasonal influenza is a severe burden on both communities and health care systems.^{1,2} The incidence of influenza infection among United States (US) residents ranges from 7-9% for persons of all ages, with children experiencing a higher incidence rate (9%-12%).² The estimated average annual cost of influenza related hospitalizations is nearly \$11 billion when including both direct costs to the health care system and indirect costs, such as lost productivity.³ Yearly vaccination against seasonal influenza is recommended for all children over 6 months of age,⁴ yet overall influenza vaccination rates remain low, with only 49% of children receiving their seasonal influenza vaccine.⁵ Low vaccination rates can result from many factors, such as socioeconomic disadvantage, infrequent well

visits and follow ups during influenza season, lack of awareness of the significance of vaccines, and negative perceptions of vaccines by the public.⁶ Children with chronic illnesses face higher risks associated with influenza infection, including higher hospitalization rates, increased risk of pneumonia and other influenza-related complications,⁷⁻¹⁰ which could be mitigated by vaccination against influenza. Among children with asthma, the most common pediatric chronic illness in the US, receiving the influenza vaccine is associated with reduced likelihood of asthma exacerbations due to influenza infection, lower risk of influenza-associated complications, and lower chances of hospital admission.^{11,13,14}

Despite documented benefits of vaccination, influenza vaccine uptake among children with asthma remains low.¹⁵⁻¹⁹ In part, this may be related to disagreement among physicians about vaccine efficacy in this population.^{11,20} Previous studies have noted the importance of physician recommendation in parental decision-making about vaccination, but inconsistent guidelines have limited pediatricians' and parents' knowledge of the benefits of influenza vaccination for children with asthma.¹⁹⁻²⁴ Although children with high-risk conditions are more likely to receive the influenza vaccine than children without high-risk conditions,^{5,25} conflicting guidance on vaccination for children with asthma may limit influenza vaccine uptake in this population. In a previous analysis of the National Health Interview Survey (NHIS), Simon and colleagues found no difference in the likelihood of caregiver-reported influenza immunization between children ages 2-17 years with and without asthma.¹⁹ However, the difference in vaccine uptake related to the presence of asthma may be more pronounced in the teenage years, when influenza vaccination rates are especially low.¹⁹

The lack of routine preventive care visits during adolescent years may decrease vaccination rates and increase the salience of barriers to vaccination (such as hesitance to receive the vaccine due to comorbid asthma). Parental perspectives on vaccines such as thinking their child is at low risk or concerns about potential adverse effects could contribute to lack of vaccination.⁶ Therefore, we used the NIS-Teen,²⁶ a nationally representative survey which includes parental and healthcare provider reports of adolescents' vaccination histories, to analyze the impact of comorbid asthma on adolescent influenza vaccination rates. We hypothesized that adolescents with asthma would be less likely to be up to date on the influenza vaccine. Our secondary aim was to identify how adolescents' socioeconomic characteristics and interaction with the health care system influence the rate of influenza vaccination among adolescents with asthma.

MATERIALS AND METHODS

The study was determined not human subjects research and ineligible for review by the Institutional Review Board at East Carolina University. We analyzed parent- and provider-reported data from the 2016-2017 NIS-Teen (data analysis was performed in 2020). The NIS-Teen is an annual random-digit dialing telephone survey of parents and adolescents (aged 13-17) in the US, and is designed to represent the population of non-institutionalized adolescents. The survey is conducted using a dual frame study design (sampling both cellphone and landline numbers) to collect responses from families, and confirms adolescents' vaccine coverage by surveying adolescents' health care providers (with parental consent). For households with more than one child in the eligible age range, only one adolescent is randomly selected for survey participation.²⁷ In 2016, 73% of 57,864 eligible households completed the household interview; while in 2017, 72% of 60,522 eligible households completed the household interview.^{27,28} Our analysis included adolescents with adequate provider-reported data on vaccine coverage, as determined by survey staff after attempting to contact health care providers who administered the adolescent's vaccinations. All analyses excluded adolescents with missing data on study outcomes or covariates. As recommended by the survey technical documentation, all analyses were adjusted for survey weights to account for unequal probability of sample selection, and standard errors were adjusted for the complex survey design.^{27,28}

Our study outcome was up-to-date status on the annual influenza vaccination, defined by the NIS-Teen as receiving the seasonal influenza vaccination in at least one of the past 3 years, according to provider records. (Influenza vaccination status in the current year is not included in the NIS-Teen public use data file). The primary independent variable was prior diagnosis of asthma, identified by a question about whether the adolescent has “ever been told by a doctor or other health professional that he or she has asthma.” Covariates for our analysis were selected based on clinical relevance and prior studies on influenza vaccination rates. These covariates included demographic factors such as maternal age, parental marital status, maternal educational attainment, and household income.^{17,21,22,29-32} Healthcare system factors included in our analysis were the number of interactions with the healthcare system in the last 12 months, insurance coverage since age 11 (continuous private coverage, continuous public coverage, interrupted coverage, or lack of coverage), and the number of years since last well-child visit.^{19,21,22} Additional covariates included the child’s age, gender, ethnicity, high-risk status for vaccination (presence of a lung condition other than asthma, a heart condition, diabetes, a kidney condition, sickle cell anemia or other anemia, or a weakened immune system), and US Census region of residence (Northeast, Midwest, South, or West).

Statistical analysis

Data were summarized using weighted means or proportions, as applicable, and we used Wald tests to compare the distribution of the study outcome and covariates according to the presence of comorbid asthma. For the primary aim of assessing the influence of asthma diagnosis on vaccine uptake, receipt of the seasonal influenza vaccination was analyzed using multivariable logistic regression in the overall study sample. Except where stated otherwise, we reported adjusted odds ratios (AOR) which controlled for all covariates in the analysis. For the secondary aim of assessing the impact of health system factors on vaccine uptake among adolescents with asthma, a multivariable logistic regression model was fitted to the subsample of adolescents who had been diagnosed with asthma. Data analysis was performed in Stata/SE 15.1 (College Station, TX: StataCorp, LP), and $P < 0.05$ was considered statistically significant.

RESULTS

Among 86,662 cases in the 2016-2017 data set, we identified 41,111 cases with adequate provider data. Cases with incomplete data on study variables were excluded, leaving 36,655 adolescents in the final sample for our analysis. The weighted mean age was 15 years and the sample was 49% female (95% confidence interval [CI]: 48%, 50%). Fifty-five percent (95% CI: 54%, 55%) of adolescents received one or more seasonal influenza vaccine doses in the last 3 years. Twenty-one percent of adolescents were diagnosed with asthma. Multivariable analysis of vaccine uptake in the subpopulation of adolescents with asthma (sample $N = 7,607$) found that adolescents with asthma were more likely to be up-to-date on their seasonal influenza vaccinations (60% vs. 53% among adolescents without asthma; crude odds ratio [OR]: 1.35; 95% CI: 1.28, 1.42; $P < 0.001$). Compared to adolescents without asthma, adolescents with asthma were also more likely to be older, male, non-Hispanic Black or White, have a high-risk condition for vaccination, live below the poverty line, have more healthcare visits within the last year, a more recent well-child visit, and have public insurance (**Table 1**). Mothers of adolescents with asthma were less likely to be married and less likely to have completed college.

Crude ORs for being up to date on the seasonal influenza vaccine are summarized in the **Appendix**. Multivariable analysis in the overall sample (**Table 2**) showed that the association between asthma diagnosis and being up to date on seasonal influenza vaccine persisted after adjustment for potential confounders (AOR: 1.29; 95% CI: 1.22, 1.36; $P < 0.001$). Among continuous variables in the model, older age and longer time since the last well visit were associated with lower odds of being up-to-

date on influenza vaccination. White and Black adolescents were less likely than Hispanic adolescents to be up-to-date on influenza vaccination, while those in a high-risk group were more likely to have received the vaccine than those without one of the high risk conditions. Compared to adolescents with no health care visits in the past year, those with any visits were more likely to be vaccinated. Adolescents living in the Northeast were more likely to be up-to-date on the influenza vaccination as compared to those living in the Midwest, South, and West regions.

Socioeconomic characteristics showed inconsistent associations with the odds of vaccination. Adolescents with part-year or year-round lack of insurance coverage were less likely to be up-to-date on the influenza vaccine than adolescents with continuous private coverage, although we did not find a difference in vaccination between adolescents with continuous private and continuous public coverage. Considering household income, adolescents in the middle income group were less likely to be vaccinated than adolescents in the top income group, but there was no statistically significant difference between the bottom and top income groups. Considering maternal socioeconomic status, children of mothers who completed 12 years of education or >12 years but no college degree were more likely to be up-to-date on the influenza vaccine, but there was no statistically significant difference between the highest and lowest educational attainment categories. Results were similar in the subgroup of adolescents with asthma (**Table 3**), with the exception that there was no longer a statistically significant difference in vaccination odds between adolescents with continuous private coverage as compared to continuous lack of coverage.

DISCUSSION

Annual influenza immunization is recommended for children ages 6 months and older.³³ Children with chronic medical conditions, including pulmonary conditions, experience increased risks associated with influenza and vaccination is highly recommended for this population. Despite these recommendations, influenza vaccine uptake remains low in children and adolescents with asthma. While prior studies have found mixed results for the association between asthma diagnosis and influenza vaccination, our analysis of the NIS-Teen revealed that adolescents with asthma were more likely to be up to date on their seasonal influenza vaccination compared to adolescents without asthma. This advantage was not large in absolute terms (unadjusted difference of 60% vs. 53%), but clearly indicated that children with asthma have equal or better vaccine coverage for the influenza vaccination, compared to children without asthma.

A key strength of the NIS is the purposive design of the survey to ascertain vaccine administration using provider reported records. In a previous study using NHIS data, influenza vaccine uptake was 46%, while in our study, this proportion was 55% representing vaccine receipt over a 3-year period.¹⁹ The discrepancy between the studies may be due in part to differences in survey design, as the NIS-teen includes a mail survey of vaccine providers, whereas the NHIS only conducts household interviews. The requirement for provider confirmation of vaccines in the NIS-teen decreases the risk of social desirability bias influencing estimates of vaccine coverage.

Our analysis found that in the overall adolescent cohort, higher health care utilization was associated with increased likelihood of vaccination. Additional encounters with the health care system may reinforce encouragement and education regarding the influenza vaccine. However, our data did not include reason for visit and the higher number of encounters among adolescents with asthma may have been due to asthma exacerbation. At visits for asthma exacerbation, physicians may have been more likely to recommend the influenza vaccine due to evidence that vaccination may significantly reduce oral steroid use, implying fewer asthma exacerbations and less opportunities for complications and serious illness.¹¹ Alternately, adolescents with more doctor visits may be more likely to be vaccinated because of a higher comorbidity burden in general, encouraging both physicians and families to support vaccination against influenza. Although we were unable to

analyze what vaccine-specific communication occurred at each health care visit, and whether this communication was different according to adolescents' asthma diagnosis, future research may consider whether providers spend more time discussing the influenza vaccine with asthmatic adolescents.

Although provider communication can encourage influenza vaccination, the opportunity to deliver this communication may be limited if adolescents do not regularly see health care providers. The AAP recommends a yearly physical exam during adolescence, providing opportunities for providers to discuss adolescent vaccines (including meningococcal, Tdap, human papillomavirus, and influenza vaccines). Despite recommendations for influenza vaccination during adolescence, vaccination rates remain low.³⁴ Adolescents are significantly less likely than younger children to have a usual source of health care that is an outpatient clinic or health center.³⁵ From the physician perspective, barriers include infrequent adolescent well visits, a lack of awareness of the need for vaccines, and lack of interest in vaccination.⁶

Interventions aimed at increasing adherence to recommended routine care visits for adolescents, such as phone, text, and email reminders, may improve attendance and encourage scheduling an annual influenza vaccine. A recent study using the 2010-2016 NIS consistently found low vaccination rates among US adolescents, which could be attributed to a lack of education on the importance of the influenza vaccine during preventive care, or disparities in accessing preventive care according to ethnicity and socioeconomic status. Consistent with the latter point and with prior analysis of the NIS,³⁴ our study found greater influenza vaccination uptake for adolescents who were non-Hispanic White and living above the poverty line, as well as those who had older mothers and mothers with a college degree.

Limitations

Our conclusions are limited by certain aspects of the NIS-Teen data set and analytic approach. First, although the AAP's recommendation for the influenza vaccination is based on receiving this vaccine annually, the NIS-Teen releases data for this vaccine only over a 3-year period, suggesting that the proportion of adolescents receiving the vaccine annually is lower than the estimates in our analysis. We also could not assess selection bias in adherence to physician recommendations, such that adolescents excluded from our study because of incomplete provider data might have had lower vaccine uptake. Future studies may consider assessing adolescents' exposure to vaccine-related messages at all health care encounters, and to compare this by encounter type (e.g., well care vs. acute care visit). We were also unable to analyze why there was a disparity in vaccination status according to ethnicity, income, or maternal education. In particular, the NIS did not collect data on ideological factors influencing vaccine acceptance, such as political beliefs, trust in societal institutions, and related concepts.³⁶ Although the NIS provides relevant data on vaccine uptake, prospective interventional studies are needed to evaluate specific interventions for increasing influenza vaccination among adolescents with asthma. Lastly, we were unable to evaluate the specific encounters during which adolescents received influenza vaccines, as only limited provider-specific data are released in the public-use NIS data file. Therefore, it is unclear how the type of clinic (e.g., primary care vs. specialist) impacts the likelihood that adolescents with asthma will be offered and accept the influenza vaccine.

Conclusions

Considering the AAP's recommendation of making a special effort to vaccinate children with asthma, it is encouraging to find greater influenza vaccination rates among adolescents with this condition. Nevertheless, the overall seasonal influenza vaccination rate remains low among

adolescents with and without asthma. The association between the number of health care visits and vaccination rate suggests that both appropriate provider communication and increased chances to discuss vaccination with patients may support increasing influenza vaccination in this age range. For adolescents who have established contact with primary care providers, additional initiatives may include reminding families to schedule their annual influenza vaccine. Annual vaccination may also factor into discussions of transition planning, encouraging adolescents to plan for scheduling and obtaining their own seasonal influenza vaccination as they reach adulthood.

Conflicts of interest and source of funding

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Author Participation

NT: interpretation of data, drafting of the manuscript

LC: conception and design, acquisition of data, interpretation of data, revision of the manuscript

CB: conception and design, interpretation of data, revision of the manuscript

DT: conception and design, acquisition of data, statistical analysis, drafting of the manuscript

SS: conception and design, interpretation of data, revision of the manuscript.

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Table 1. Adolescent characteristics and influenza vaccination according to asthma diagnosis.

Variable	No asthma (N = 29,048)		Diagnosed with asthma (N = 7,607)		P ^a
	Weighted mean or percent	95% CI	Weighted mean or percent	95% CI	
Received seasonal influenza vaccine in last 3 years	0.53	0.52, 0.54	0.60	0.59, 0.61	<0.001
Age (yr)	14.96	14.93, 14.99	15.07	15.01, 15.12	<0.001
Sex					
Male	0.49	0.48, 0.50	0.56	0.54, 0.58	<0.001
Female	0.51	0.50, 0.52	0.44	0.42, 0.46	<0.001
Ethnicity					
Hispanic	0.22	0.21, 0.26	0.24	0.22, 0.26	0.086
Non-Hispanic White	0.56	0.55, 0.57	0.48	0.46, 0.50	<0.001
Non-Hispanic Black	0.13	0.12, 0.13	0.17	0.16, 0.19	<0.001
Other	0.10	0.09, 0.10	0.11	0.10, 0.12	0.096
High risk condition ^b	0.03	0.03, 0.04	0.08	0.07, 0.09	<0.001
Mother's age					
≤34 years	0.08	0.08, 0.09	0.10	0.09, 0.11	0.049
35-44 years	0.43	0.42, 0.44	0.44	0.42, 0.46	0.241
≥45 years	0.49	0.48, 0.50	0.46	0.44, 0.48	0.015
Mother's education					
<12 years	0.12	0.11, 0.13	0.12	0.11, 0.13	0.737
12 years	0.22	0.21, 0.22	0.22	0.21, 0.24	0.455
>12 years (no college degree)	0.24	0.23, 0.25	0.27	0.25, 0.29	0.001
College degree	0.43	0.42, 0.44	0.39	0.37, 0.40	<0.001
Mother's marital status					
Married	0.64	0.63, 0.65	0.56	0.54, 0.58	<0.001
Not married	0.36	0.35, 0.37	0.44	0.42, 0.46	<0.001

Annual household income					
Above poverty, >\$75,000	0.44	0.43, 0.45	0.39	0.37, 0.40	<0.001
Above poverty, ≤\$75,000	0.35	0.34, 0.36	0.36	0.34, 0.38	0.129
Below poverty line	0.21	0.20, 0.22	0.25	0.24, 0.27	<0.001
Health care visits in past year					
0	0.16	0.15, 0.17	0.10	0.09, 0.11	<0.001
1	0.32	0.31, 0.33	0.25	0.23, 0.26	<0.001
2-3	0.35	0.34, 0.36	0.36	0.35, 0.38	0.2307
4 or more	0.17	0.16, 0.18	0.29	0.28, 0.31	<0.001
Health insurance coverage					
Continuous private	0.56	0.55, 0.57	0.33	0.32, 0.34	<0.001
Continuous public	0.33	0.32, 0.34	0.39	0.37, 0.41	<0.001
Discontinuous	0.10	0.10, 0.11	0.11	0.10, 0.13	0.074
Continuously uninsured	0.01	0.01, 0.02	0.01	0.01, 0.02	0.719
Years since last well-child visit	0.80	0.77, 0.83	0.72	0.66, 0.79	0.034
Census region of residence					
Northeast	0.16	0.15, 0.16	0.17	0.16, 0.19	0.024
Midwest	0.23	0.22, 0.23	0.20	0.19, 0.21	<0.001
South	0.38	0.37, 0.39	0.38	0.36, 0.40	0.851
West	0.24	0.23, 0.25	0.25	0.23, 0.27	0.395

^aP-values comparing weighted means or proportions by Wald test.

^bDiagnosed with lung condition other than asthma, a heart condition, diabetes, a kidney condition, sickle cell anemia or other anemia, or a weakened immune system.

CI, confidence interval

Table 2. Multivariable logistic regression of vaccine receipt within past 3 years for all adolescents.

Variable	AOR	95% CI	P
Diagnosed with asthma	1.29	1.22, 1.36	<0.001
Age	0.91	0.89, 0.92	<0.001
Female	1.03	0.98, 1.07	0.229
Ethnicity			
Hispanic	(Ref.)		
Non-Hispanic White	0.75	0.70, 0.80	<0.001
Non-Hispanic Black	0.76	0.70, 0.84	<0.001
Other	0.92	0.84, 0.997	0.043
High Risk ^a	1.26	1.13, 1.40	<0.001
Mother's Age			
≤34 years	(Ref.)		
35-44 years	1.03	0.94, 1.11	0.563
≥45 years	1.10	1.01, 1.20	0.037
Mother's education			
<12 years	(Ref.)		
12 years	0.79	0.72, 0.86	<0.001
>12 years (no college degree)	0.78	0.71, 0.85	<0.001
College degree	0.94	0.87, 1.03	0.205
Mother not married	0.92	0.87, 0.97	0.001
Annual household income			
Above poverty, >\$75,000	(Ref.)		
Above poverty, ≤\$75,000	0.83	0.78, 0.88	<0.001
Below poverty line	1.00	0.92, 1.08	0.933
Health care visits in past year			
0	(Ref.)		
1	1.21	1.12, 1.30	<0.001
2-3	1.48	1.38, 1.59	<0.001
4 or more	1.66	1.53, 1.79	<0.001
Years since last well-child visit	0.94	0.93, 0.95	<0.001
Health insurance coverage			
Continuous private	(Ref.)		
Continuous public	1.03	0.97, 1.10	0.368
Discontinuous	0.75	0.69, 0.82	<0.001
Continuously uninsured	0.67	0.55, 0.83	<0.001
Census region of residence			
Northeast	(Ref.)		
Midwest	0.64	0.60, 0.69	<0.001
South	0.57	0.54, 0.61	<0.001
West	0.59	0.56, 0.64	<0.001

^aDiagnosed with lung condition other than asthma, a heart condition, diabetes, a kidney condition, sickle cell anemia or other anemia, or a weakened immune system.

AOR, adjusted odds ratio; CI, confidence interval

Table 3. Multivariable logistic regression of vaccine receipt within past 3 years for adolescents with asthma.

Variable	AOR	95% CI	P
Age	0.92	0.89, 0.96	<0.001
Female	1.01	0.92, 1.11	0.825
Ethnicity			
Hispanic	(Ref.)		
Non-Hispanic White	0.77	0.66, 0.88	<0.001
Non-Hispanic Black	0.81	0.67, 0.96	0.018
Other	0.94	0.79, 1.14	0.544
High Risk ^a	1.25	1.05, 1.50	0.014
Mother's Age			
≤34 years	(Ref.)		
35-44 years	1.00	0.83, 1.19	0.962
≥45 years	1.09	0.90, 1.31	0.382
Mother's education			
<12 years	(Ref.)		
12 years	0.81	0.67, 0.97	0.024
>12 years (no college degree)	0.84	0.70, 0.996	0.045
College degree	0.96	0.80, 1.16	0.696
Mother not married	0.88	0.79, 0.99	0.030
Annual household income			
Above poverty, >\$75,000	(Ref.)		
Above poverty, ≤\$75,000	0.81	0.71, 0.93	0.002
Below poverty line	1.02	0.85, 1.22	0.860
Health care visits in past year			
0	(Ref.)		
1	1.31	1.08, 1.58	0.005
2-3	1.63	1.36, 1.95	<0.001
4 or more	1.71	1.42, 2.06	<0.001
Years since last well-child visit	0.96	0.92, 0.99	0.013
Health insurance coverage			
Continuous private	(Ref.)		
Continuous public	1.06	0.92, 1.22	0.428
Discontinuous	0.75	0.63, 0.90	0.002
Continuously uninsured	1.05	0.62, 1.79	0.846
Census region of residence			
Northeast	(Ref.)		
Midwest	0.62	0.53, 0.72	<0.001
South	0.52	0.46, 0.60	<0.001
West	0.63	0.54, 0.73	<0.001

^a Diagnosed with lung condition other than asthma, a heart condition, diabetes, a kidney condition, sickle cell anemia or other anemia, or a weakened immune system.

AOR, adjusted odds ratio; CI, confidence interval

Appendix. Crude odds ratios of vaccine receipt within past 3 years for all adolescents.

Variable	OR	95% CI	P
Diagnosed with asthma	1.35	1.28, 1.42	<0.001
Age	0.91	0.90, 0.93	<0.001
Female	1.04	1.00, 1.08	0.071
Ethnicity			
Hispanic	(Ref.)		
Non-Hispanic White	0.84	0.80, 0.89	<0.001
Non-Hispanic Black	0.79	0.72, 0.86	<0.001
Other	0.99	0.91, 1.07	0.801
High Risk ^a	1.41	1.28, 1.57	<0.001
Mother's Age			
≤34 years	(Ref.)		
35-44 years	0.99	0.91, 1.07	0.791
≥45 years	1.11	1.02, 1.20	0.010
Mother's education			
<12 years	(Ref.)		
12 years	0.76	0.70, 0.82	<0.001
>12 years (no college degree)	0.75	0.69, 0.81	<0.001
College degree	1.00	0.93, 1.07	0.976
Mother not married	0.90	0.86, 0.94	<0.001
Annual household income			
Above poverty, >\$75,000	(Ref.)		
Above poverty, ≤\$75,000	0.74	0.71, 0.78	<0.001
Below poverty line	0.96	0.90, 1.01	0.121
Health care visits in past year			
0	(Ref.)		
1	1.33	1.24, 1.42	<0.001
2-3	1.65	1.54, 1.76	<0.001
4 or more	1.87	1.74, 2.01	<0.001
Years since last well-child visit	0.90	0.89, 0.92	<0.001
Health insurance coverage			
Continuous private	(Ref.)		
Continuous public	0.98	0.94, 1.03	0.511
Discontinuous	0.66	0.61, 0.71	<0.001
Continuously uninsured	0.55	0.45, 0.67	<0.001
Census region of residence			
Northeast	(Ref.)		
Midwest	0.60	0.56, 0.64	<0.001
South	0.56	0.53, 0.59	<0.001
West	0.57	0.53, 0.61	<0.001

^aDiagnosed with lung condition other than asthma, a heart condition, diabetes, a kidney condition, sickle cell anemia or other anemia, or a weakened immune system.

OR, odds ratio; CI, confidence interval