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Influenza Vaccination Among US Children With Asthma, 2005–2013

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Abstract

Background—Children with asthma face higher risk of complications from influenza. Trends in influenza vaccination among children with asthma are unknown.

Methods—We used 2005–2013 National Health Interview Survey data for children 2 to 17 years of age. We assessed, separately for children with and without asthma, any vaccination (received August through May) during each of the 2005–2006 through 2012–2013 influenza seasons and, for the 2010–2011 through 2012–2013 seasons only, early vaccination (received August through October). We used April–July interviews each year ($n = 31,668$) to assess vaccination during the previous influenza season. Predictive margins from logistic regression with time as the independent and vaccination status as the dependent variable were used to assess time trends. We also estimated the association between several sociodemographic variables and the likelihood of influenza vaccination.

Results—From 2005 to 2013, among children with asthma, influenza vaccination receipt increased about 3 percentage points per year ($P < .001$), reaching 55% in 2012–2013. The percentage of all children with asthma vaccinated by October (early vaccination) was slightly above 30% in 2012–2013. In 2010–2013, adolescents, the uninsured, children of parents with some college education, and those living in the Midwest, South, and West were less likely to be vaccinated.

Conclusions—The percentage of children 2 to 17 years of age with asthma receiving influenza vaccination has increased since 2004–2005, reaching approximately 55% in 2012–2013.

Keywords

asthma; children; influenza vaccination

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Supplementary data

Supplementary data related to this article can be found at <http://dx.doi.org/10.1016/j.acap.2015.10.006>.

Annual influenza vaccination is recommended by the Advisory Committee on Immunization Practices (ACIP) for all children more than 6 months of age.¹ However, ACIP and others have historically regarded the influenza vaccination as particularly important for children with asthma because of their increased risk for severe complications from influenza compared to children without asthma.^{2,3} Although asthma is one of several medical conditions that ACIP suggests confers higher risk on children,³ asthma represents one of the most prevalent chronic conditions among children, with approximately 9.3% of children, or more than 6.8 million children, with a current diagnosis of asthma in 2012.⁴ Further, patterns of vaccine use may differ for children with different medical conditions, so examination of vaccination among children with asthma is of interest.⁵ ACIP also recommends early vaccination, preferably by October, for all children, including those with asthma, to confer protection during the entire influenza season.¹

Although influenza vaccination has been recommended for children with asthma and other chronic conditions since before 1990,⁶ recommendations for children without chronic conditions have changed over time. In 2004, influenza vaccination was recommended for all children 6 to 23 months of age as well as their household contacts.⁷ In 2006, the recommendation was expanded to all children 6 months to younger than 5 years of age.⁸ Starting with the 2008–2009 season, the recommendation was further expanded to include all children >6 months of age (barring contraindication).⁹

Previous assessments of influenza vaccination among children with asthma are sparse. One study examined the rate of influenza vaccination among children with asthma for the 1995–1997 influenza season among children enrolled in 4 health maintenance organizations on the West Coast of the United States, finding that approximately 10% of children with asthma received an influenza vaccination during each season.¹⁰ To our knowledge, Brim et al¹¹ was the first to provide national population-level estimates of influenza vaccination coverage among children with asthma, examining the 2004–2005 influenza season and finding that the influenza vaccination rate was 29.0% among children 2 to 17 years of age with asthma and 10.3% among those without asthma. Although recent research has shown that coverage has increased since then among children with and without chronic conditions,¹² influenza vaccination among children with asthma specifically has not been evaluated since the 2004–2005 season, and trends over time are unknown.¹¹ In addition, the percentage of children with asthma who receive early influenza vaccination has not been examined.

In this study, we use nationally representative data to examine influenza vaccination among children 2 to 17 years of age from the 2004–2005 through the 2012–2013 influenza seasons, and we assess whether vaccination trends differ by asthma status. Also, we assessed, among children with asthma, which characteristics were associated with receiving any influenza vaccination and with receiving influenza vaccination early in the season (by the end of October).

Methods

Data Source

Data are from the 2005–2013 National Health Interview Survey (NHIS), a nationally representative survey with a complex sample design, administered by the National Center for Health Statistics (NCHS). Data were from in-house NCHS files, which can be accessed in the NCHS Research Data Center. Within each participating family, one child 0 to 17 years of age (the sample child) was randomly selected, and health-related information was obtained from in-person interviews with a knowledgeable adult (usually a parent). The NHIS 2005–2013 sample child questionnaires included questions about the year and month of the child's most recent influenza vaccinations. Response rates for the NHIS sample child component ranged from 78.8% in 2006 to 69.0% in 2013.¹³ The NHIS was approved by the NCHS Research Ethics Review Board; this study did not require separate institutional review board approval.

Identification Of Children With Asthma

Current asthma status was based on affirmative responses to both of 2 questions: "Has a doctor ever told you that your child had asthma?" and "Does your child still have asthma?" We excluded children <2 years of age, given the difficulty of diagnosing asthma in this age group.¹⁴

Identification Of Influenza Vaccination

During 2005–2009, the respondent was asked whether the child had received an influenza vaccination injection in the last 12 months and, if so, when the most recent influenza vaccination injection was. Then the respondent was asked whether the child had received an influenza vaccine by nasal spray (Flumist/Live Attenuated Virus vaccine) in the last 12 months. Children <9 years of age receiving the influenza vaccine for the first time should receive 2 doses of influenza vaccine, spaced at least 1 month apart.¹ Consequently, for children <9 years of age interviewed late in the season, the most recent influenza vaccination reported could be a second dose, creating a bias toward being identified as a later vaccination compared to when the initial vaccination actually occurred. Therefore, data from 2005–2009 were not included in our analyses estimating early vaccination.

For the 2010–2013 seasons, the NHIS questions were revised to assess whether a child had received any influenza vaccine in the last 12 months, how many vaccines they had received, when they received each vaccine, and whether each vaccine was an injection or a nasal spray. This new questionnaire structure allowed for determination of whether the first vaccination (if multiple vaccinations were reported) was received early or late in the influenza season. Vaccinations received during August through the following May were categorized as occurring during that influenza season. Vaccinations received during August through October were categorized as early vaccination. During the 2009–2010 influenza season, when both the seasonal trivalent influenza vaccine and the monovalent pandemic H1N1 vaccine were administered, NHIS asked about these 2 vaccinations separately. Only the seasonal trivalent influenza vaccine was used in our analysis because inclusion of either vaccination for the 2009–2010 season would have created an outlier from the overall

vaccination trend.¹⁵ Live attenuated influenza vaccination and inactivated influenza vaccination are included together in all analyses. We examined the percentage of children receiving live attenuated influenza vaccine, but the percentage of children was too low among children with asthma to obtain separate statistically reliable estimates from these data. Because the focus of this study was to examine trends among children with asthma, we did not separately report estimates of live attenuated influenza vaccine for children without asthma.

Covariates

We included the following sociodemographic/geographic factors in our analysis on the basis of previously identified factors related to influenza vaccination in children^{10,12,16}: age group (2–5, 6–11, 12–17 years), sex, race/ethnicity (non-Hispanic white, non-Hispanic black, non-Hispanic other/multiple race, Hispanic), insurance type (private insurance, Medicaid/State Children's Health Insurance Program/other state insurance plan, other insurance, uninsured), highest level of parental education (less than high school, high school graduate/GED, some college/associates degree/technical school degree, college degree or more), urban or rural status based on NCHS urban–rural coding¹⁷ (large central–metro, large fringe–metro [suburbs], medium and small metropolitan areas, micropolitan and noncore areas), and geographic region (Northeast, Midwest, South, West). Measures of asthma severity were not available in the NHIS for the years used in this analyses, but a crude measure of asthma control was available and included in our analysis: whether the child had an asthma episode or attack in the past 12 months.

Statistical Analysis

At the time of the interview, respondents could report that the child had not yet have received a vaccine for that season, but the child could go on to be vaccinated that season after the date of the interview. This could result in misclassification (underreporting) of seasonal vaccination status. Two separate methodologies have previously been used to account for this issue and to estimate influenza vaccine coverage using the National Health Interview Survey.^{11,12} For the primary analysis in our study, we build on the approach of Brim et al,¹¹ restricting our analysis to interview months during the spring and summer. Additionally, we conducted a second analysis consistent with the approach of Santibanez et al¹² that relies on survival analysis to generate yearly estimates of influenza vaccination rates, including all interview months and censoring observations at the time of interview if an influenza vaccination had not yet occurred. Results from both approaches were similar; therefore, the methods and results from the second approach are presented in an online appendix (Online Appendix 1, Online Appendix Figure, Online Appendix Tables).

Brim et al¹¹ estimated the cumulative incidence of influenza vaccination for a single season, but we extend their methodology to examine trends over several seasons.¹¹ Analyses were limited to interviews conducted during April through July of each year, and identified whether a vaccination was received during the previous influenza season lasting August through May. Respondents in April–July were unlikely to be given the vaccine after the interview date because the current influenza season had ended. Because the NHIS sample is designed to be nationally representative for each calendar month, using only these 4 months

still provided national estimates. The percentage of children 2 to 17 years of age with and without asthma who received an influenza vaccine from August to May of each season was estimated. Logistic regression with receipt of influenza vaccination as the dependent variable and influenza season as the independent variable was used to examine time trends in vaccine receipt over the observed time period, and an interaction term for asthma status was used to examine whether trends differed by asthma status. A significant interaction term led to stratification by asthma status. After stratification, the addition of a quadratic term for influenza season was added to see if model fit could be improved using a curvilinear model. The quadratic term was only significant for the model of children without asthma and therefore is only presented for this group. Predictive margins from these regression models were used to estimate percentage point increases in vaccination rates per influenza season.

In addition, for 2010–2013, the percentage of children who received an early influenza vaccination (receiving their first influenza vaccination for the season during August 1 through October 31) was estimated. Because only 3 seasons of early influenza vaccination data were available, no trend analysis was performed; however, the 2010–2011 and 2012–2013 season vaccination estimates were compared by a Wald test. For the 2012–2013 season, comparisons of vaccination rates between children with and without asthma were also conducted by a Wald test.

Among children with asthma, the cumulative incidence of influenza vaccination is presented by sociodemographic/geographic characteristics. Bivariate logistic regressions were used to estimate the odds ratios (ORs) for each characteristic for receiving any versus no influenza vaccine, and among the group of children who received vaccines, early versus late influenza vaccination. These 2 models provide different information. The analysis comparing influenza vaccine versus no influenza vaccine was designed to assess whether differences exist between those who consent to receive the influenza vaccine (even including late receivers) versus those who do not. The analysis comparing early versus late receivers among those who do agree to receive the influenza vaccine was designed to examine if certain characteristics were associated with receiving the vaccine early, as recommended.

Missing Data

Two non–mutually exclusive populations were used for analyses. First, the estimation of any vaccination included children 2 to 17 years of age at the time of interview during April through July of the years 2005–2013 ($n = 3303$ with asthma and 31,668 with and without asthma). Second, for analyses concerning early vaccination, only interviews from 2010–2013 were included ($n = 3303$ with asthma, $n = 10,132$ with and without asthma). The percentage of observations missing data for asthma status was 0.2% for the 2005–2013 sample and 0.3% for the 2010–2013 sample. The percentage of missing information on whether the child had an influenza vaccination during the previous 12 months was 3.1% for both the 2005–2013 sample and the 2010–2013 sample. In addition, of those who reported receiving a vaccination, the percentage missing information on the timing of the vaccine was 9.8% for the 2005–2013 sample and 7.5% for the 2010–2013 sample. The exact number of missing observations for each sample is presented in Online Appendix 1 and Online Appendix Table 1. Missing values were multiply imputed with a conditional multiple

imputation by chained equations.^{18,19} Imputation models for vaccination status were logistic regressions and imputation models for year and month of vaccination (among those vaccinated) were predictive mean matching models.^{18,19} Online Appendix 1 contains more specific information concerning the multiple imputation methodology. Multiply imputed values were used in all analyses.

Results

Approximately 10% of children (standard error [SE] 0.2) had asthma across the 2005–2013 influenza seasons (Online Appendix Table 2), or an average of approximately 6.6 million children during each influenza season.

Trends in Vaccination

The percentage of children with asthma receiving influenza vaccination increased, on average, 3.2 percentage points per year (SE 0.4; $P < .001$ for trend), reaching 54.7% (SE 3.3%) in 2012–2013 (Figure). The percentage of children without asthma receiving influenza vaccination increased approximately 4.2 percentage points per year (SE 0.1; $P < .001$ for trend), reaching 45.2% (SE 1.2%) in 2012–2013, a lower percentage than for those with asthma in 2012–2013 ($P < .01$).

The addition of a quadratic term to the model improved fit for children without asthma ($P < .001$ for quadratic term), but not for children with asthma. This model suggested that there was a steeper slope during earlier years for children without asthma, reaching a maximum increase of approximately 5.3 percentage points per year (SE 0.3) during the 2006–2007 season and flattening to an increase of only 1.1 percentage points per year (SE 0.6) during 2012–2013—an increase that was not significantly different than 0 ($P = .08$). In an overall model, including children with and without asthma, the significance of the interaction term ($P < .001$) between time and asthma status suggested statistically different trends for children with and without asthma. Overall estimates of the percentage of all children who have received influenza vaccination are closer to those for children without asthma because only approximately 10% of children had asthma during the study period. Overall, the percentage of all children 2 to 17 years old receiving influenza vaccination increased an average of 4.1 percentage points per year (SE 0.1; $P < .001$ for trend), from 13.6% (SE 0.6%) during the 2004–2005 influenza season to 46.2% (SE 1.1%) during the 2012–2013 influenza season.

Early Vaccination

Among children with asthma, the percentage receiving early influenza vaccination was not statistically different between 2010–2011 (29.9% [SE 2.7%]) and 2012–2013 (32.3% [SE 3.1%]) ($P = .57$). Among children without asthma, the percentage receiving early influenza vaccination was higher in 2012–2013 (26.8% [SE 1.1%]) than in 2010–2011 (23.3% [SE 0.9%]) ($P = .02$). In 2012–2013, no significant difference was found between the percentages of children receiving early vaccination by asthma status ($P = .10$).

Characteristics Associated With Vaccination Among Children With Asthma

Receiving any influenza vaccination (as compared to no influenza vaccination) was less likely among children 12 to 17 years of age compared to children 2 to 5 years of age (OR 0.52, $P < .01$); uninsured children compared to those with private insurance (OR 0.46, $P = .03$); children of parents whose highest level of education was some college/associates degree/technical school compared to those with a college degree or more (OR 0.62, $P = .02$); and children who live in the Midwest, South, or West compared to those in the Northeast (OR 0.54, $P < .01$; OR 0.64, $P = .03$; and OR 0.61, $P = .02$; respectively). However, no characteristics were significantly associated with receiving an early versus late influenza vaccination among children with asthma (Table).

Discussion

Between 2005 and 2013, the percentage of children in the United States with asthma who received an influenza vaccination increased approximately 3 percentage points per year. The overall gain for children with asthma of approximately 23 percentage points (from 32% in 2004–2005 to nearly 55% in 2012–2013) was smaller than the overall gain for children without asthma of 33 percentage points (from approximately 12% in 2004–2005 to 45% in 2012–2013). The changes in the ACIP recommendations in 2006 and 2008, which expanded recommendations to include all children >6 months of age, may account for the greater increase among children without asthma during the observed time period. Despite the expanded recommendations, for 2012–2013, the percentage of children with asthma who received the influenza vaccination was still greater than that for children without asthma. In general, our results are similar to those from a recent analysis that evaluated trends from 2004–2012 for children with high-risk medical conditions (which include asthma).¹² However, in contrast to other work, we observed that the rate of increase among children without asthma may have slowed, having reached a maximum rate of increase during 2006–2007 and flattening by 2012–2013. Future years of data will be necessary to determine whether the rate of increase among children without asthma has indeed slowed.

Of note, during the 2012–2013 influenza season (the most recent season for which data were available), 45% of children with asthma and 55% of children without asthma did not receive an influenza vaccination. The Healthy People 2020 target (immunization and infectious disease objective number 12.11) for the percentage of children aged 6 months through 17 years vaccinated annually against seasonal influenza, is 70%.²⁰ This goal has not yet been reached.

The percentage of children with asthma who were vaccinated early in the season (by the end of October) was slightly above 30%, leaving 20% to 25% of children with asthma receiving their influenza vaccination later in the season than recommended. Whether the percentage of children with asthma who received early vaccination is increasing is unclear given the limited years of data available in our analysis. Early vaccination maximizes the chance that children will be vaccinated before the peak of the influenza season, which occurred in December or earlier 8 times between the 1982–1983 and the 2013–2014 seasons.²¹

Many interventions to improve vaccination coverage have been explored,^{22,23} some which focus on all children²⁴ and others of which focus more narrowly on children with asthma¹⁶ and/or other chronic diseases.^{25,26} The extent to which trends observed in our study have resulted from interventions on the part of the medical or public health community, changes in reimbursement rates for influenza vaccination,²⁷ changes in parental opinion concerning the influenza vaccine,²⁸ or other factors is not known. Improved epidemiologic knowledge about groups that do not obtain influenza vaccination may be useful for public health practitioners and clinicians trying to improve vaccination coverage.

In this study, we find that among children with asthma, adolescents, the uninsured, children of parents with some college/associate degree/technical school, and those living in the Midwest, South, and West were less likely to be vaccinated for influenza. Among all children and among children with asthma, other researchers have also found lower rates of influenza vaccination among adolescents.^{11,12,29} Across the 3 most recent influenza seasons for which data were available, we did not find differences in vaccination rates by race/ethnicity. However, Santibanez et al¹² considered influenza seasons separately among all children and found several seasons for which Hispanic children had higher influenza vaccination rates than non-Hispanic white children. Whether these differences result from examining different populations or are due to different methodologies requires further research. National estimates of influenza vaccination among children with asthma categorized by other sociodemographic characteristics, to our knowledge, have not been previously presented.

Limitations

This study has some limitations. Receipt and timing of influenza vaccination were based on parent recall, which may overestimate influenza vaccination prevalence as a result of perceived social acceptability in reporting vaccination.^{30,31} Second, there was missing information for receipt and timing of influenza vaccination for some children. Although we addressed this limitation with multiple imputation, our initial models would not converge, and our subsequently simplified models excluded some covariates that may have improved model fit had convergence been achieved. Also, our findings regarding the association between vaccination and parents' level of education are difficult to interpret, as an increasing level of vaccination across the education gradient was not observed. In addition, we were not able to assess whether children receiving influenza vaccine for the first time received 1 or 2 doses. Finally, statistical power may have been limited by smaller sample size for the analysis of whether sociodemographic/geographic characteristics were related to receipt of early vaccination.

Conclusion

This study focused on national trends in influenza vaccination prevalence for children with asthma, finding that rates have increased over time. These analyses also showed for the first time that only approximately 30% of children with asthma were vaccinated by the end of October. Further, we observed that among children with asthma, adolescents, uninsured children, and children in the Midwest, South, and West have lower prevalence of vaccination.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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What's New

From 2005 to 2013, the percentage of children with asthma receiving the influenza vaccination increased approximately 3 percentage points per influenza season, reaching 55% in the 2012–2013 season. Approximately 30% of children with asthma received early vaccination in 2012–2013.

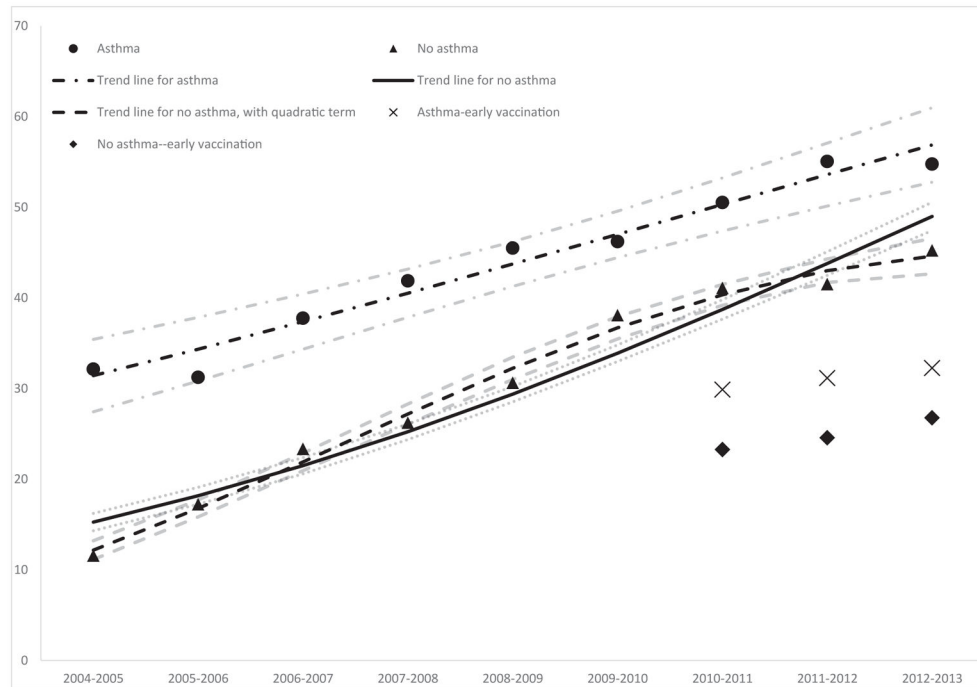


Figure.

Percentage of children aged 2 to 17 years with and without asthma receiving influenza vaccination by influenza season. Each time point represents a mutually exclusive influenza season. Data are from National Health Interview Survey interviews conducted during April–July of each year, identifying whether a vaccination was received during the previous August–May. Gray lines represent 95% pointwise confidence bands. The percentage of all children aged 2 to 17 years with asthma ranged from 8.3% in during the 2006–2007 influenza season to 11.1% during the 2008–2009 influenza season.

Table

Any and Early (August–October) Influenza Vaccination of Children Aged 2 to 17 Years With Asthma for 2010–2013 Influenza Seasons by Sociodemographic and Geographic Characteristics

Characteristic	n	Any Influenza Vaccine (SE)	Unadjusted OR [95% CI], Any Versus None	Early Influenza Vaccine (SE)	Unadjusted OR [95% CI], Early Versus Late
Total	1305	53.4 (2.0)		31.1 (1.7)	
Age					
2–5 y	229	62.0 (4.1)	Reference	31.9 (3.9)	Reference
6–11 y	524	57.3 (3.0)	0.82 [0.54, 1.23]	33.0 (2.8)	1.28 [0.74, 2.22]
12–17 y	552	45.9 (3.0)**	0.52 [0.34, 0.79]**	28.7 (2.6)	1.58 [0.93, 2.69]
Sex					
Male	762	55.2 (2.4)	Reference	32.7 (2.3)	Reference
Female	543	51.0 (3.1)	0.84 [0.63, 1.14]	28.9 (2.5)	0.90 [0.60, 1.34]
Race/Ethnicity [†]					
Non-Hispanic white	483	52.7 (3.1)	Reference	31.1 (2.8)	Reference
Non-Hispanic black	360	50.3 (3.8)	0.91 [0.62, 1.33]	29.0 (3.3)	0.95 [0.54, 1.66]
Non-Hispanic other/multiple race	124	51.6 (6.1)	0.96 [0.56, 1.64]	33.3 (5.5)	1.27 [0.62, 2.58]
Hispanic	338	58.9 (3.5)	1.29 [0.89, 1.85]	32.3 (3.6)	0.84 [0.47, 1.52]
Insurance [‡]					
Private (any)	596	53.7 (2.9)	Reference	33.7 (2.6)	Reference
Public only	619	54.6 (2.9)	1.04 [0.75, 1.42]	29.7 (2.5)	0.71 [0.43, 1.16]
Uninsured	68	34.7 (7.8)*	0.46 [0.22, 0.93]*	20.4 (6.8)	0.84 [0.26, 2.73]
Highest level of education in family					
College or greater	357	59.1 (3.5)	Reference	35.8 (3.2)	Reference
Some college/associate degree/technical degree	509	47.3 (3.4)*	0.62 [0.42, 0.91]*	27.1 (2.9)	0.87 [0.49, 1.56]
High school graduate/GED	289	50.8 (4.1)	0.71 [0.47, 1.09]	31.0 (3.5)	1.02 [0.57, 1.83]
Less than high school	149	64.8 (5.4)	1.27 [0.74, 2.20]	32.0 (5.5)	0.63 [0.32, 1.23]
Urban/rural status					
Large central metro	425	53.7 (3.1)	Reference	28.0 (2.7)	Reference
Large fringe metro	302	58.6 (4.2)	1.22 [0.81, 1.84]	33.0 (3.6)	1.18 [0.66, 2.14]
Medium/small metro	373	51.3 (3.6)	0.91 [0.62, 1.33]	32.2 (3.2)	1.55 [0.92, 2.62]

Characteristic	n	Any Influenza Vaccine (SE)	Unadjusted OR [95% CI], Any Versus None	Early Influenza Vaccine (SE)	Unadjusted OR [95% CI], Early Versus Late
Metropolitan/noncore Region	205	46.7 (5.4)	0.75 [0.46, 1.23]	31.6 (4.8)	1.92 [0.92, 4.02]
Northeast	247	63.6 (3.6)	Reference	37.1 (3.8)	Reference
Midwest	226	48.5 (4.4) **	0.54 [0.34, 0.86] **	32.1 (4.2)	1.40 [0.71, 2.73]
South	502	52.7 (3.5) *	0.64 [0.42, 0.96] *	29.1 (2.9)	0.89 [0.47, 1.68]
West	330	51.4 (3.8) *	0.61 [0.40, 0.93] *	28.6 (3.5)	0.90 [0.50, 1.59]
Asthma attack in past 12 mo [§]					
No	677	52.4 (2.7)	Reference	30.7 (2.5)	Reference
Yes	626	54.3 (2.7)	1.08 [0.81, 1.44]	31.3 (2.4)	0.97 [0.63, 1.48]

SE indicates standard error; OR, odds ratio; and CI, confidence interval.

Significantly different than reference group.

* $P < .05$ and

** $P < .01$.

[†] Race/ethnicity determined by parental (or knowledgeable adult) report. Children of Hispanic ethnicity may be of any race.

[‡] Other insurance not presented due to small sample size of 18.

[§] Two observations were missing data for asthma attack in past 12 months.