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Pneumococcal Vaccination Among Adults With Work-related Asthma

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Abstract

Introduction—Pneumococcal vaccination is recommended for all adults with asthma and a Healthy People 2020 goal aims to achieve 60% coverage among high-risk adults, including those with asthma. Adults with work-related asthma have more severe asthma symptoms than those with non–work-related asthma and are particularly vulnerable to pneumococcal pneumonia.

Methods—To assess pneumococcal vaccination coverage by work-related asthma status among ever-employed adults aged 18–64 years with current asthma, data from the 2012–2013 Behavioral Risk Factor Surveillance System Asthma Call-back Survey for ever-employed adults (18–64 years) with current asthma from 29 states were examined in 2016. Adults with work-related asthma had ever been told by a physician their asthma was work-related. Pneumococcal vaccine recipients self-reported having ever received a pneumococcal vaccine. Multivariate logistic regression was used to calculate adjusted prevalence ratios and associated 95% CIs.

Results—Among an estimated 12 million ever-employed adults with current asthma in 29 states, 42.0% received a pneumococcal vaccine. Adults with work-related asthma were more likely to have received a pneumococcal vaccine than adults with non–work-related asthma (53.7% versus 35.0%, respectively, prevalence ratio=1.24, 95% CI=1.06, 1.45). Among adults with work-related asthma, pneumococcal vaccine coverage was lowest among Hispanics (36.2%) and those without health insurance (38.5%).

Conclusions—Pneumococcal vaccination coverage among adults with work-related asthma and non–work-related asthma is below the Healthy People 2020 target level. Healthcare providers should verify pneumococcal vaccination status in their patients with asthma and offer the vaccine to those not vaccinated.

INTRODUCTION

Asthma, a chronic airway disease, affected 18.4 million adults in the U.S. in 2015.[1] Adults with asthma are at greater risk of pneumococcal infection, with an estimated population attributable risk between 12% and 17% for adults with asthma.[2–5] Pneumococcal infection is a vaccine-preventable illness caused by the bacterium *Streptococcus pneumoniae*, which can

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present as meningitis, pneumonia, bacteremia, bronchitis, sinusitis, and otitis media.[6] Adults with asthma who have pneumococcal infection are at greater risk of asthma exacerbation and invasive pneumococcal disease.[7] The Centers for Disease Control and Prevention (CDC) Advisory Committee on Immunization Practices recommends that all adults with asthma receive a pneumococcal vaccine.[8]

Work-related asthma (WRA) is asthma that is caused or made worse by exposures at work.[9] Adults with WRA have more severe asthma than those with non-WRA, characterized by poorly controlled asthma, more asthma attacks, and more frequent asthma-related healthcare utilization.[9,10] Studies have shown that adults with severe, uncontrolled asthma are at greater risk of pneumococcal infection and subsequent asthma complications, such as severe asthma exacerbations.[2,11] Moreover, Weycker et al.[12] found that the annual economic costs associated with pneumococcal infection increased with the severity of asthma. For example, the cost of invasive pneumococcal disease among adults aged 18–64 years with severe asthma was more than $1.3 million per 100,000 person-years, 12 times the cost for invasive pneumococcal disease among adults without asthma.[12] Therefore, adults with WRA would particularly benefit, both in health outcomes and economically, from receiving a pneumococcal vaccine.

Healthy People 2020 immunization and infectious disease objective IID-13.2 aims to increase the percentage of high-risk persons, including those with asthma, aged 18–64 years who are vaccinated against pneumococcal infection from 16.6% in 2008 to 60.0% in 2020.[13] The objective of this study is to assess pneumococcal vaccination coverage by WRA status among ever-employed adults with current asthma.

METHODS

Study Sample

The Behavioral Risk Factor Surveillance System (BRFSS) is a state-based, random-digit-dialed landline and cellular telephone survey of the non-institutionalized U.S. population. The Asthma Call-back Survey is an optional follow-up survey conducted within 2 weeks of the initial BRFSS interview that collects detailed information on asthma.[14] BRFSS respondents that indicated they had ever been told by a health professional that they have asthma were invited to participate in the Asthma Call-back Survey.[15] Data from the 2012–2013 Asthma Call-back Survey from 29 states (California, Connecticut, Georgia, Hawaii, Illinois, Indiana, Iowa, Maryland, Michigan, Mississippi, Missouri, Montana, Nebraska, Nevada, New Hampshire, New Jersey, New Mexico, New York, North Carolina, Ohio, Oklahoma, Oregon, Pennsylvania, Texas, Utah, Vermont, Washington, West Virginia, Wisconsin) conducting landline and cellular telephone household surveys were assessed.

The adult Asthma Call-back Survey was administered in 22 states in 2012, and in 28 states in 2013. Based on the American Association for Public Opinion Research guidelines, the median response rate in 2012 among the 22 states was 44.9% (range, 27.7%–56.8%) for BRFSS and 47.2% (range, 38.5%–60.6%) for the Asthma Call-back Survey, and in 2013 among the 28 states was 43.9% (range, 31.1% –57.2%) for BRFSS and 46.0% (range, 32.5%–57.1%) for the Asthma Call-back Survey. The IRB at CDC has granted a

surveillance exemption for BRFSS; however, states participating in BRFSS are subject to the IRB requirements of their state.

Measures

Adults with current asthma were identified by affirmative responses to the questions: *Have you ever been told by a doctor or other health professional that you have asthma?* And, *Do you still have asthma?* These adults were then classified as having WRA, possible WRA, or non-WRA. Persons with WRA were identified by an affirmative response to the question: *Have you ever been told by a doctor or other health professional that your asthma was caused by, or your symptoms made worse by, any job you ever had?* Adults with possible WRA were those who did not have WRA as defined previously and responded yes to any of the following questions: *Are your asthma symptoms made worse by things like chemicals, smoke, dust, or mold in your current job? Was your asthma first caused by things like chemicals, smoke, dust, or mold in your current job? Were your asthma symptoms made worse by things like chemicals, smoke, dust, or mold in any previous job you ever had?* And *Was your asthma first caused by things like chemicals, smoke, dust, or mold in any previous job you ever had?* Adults with current asthma who did not meet definitions for WRA or possible WRA were classified as non-WRA.

Pneumococcal vaccine recipients were defined as those who indicated during the interview that they had ever received a pneumococcal vaccine. Other chronic conditions placing persons at increased risk for pneumococcal infection, including diabetes, chronic obstructive pulmonary disease, and cardiovascular disease, were determined based on individual responses to survey questions and grouped as “other chronic disease” for analyses. Previously established definitions were used to describe asthma-related healthcare utilization, adverse asthma outcomes, and asthma control.[10,16–18]

Statistical Analysis

Analyses were performed in 2016 using SAS, version 9.3 and SUDAAN, release 11.0.1. Data from 2012–2013 were combined and weighted to account for unequal probability of sample selection and survey non-response. Weights for analyses were established by multiplying the percentage of subjects in each state and survey year by the corresponding survey year’s weight. Weights were unaltered for eight states (Connecticut, Georgia, Illinois, Maryland, New Jersey, North Carolina, Utah, and West Virginia) with 1 year of data available. Estimates based on a sample of <50 respondents or with a relative SE >30% were not reported.

Analyses were restricted to adults aged 18–64 years with current asthma because of the age- and condition-specific recommendations for pneumococcal vaccination during 2012–2013. The demographic and clinical characteristics of ever-employed adults with current asthma were examined. Multivariate logistic regression was used to calculate adjusted prevalence ratios (PRs) using the predicted marginal risk ratio method. Age, household income, education, current employment status, smoking status, health insurance, and other chronic disease were all independently associated with WRA status or pneumococcal vaccination, and were simultaneously included in the multivariate logistic regression models. Using

backward selection, non-significant covariates were removed from the model. Results were considered statistically significant at an α of <0.05.

RESULTS

A sample of 20,823 adults from 29 states participated in the Asthma Call-back Survey during 2012–2013. Respondents aged ≥65 years (*n*=6,684), with no current asthma (*n*=3,630), who were never employed (*n*=203), and with missing information on age, employment, or current asthma status (*n*=383) were excluded, leaving 9,923 ever-employed respondents aged 18–64 years with current asthma for analyses.

Among an estimated 12 million ever-employed adults with current asthma in these 29 states, 42.0% of ever-employed adults with current asthma had ever received a pneumococcal vaccine. The coverage was below 42% among adults aged 18–44 years (32.7%), men (39.0%), those with a college degree (36.7%), with a household income ≥$50,000 (36.3%), employed in the last year (37.2%), without health insurance (33.2%), never smokers (38.9%), with well-controlled asthma (35.2%), and those who did not have a routine checkup for asthma in the last 12 months (33.7%) (Table 1).

Among the estimated 15.2% of adults with current asthma who had WRA, 53.7% had ever received a pneumococcal vaccine, significantly greater coverage compared with the 35.0% of adults with non-WRA who received a pneumococcal vaccine (adjusted PR=1.24, 95% CI=1.06, 1.45). Among adults with WRA, pneumococcal vaccine coverage was lowest among Hispanics (36.2%) and those without health insurance (38.5%; Table 2). Multivariate analysis revealed that adults with WRA were more likely to have received a pneumococcal vaccine among those aged 45–64 years, not employed in the last year, with health insurance, who had used an inhaled corticosteroid in the 3 months prior to the survey, who had received the influenza vaccine, and who have poorly controlled asthma (Table 2).

Among the estimated 40.8% of adults with current asthma who had possible WRA, 44.7% had ever received a pneumococcal vaccine (Table 1), significantly greater coverage than the 35.0% among adults with non-WRA who received a pneumococcal vaccine (adjusted PR=1.15, 95% CI=1.01, 1.31). Among adults with possible WRA, the prevalence of pneumococcal vaccination was lowest among those without the ability to see a specialist for their asthma (34.3%), employed in the last year (34.9%), and with no other chronic diseases (35.2%; Table 2).

Pneumococcal vaccination coverage was ≥60% among adults with WRA in six states and was <60% among adults with possible WRA and non-WRA in all states assessed (Table 3).

DISCUSSION

The results of this analysis indicated that pneumococcal vaccination coverage among adults aged 18–64 years was 53.7% for adults with WRA, 44.7% for adults with possible WRA, and 35.0% for adults with non-WRA. Compared with adults with non-WRA, pneumococcal vaccination coverage was significantly greater among adults with WRA and possible WRA; however, coverage among all groups was less than the Healthy People 2020 target of 60%.[13]

According to CDC, adults with asthma should receive a single dose of the 23-valent pneumococcal polysaccharide vaccine.[8] Administration of the 13-valent pneumococcal conjugate vaccine is not indicated for adults with asthma aged <65 years unless the patient has iatrogenic immunodeficiency, such as through long-term systemic corticosteroid use, or has another immunosuppressing medical condition.[19–21] Among adults in whom 13-valent pneumococcal conjugate vaccine is indicated, a single dose of 13-valent pneumococcal conjugate vaccine should be administered prior to or at least a year after receiving the 23-valent pneumococcal polysaccharide vaccine. Adults should not receive a pneumococcal vaccine if a severe allergic reaction occurred after a previous dose or to any component of the vaccine; however, an event such as this is exceedingly rare.[22] Additional barriers to pneumococcal vaccination include lack of awareness of the disease risk or vaccine among both patients and physicians, healthcare system delivery challenges (i.e., lack of information on patients' vaccination status, lack of communication between healthcare providers), and financial barriers, among others.[23] The Asthma Call-back Survey did not collect information on why respondents did not receive a pneumococcal vaccine.

In this study, adults with WRA who did not have health insurance were significantly less likely to have received a pneumococcal vaccine compared with those with health insurance (38.5% vs 57.5%). This is similar to results from a study by Lu and colleagues[24] that found lower pneumococcal vaccination coverage among uninsured adult populations. Moreover, a study by Knoeller et al.,[17] reported that adults with WRA were more likely to have financial barriers to asthma care than those with non-WRA. Increasing access to health insurance coverage may help improve WRA patients' access to preventive care services and increase the proportion of adults receiving pneumococcal vaccination.

In this study, adults who were not employed in the last year were more likely to have received a pneumococcal vaccine. This association remained statistically significant among adults with WRA (PR=1.51, 95% CI=1.12, 2.05) and possible WRA (PR=1.61, 95% CI=1.25, 2.07), and may reflect the severity of WRA, as more severe asthma has been shown to be associated with loss of employment.[25,26] Moreover, patients with a high-risk chronic condition who are hospitalized for community-acquired pneumonia are more likely to leave their job.[27,28] Similar results were found for influenza vaccine uptake among adults with WRA.[29] Interventions to improve pneumococcal vaccine uptake, such as offering pneumococcal vaccination through occupational health services or at the same time as influenza vaccination, may help prevent adverse pneumococcal disease-related outcomes and job loss among employed adults with WRA.[23,30]

Inhaled steroid use has been associated with increased risk of pneumonia in patients with asthma and chronic airflow disease.[31] In this study, the authors observed greater pneumococcal vaccination coverage among adults who had used inhaled corticosteroids in the 3 months prior to the interview (PR=1.32, 95% CI=1.19, 1.47) compared with those who had not used inhaled corticosteroids. The association remained statistically significant among adults with WRA, possible WRA, and non-WRA when stratified by WRA status. Moreover, pneumococcal vaccination coverage exceeded the Healthy People 2020 goal among those with WRA who had used inhaled corticosteroids (67.8%, 95% CI=60.2, 75.3).

Physicians should continue to offer pneumococcal vaccination to adults with asthma taking inhaled corticosteroids.

The results of this study indicated that those with additional chronic diseases, such as diabetes, chronic obstructive pulmonary disease, and cardiovascular disease, were more likely to have received a pneumococcal vaccine overall. This association remained significant among adults with possible WRA and non-WRA, but not among adults with WRA. Studies have shown that having multiple high-risk chronic conditions increases the risk of pneumococcal infection, with particularly high rates among individuals with three or more conditions.[3,27] Moreover, the presence of chronic diseases can adversely affect the severity and outcomes of pneumococcal infection (i.e., bacteremia, respiratory failure, cardiac complications, death).[27] No information was available to ascertain if these individuals were recommended pneumococcal vaccination because of their WRA or because of the concomitant presence of other high-risk conditions. Nonetheless, adults with WRA and additional chronic disease may be at greater risk for pneumococcal infection and related complications and, thus, may be an important group for targeted interventions.

Pneumococcal vaccination coverage was greater than the Healthy People 2020 target of 60% among adults with WRA in six states. Differences in pneumococcal vaccination coverage by state may be explained by state variations in access to health care, health insurance coverage, prevention programs, and state vaccination laws.[32,33] For example, Ohio, which had the highest pneumococcal vaccination coverage of any state in this study, requires that a pneumococcal vaccine be offered to each patient admitted to the hospital in accordance with the Advisory Committee on Immunization Practices guidelines.[34] Studies have shown an improvement in pneumococcal vaccination rates and physician awareness of Advisory Committee on Immunization Practices guidelines after implementation of standing orders programs.[35,36] Implementation of state laws that reduce barriers to vaccination, such as statewide standing orders programs, may improve pneumococcal vaccination rates.[33]

Potential interventions to improve pneumococcal vaccination coverage include educating and encouraging healthcare practitioners to take an active role in advising patients to be vaccinated, educating potential vaccine recipients about the impact of pneumococcal infection and the importance of prevention, creating systems to make patient pneumococcal vaccination status readily available for physicians (i.e., through electronic medical records), and clarifying third-party reimbursement for vaccination.[23,35] Community-acquired pneumonia has been shown to worsen a patient's underlying chronic condition, such as asthma, therefore, prevention of serious infection is essential.[23,27,37]

Limitations

A strength of this study is the inclusion of the possible WRA group. WRA is often under-recognized and adults with possible WRA may have undiagnosed WRA.[9,38] Because of this, the true vaccination prevalence among adults with WRA is likely lower than reported, as adults with physician-diagnosed WRA may receive more medical care and may be more likely to receive a pneumococcal vaccine. This study is also subject to several limitations. Information on both asthma and pneumococcal vaccination status was self-reported and was not validated by medical records or follow-up with a health care provider, and may be

subject to misclassification. Moreover, the survey did not collect information on the type of pneumococcal vaccine administered or when administration occurred. Finally, data used in this analysis were for adults living in 29 states, thus, results may not be representative nationally or of non-participating states.

CONCLUSIONS

Adults with WRA were more likely to have received a pneumococcal vaccination than adults with non-WRA; however, pneumococcal vaccination coverage among adults with WRA, possible WRA, and non-WRA was below the Healthy People 2020 target level. These results indicate that among some subgroups, such as those who had taken inhaled corticosteroids, pneumococcal vaccination coverage is approaching or has exceeded the Healthy People 2020 goal. Public health and clinical efforts should continue to focus strategies on meeting or exceeding the Healthy People 2020 pneumococcal vaccination goal among adults with WRA, particularly those at high risk, such as patients taking inhaled corticosteroids, with other chronic conditions, or with poorly controlled asthma. Moreover, healthcare providers should verify pneumococcal vaccination status in their patients with asthma and offer the vaccine to those not vaccinated.

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Table 1

Proportion of Pneumococcal Vaccination Coverage Among Ever-employed Adults With Current Asthma

			Pneumococcal vaccine coverage	
Characteristics	**Sample, *n*[a]**	**Population, %[b] (95% CI)**	**%[b] (95% CI)**	**PR[c] (95% CI)**
Total	9,923	–	42.0 (39.6, 44.3)	–
Age				
18–44 years	3,099	55.0 (52.9, 57.2)	32.7 (28.9, 36.5)	1.00
45–64 years	6,824	45.0 (42.8, 47.1)	52.1 (49.5, 54.7)	**1.46 (1.28, 1.66)**
Sex				
Male	2,955	35.2 (33.0, 37.4)	39.0 (34.9, 43.1)	1.00
Female	6,968	64.8 (62.6, 67.0)	43.5 (40.6, 46.4)	1.06 (0.94, 1.19)
Race/ethnicity				
Non-Hispanic white	7,611	68.5 (66.2, 70.8)	42.9 (40.2, 45.5)	1.00
Non-Hispanic black	812	13.0 (11.4, 14.7)	42.5 (35.5, 49.5)	0.98 (0.82, 1.18)
Hispanic	570	11.7 (9.9, 13.5)	35.5 (26.8, 44.2)	0.91 (0.71, 1.15)
Other	805	6.8 (5.5, 8.0)	42.2 (31.6, 52.7)	0.92 (0.71, 1.19)
Education				
≤High school	3,327	35.2 (33.0, 37.3)	43.2 (39.2, 47.1)	1.02 (0.87, 1.19)
Some college	3,107	38.2 (35.9, 40.5)	44.5 (40.2, 48.7)	1.10 (0.96, 1.26)
College graduate	3,482	26.6 (24.8, 28.4)	36.7 (33.2, 40.1)	1.00
Household income				
<$15,000	1,817	17.5 (15.8, 19.3)	48.3 (42.4, 54.1)	**1.19 (1.01, 1.42)**
$15,000–$24,999	1,636	17.4 (15.7, 19.1)	42.5 (36.9, 48.0)	1.10 (0.93, 1.30)
$25,000–$34,999	832	9.2 (7.8, 10.6)	49.1 (40.7, 57.5)	**1.31 (1.06, 1.61)**
$35,000–$49,999	1,130	11.6 (10.2, 13.0)	45.5 (38.9, 52.0)	**1.24 (1.05, 1.46)**
≥$50,000	3,706	44.2 (41.9, 46.5)	36.3 (32.7, 39.8)	1.00
Employment status in last year				
Employed	2,768	56.0 (53.0, 59.1)	37.2 (33.0, 41.4)	1.00
Not employed	2,264	44.0 (40.9, 47.0)	49.9 (44.9, 55.0)	**0.79 (0.67, 0.95)**
Health insurance				
Yes	8,553	83.9 (82.2, 85.6)	43.7 (41.1, 46.2)	**1.30 (1.05, 1.59)**
No	1,347	16.1 (14.4, 17.8)	33.2 (27.3, 39.2)	1.00
Smoking status				
Current	2,134	22.2 (20.3, 24.0)	44.2 (39.3, 49.0)	1.00
Former	2,704	22.7 (21.0, 24.5)	47.2 (42.7, 51.7)	1.06 (0.91, 1.25)
Never	5,066	55.1 (52.8, 57.3)	38.9 (35.5, 42.3)	0.99 (0.84, 1.16)
Inhaler corticosteroid use[d]				
Yes	3,694	31.5 (29.5, 33.5)	52.7 (48.8, 56.6)	**1.32 (1.19, 1.47)**
No	6,225	68.5 (66.5, 70.5)	36.9 (34.0, 39.8)	1.00

Characteristics	Sample, n^a	Population, %^{b} (95% CI)	Pneumococcal vaccine coverage	
			%^{b} (95% CI)	PR^c (95% CI)
Received influenza vaccine				
Yes	2,545	42.9 (39.9, 45.9)	55.5 (50.9, 60.0)	**1.62 (1.40, 1.89)**
No	2,488	57.1 (54.1, 60.1)	32.8 (28.4, 37.1)	1.00
Routine checkup for asthma				
Yes	5,668	63.4 (61.0, 65.8)	47.3 (44.2, 50.5)	**1.21 (1.04, 1.41)**
No	2,829	36.6 (34.2, 39.0)	33.7 (29.2, 38.2)	1.00
Ability to see doctor for asthma if needed				
Yes	8,620	85.3 (83.7, 86.9)	42.0 (39.5, 44.6)	1.00 (0.84, 1.20)
No	1,288	14.7 (13.1, 16.3)	41.7 (35.5, 48.0)	1.00
Ability to see specialist				
Yes	9,244	92.1 (90.9, 93.4)	42.1 (39.6, 44.5)	1.13 (0.89, 1.43)
No	669	7.9 (6.6, 9.1)	40.7 (32.7, 48.8)	1.00
Asthma control				
Well controlled	4,662	51.1 (48.9, 53.4)	35.2 (31.8, 38.6)	1.00
Not well controlled	2,591	25.7 (23.8, 27.6)	46.5 (42.0, 51.1)	**1.22 (1.06, 1.40)**
Very poorly controlled	2,668	23.2 (21.4, 25.0)	51.4 (46.9, 55.8)	**1.19 (1.03, 1.38)**
Adverse asthma outcomes^e				
Asthma attack				
Yes	5,404	53.0 (50.7, 55.3)	45.6 (42.5, 48.7)	**1.15 (1.02, 1.29)**
No	4,449	47.0 (44.7, 49.3)	37.7 (34.1, 41.3)	1.00
Urgent treatment for worsening asthma				
Yes	2,420	42.0 (39.0, 44.9)	50.9 (46.5, 55.3)	**1.30 (1.11, 1.53)**
No	2,829	58.0 (55.1, 61.0)	33.7 (29.2, 38.2)	1.00
Asthma-related emergency room visit				
Yes	1,322	14.1 (12.5, 15.7)	49.2 (43.0, 55.4)	1.12 (0.96, 1.30)
No	8,587	85.9 (84.3, 87.5)	40.8 (38.2, 43.3)	1.00
Overnight stay in hospital because of asthma				
Yes	323	3.6 (2.8, 4.4)	66.1 (54.9, 77.3)	**1.35 (1.05, 1.73)**
No	9,586	96.4 (95.6, 97.2)	41.0 (38.6, 43.4)	1.00
Asthma status				
WRA	1,681	15.2 (13.7, 16.8)	53.7 (48.2, 59.2)	**1.24 (1.06, 1.45)**
Possible WRA	4,244	40.8 (38.6, 42.9)	44.7 (41.1, 48.3)	**1.15 (1.01, 1.31)**
Non-WRA	3,982	44.0 (41.8, 46.3)	35.0 (31.4, 38.6)	1.00
Other chronic disease^f				
Yes	4,687	38.2 (36.1, 40.3)	54.7 (51.5, 57.9)	**1.48 (1.30, 1.67)**
No	5,236	61.8 (59.7, 63.9)	33.7 (30.4, 36.9)	1.00

Note: Boldface indicates statistical significance ($p<0.05$).

[a]Unweighted sample size. Numbers may not add to total because of missing values.

[b] Weighted average annual estimate.

[c] PR adjusted for age, household income, health insurance, and other chronic disease.

[d] In the last 3 months.

[e] In the last 12 months.

[f] Diabetes, chronic obstructive pulmonary disease, or cardiovascular disease.

PR, prevalence ratio; WRA, work-related asthma.

Table 2

Proportion of Pneumococcal Vaccination Coverage by Work-related Asthma Status and Demographic Characteristics Among Ever-employed Adults With Current Asthma

	Pneumococcal vaccine coverage					
	Work-related asthma		Possible work-related asthma		Non–work-related asthma	
Characteristics	**%[a] (95% CI)**	**PR[b] (95%CI)**	**%[a] (95% CI)**	**PR[b] (95%CI)**	**%[a] (95% CI)**	**PR[b] (95%CI)**
Age						
18–44 years	41.8 (31.9, 51.6)	1.00	35.8 (29.7, 41.9)	1.00	27.8 (22.4, 33.2)	1.00
45–64 years	60.9 (54.7, 67.1)	**1.44 (1.09, 1.91)**	54.1 (50.5, 57.8)	**1.37 (1.14, 1.64)**	45.0 (40.8, 49.3)	**1.51 (1.22, 1.87)**
Sex						
Male	53.9 (44.1, 63.8)	1.00	40.1 (33.8, 46.5)	1.00	31.3 (25.9, 36.7)	1.00
Female	53.7 (47.0, 60.3)	0.96 (0.79, 1.18)	47.5 (43.2, 51.8)	1.13 (0.95, 1.34)	36.6 (32.0, 41.2)	1.08 (0.88, 1.34)
Race/ethnicity						
Non-Hispanic white	56.3 (50.5, 62.1)	1.00	45.8 (41.7, 49.9)	1.00	35.3 (31.3, 39.4)	1.00
Non-Hispanic black	48.9 (32.9, 64.8)	0.90 (0.63, 1.27)	45.3 (34.4, 56.1)	0.96 (0.74, 1.25)	37.1 (26.5, 47.7)	1.06 (0.77, 1.46)
Hispanic	36.2 (19.1, 53.2)	0.74 (0.49, 1.12)	39.7 (27.0, 52.4)	0.86 (0.63, 1.19)	31.0 (16.3, 45.7)	1.04 (0.67, 1.61)
Other	64.8 (41.5, 88.0)	1.03 (0.68, 1.56)	40.9 (27.9, 53.9)	0.88 (0.66, 1.18)	31.3 (15.9, 46.7)	0.81 (0.53, 1.25)
Education						
≤High school	54.0 (46.4, 61.6)	1.13 (0.87, 1.48)	44.4 (38.4, 50.3)	0.95 (0.77, 1.18)	36.5 (30.0, 43.0)	1.00 (0.74, 1.34)
Some college	55.3 (45.4, 65.2)	1.15 (0.87, 1.53)	46.9 (40.6, 53.2)	1.06 (0.88, 1.29)	37.5 (30.5, 44.5)	1.08 (0.86, 1.35)
College graduate	48.8 (39.8, 57.9)	1.00	41.8 (36.0, 47.6)	1.00	30.9 (26.2, 35.5)	1.00
Household income						
<$15,000	47.7 (37.2, 58.1)	0.85 (0.63, 1.16)	52.1 (43.8, 60.5)	1.22 (0.97, 1.53)	43.7 (32.8, 54.6)	1.35 (0.97, 1.87)
$15,000–$24,999	47.6 (35.2, 60.0)	0.88 (0.64, 1.21)	45.2 (37.2, 53.2)	1.10 (0.87, 1.40)	35.2 (26.0, 44.5)	1.17 (0.86, 1.59)
$25,000–$34,999	62.4 (45.6, 79.2)	1.15 (0.82, 1.62)	47.3 (33.4, 61.2)	1.25 (0.89, 1.74)	45.3 (33.0, 57.7)	**1.40 (1.01, 1.95)**
$35,000–$49,999	60.6 (48.7, 72.5)	1.07 (0.81, 1.41)	51.4 (41.6, 61.3)	**1.37 (1.09, 1.72)**	34.2 (23.1, 45.2)	1.13 (0.81, 1.57)
≥$50,000	53.9 (42.8, 65.0)	1.00	37.1 (31.5, 42.7)	1.00	31.4 (26.7, 36.0)	1.00
Employment status in last year						
Employed	49.0 (37.5, 60.5)	1.00	34.9 (28.4, 41.5)	1.00	36.2 (30.2, 42.2)	1.00

Characteristics	Pneumococcal vaccine coverage					
	Work-related asthma		Possible work-related asthma		Non–work-related asthma	
	%[a] (95% CI)	PR[b] (95%CI)	%[a] (95% CI)	PR[b] (95%CI)	%[a] (95% CI)	PR[b] (95%CI)
Not employed	60.9 (51.1, 70.7)	**1.51 (1.12, 2.05)**	57.4 (50.3, 64.5)	**1.61 (1.25, 2.07)**	37.1 (28.3, 45.8)	0.80 (0.61, 1.06)
Health insurance						
Yes	57.5 (51.4, 63.6)	**1.47 (1.07, 2.03)**	45.8 (41.9, 49.6)	1.16 (0.87, 1.54)	37.0 (33.1, 41.0)	1.55 (0.99, 2.41)
No	38.5 (27.4, 49.5)	1.00	39.9 (30.4, 49.5)	1.00	21.5 (13.0, 29.9)	1.00
Smoking status						
Current	50.2 (38.8, 61.6)	1.00	47.3 (40.4, 54.3)	1.00	37.1 (29.3, 44.9)	1.00
Former	63.4 (54.8, 72.1)	1.14 (0.88, 1.47)	48.7 (42.3, 55.1)	1.07 (0.85, 1.33)	39.2 (31.6, 46.7)	1.05 (0.77, 1.43)
Never	51.3 (43.2, 59.5)	0.95 (0.72, 1.25)	41.5 (36.1, 47.0)	1.02 (0.80, 1.30)	33.0 (28.1, 37.9)	0.99 (0.74, 1.31)
Inhaler corticosteroid use[c]						
Yes	67.8 (60.2, 75.3)	**1.49 (1.22, 1.81)**	54.1 (48.2, 60.0)	**1.23 (1.06, 1.44)**	43.8 (37.7, 49.9)	**1.30 (1.07, 1.57)**
No	45.0 (38.1, 51.9)	1.00	40.1 (35.5, 44.6)	1.00	31.4 (26.9, 35.9)	1.00
Received influenza vaccine						
Yes	64.9 (54.7, 75.0)	**1.39 (1.06, 1.81)**	56.6 (50.1, 63.1)	**1.65 (1.32, 2.07)**	50.3 (42.4, 58.3)	**1.72 (1.33, 2.24)**
No	45.9 (35.0, 56.8)	1.00	35.6 (28.3, 42.9)	1.00	26.0 (20.4, 31.6)	1.00
Routine checkup for asthma						
Yes	58.4 (51.9, 64.8)	1.30 (0.94, 1.80)	49.3 (44.6, 54.0)	1.17 (0.95, 1.45)	40.4 (35.1, 45.6)	1.20 (0.93, 1.54)
No	45.1 (30.8, 59.4)	1.00	36.7 (29.6, 43.8)	1.00	28.4 (22.4, 34.3)	1.00
Ability to see doctor for asthma if needed						
Yes	56.2 (50.1, 62.4)	1.04 (0.79, 1.36)	45.2 (41.4, 49.1)	1.04 (0.81, 1.34)	34.9 (31.1, 38.7)	0.94 (0.63, 1.39)
No	45.4 (33.9, 56.9)	1.00	42.4 (33.1, 51.8)	1.00	36.5 (25.1, 48.0)	1.00
Ability to see specialist						
Yes	55.0 (49.0, 60.9)	1.06 (0.77, 1.45)	45.6 (41.8, 49.4)	**1.41 (1.00, 2.00)**	34.7 (31.0, 38.4)	0.89 (0.55, 1.43)
No	48.4 (34.3, 62.6)	1.00	34.3 (23.4, 45.2)	1.00	41.6 (24.2, 59.1)	1.00
Asthma control						
Well controlled	43.5 (34.5, 52.5)	1.00	37.1 (31.9, 42.3)	1.00	32.0 (27.0, 37.0)	1.00
Not well controlled	60.3 (51.0, 69.6)	**1.43 (1.10, 1.87)**	52.2 (45.4, 59.1)	**1.30 (1.06, 1.58)**	33.8 (27.4, 40.2)	1.02 (0.80, 1.30)
Very poorly controlled	59.2 (50.4, 67.9)	**1.37 (1.05, 1.79)**	49.5 (43.0, 56.0)	1.10 (0.89, 1.36)	48.2 (40.2, 56.2)	1.19 (0.91, 1.54)

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Characteristics	Pneumococcal vaccine coverage					
	Work-related asthma		Possible work-related asthma		Non–work-related asthma	
	%[a] (95% CI)	PR[b] (95%CI)	%[a] (95% CI)	PR[b] (95%CI)	%[a] (95% CI)	PR[b] (95%CI)
Adverse asthma outcomes[d]						
Asthma attack						
Yes	52.8 (46.1, 59.6)	1.03 (0.82, 1.29)	49.0 (44.4, 53.6)	1.18 (0.99, 1.41)	36.6 (31.5, 41.8)	1.09 (0.89, 1.32)
No	55.6 (46.3, 64.9)	1.00	38.7 (33.0, 44.4)	1.00	33.7 (28.6, 38.8)	1.00
Urgent treatment for worsening asthma						
Yes	53.6 (44.9, 62.3)	1.24 (0.88, 1.75)	58.0 (51.2, 64.8)	**1.40 (1.12, 1.75)**	39.7 (32.8, 46.6)	1.13 (0.88, 1.47)
No	45.1 (30.8, 59.4)	1.00	36.7 (29.6, 43.8)	1.00	28.4 (22.4, 34.3)	1.00
Asthma-related emergency room visit						
Yes	50.3 (38.5, 62.1)	1.00 (0.79, 1.26)	58.9 (49.5, 68.4)	**1.38 (1.14, 1.67)**	35.3 (25.9, 44.7)	0.85 (0.62, 1.16)
No	55.0 (48.9, 61.2)	1.00	42.3 (38.4, 46.1)	1.00	35.0 (31.1, 38.9)	1.00
Overnight stay in hospital because of asthma						
Yes	62.4 (45.3, 79.5)	1.02 (0.75, 1.38)	79.8 (66.2, 93.3)	**1.71 (1.33, 2.18)**	46.1 (26.3, 65.9)	0.98 (0.55, 1.74)
No	53.2 (47.5, 58.9)	1.00	43.1 (39.5, 46.7)	1.00	34.7 (31.0, 38.4)	1.00
Other chronic disease[e]						
Yes	55.8 (49.3, 62.4)	1.20 (0.93, 1.55)	57.3 (52.6, 61.9)	**1.50 (1.25, 1.79)**	50.2 (44.3, 56.2)	**1.52 (1.24, 1.86)**
No	50.5 (40.7, 60.3)	1.00	35.2 (30.0, 40.3)	1.00	29.0 (24.6, 33.5)	1.00

Note: Boldface indicates statistical significance ($p<0.05$).

[a] Weighted average annual estimate.

[b] PR adjusted for age, household income, health insurance, and other chronic disease.

[c] In the last 3 months.

[d] In the last 12 months.

[e] Diabetes, chronic obstructive pulmonary disease, or cardiovascular disease.

PR, prevalence ratio.

Table 3

Pneumococcal Vaccination Coverage by Work-related Asthma Status and State Among Ever-employed Adults With Current Asthma

State	Pneumococcal vaccine coverage		
	Work-related asthma, %[a] (95% CI)	Possible work-related asthma, %[a] (95% CI)	Non-work-related asthma, %[a] (95% CI)
California	51.5 (31.9, 71.0)	43.7 (31.4, 55.9)	31.2 (21.1, 41.3)
Connecticut	–	34.2 (16.0, 52.5)	26.9 (13.9, 39.9)
Georgia	–	–	–
Hawaii	–	36.4 (22.5, 50.4)	38.5 (24.0, 52.9)
Illinois	–	56.9 (38.9, 75.0)	–
Indiana	61.5 (48.1, 74.8)	41.0 (32.3, 49.7)	32.2 (23.3, 41.0)
Iowa	–	51.6 (39.2, 64.1)	46.8 (34.2, 59.4)
Maryland	–	45.7 (26.7, 64.6)	41.2 (25.1, 57.2)
Michigan	47.3 (33.9, 60.7)	39.0 (31.9, 46.1)	44.1 (36.3, 51.9)
Mississippi	60.9 (44.0, 77.8)	36.8 (26.4, 47.1)	37.4 (21.8, 52.9)
Missouri	61.9 (44.4, 79.3)	43.0 (30.4, 55.6)	46.4 (31.1, 61.7)
Montana	59.4 (43.6, 75.2)	30.5 (20.6, 40.5)	45.5 (33.4, 57.5)
Nebraska	45.7 (33.2, 58.1)	41.0 (32.0, 49.9)	39.4 (29.8, 48.9)
Nevada	–	35.2 (18.5, 52.0)	42.5 (22.1, 63.0)
New Hampshire	56.0 (36.3, 75.7)	46.6 (35.3, 57.9)	28.4 (17.3, 39.5)
New Jersey	–	31.4 (15.4, 47.4)	36.1 (22.2, 50.1)
New Mexico	53.1 (33.6, 72.6)	43.3 (32.5, 54.1)	27.4 (19.2, 35.6)
New York	–	42.2 (26.4, 58.0)	35.5 (21.1, 49.8)
North Carolina	–	–	–
Ohio	66.8 (49.2, 84.3)	47.5 (34.6, 60.4)	35.5 (25.7, 45.3)
Oklahoma	62.5 (44.3, 80.8)	44.4 (33.1, 55.6)	40.8 (27.1, 54.5)
Oregon	–	48.4 (34.0, 62.8)	32.5 (20.1, 44.8)
Pennsylvania	55.7 (42.9, 68.5)	47.4 (38.2, 56.6)	40.3 (31.2, 49.5)
Texas	64.4 (46.4, 82.4)	41.2 (29.6, 52.9)	–
Utah	–	47.4 (34.7, 60.1)	38.4 (26.8, 49.9)
Vermont	–	44.3 (32.5, 56.1)	27.1 (16.3, 37.9)
Washington	47.9 (33.1, 62.6)	45.5 (35.8, 55.1)	36.6 (27.8, 45.4)
West Virginia	–	44.8 (29.6, 60.1)	–
Wisconsin	55.7 (37.7, 73.7)	41.3 (25.5, 57.1)	46.6 (34.4, 58.9)

[a]Weighted average annual estimate.

"–" indicates relative SE >30% or sample denominator <50 respondents, estimate not reportable.