

## OCCUPATIONAL ASTHMA

**Work-related asthma and employment status – 38 states and District of Columbia, 2006–2009**Gretchen E. White, MPH<sup>1</sup>, Jacek M. Mazurek, MD, MS, PhD<sup>1</sup>, and Jeanne E. Moorman, MS<sup>2</sup><sup>1</sup>Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, Division of Respiratory Disease Studies, Morgantown, WV, USA, and <sup>2</sup>Centers for Disease Control and Prevention, National Center for Environmental Health, Division of Environmental Hazards and Health Effects, Atlanta, GA, USA**Abstract**

**Objectives:** To examine differences in current employment status between persons with health professional-diagnosed work-related asthma and non-work-related asthma and to examine factors associated with unemployment in these groups. **Methods:** We analyzed the 2006–2009 Behavioral Risk Factor Surveillance System Asthma Call-back Survey for ever-employed adults (excluding those who were retired, homemakers and students at the time of the interview) with current asthma in 38 states and District of Columbia ( $N = 25\,680$ ). We calculated prevalence ratios (PRs) adjusted for age, sex, race/ethnicity, education and income. **Results:** Among adults with current asthma, individuals with work-related asthma were less likely to be currently employed for wages (PR = 0.89; 95% confidence interval [CI] = 0.84–0.95) and more likely to be unable to work (PR = 1.44; 95% CI = 1.24–1.67) than those with non-work-related asthma. Among adults with current asthma who were unemployed at the time of the interview, adults with work-related asthma did not differ from those with non-work-related asthma in naming disability as reason for unemployment (PR = 1.09; 95% CI = 0.94–1.26). However, those with work-related asthma were more likely to be unable to work for health reasons other than disability (PR = 1.46; 95% CI = 1.01–2.12) than adults with non-work-related asthma. **Conclusions:** Additional studies are needed to determine what health reasons prevent individuals with work-related asthma from working and if the health reasons are asthma-related.

**Keywords**

Asthma, behavioral risk factor surveillance system, employment, occupational health

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**Introduction**

In 2010, 8.2% of adults (an estimated 18.7 million adults) in the United States had current asthma [1]. Work-related asthma, a subset of asthma, is a preventable occupational lung disease that includes occupational asthma (new onset or previously quiescent asthma caused by workplace exposures) and work-exacerbated asthma (preexisting asthma made worse by workplace exposures) [2]. Approximately, 17% of adult asthma is attributable to work-place exposures [3].

Work-related asthma is associated with increased disability, mortality and adverse social and economic outcomes including poor quality of life, loss of income and unemployment [4–9]. A French study of patients with occupational asthma seeking care at occupational medicine clinics found that approximately three years after diagnosis of occupational asthma, 44% of individuals had left their jobs and 25% were unemployed; most (75%) as a result of their occupational asthma [10]. Using data from a population-based survey in 37 states and the District of Columbia (DC), we previously demonstrated that individuals who had ever been diagnosed with work-related asthma were

30% more likely to be unemployed at the time of the survey than individuals with non-work-related asthma [11]. For individuals with work-related asthma, for whom it is recommended to avoid or reduce further exposure to the offending agent [12,13], the current labor market [14] might make changing jobs particularly difficult.

To date, there is limited population-based information on the impact of work-related asthma on employment in the United States. To address this gap, we examined the association between work-related asthma and current employment status using data from the 2006–2009 Behavioral Risk Factor Surveillance System (BRFSS) Asthma Call-back Survey (ACBS) for ever-employed adults with current asthma in 38 states and DC. Furthermore, among individuals who were unemployed at the time of the interview, we examined 1) reasons for unemployment and 2) current asthma-related characteristics.

**Methods**

The BRFSS is a state-based, random-digit-dialed telephone survey of non-institutionalized U.S. adults aged  $\geq 18$  years that collects information on health behaviors [15]. In 2006–2009, BRFSS respondents in 39 states, District of Columbia (DC) and Puerto Rico who indicated that they had lifetime asthma (had ever been told by a doctor or other health

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professional that they had asthma) were eligible to participate in the Asthma Call-back Survey. The Asthma Call-back Survey was conducted approximately 2 weeks after the BRFSS interview and collected information on asthma including work-related asthma [16]. The median response rates for 2006–2009 among the participating areas ranged from a low of 47.5% in 2007 to a high of 51.4% in 2009 for BRFSS and from a low of 47.2% in 2009 to a high of 54.3% in 2007 for the Asthma Call-back Survey. The BRFSS has a surveillance exemption from Institutional Review Board review at the Centers for Disease Control and Prevention and requires participants' informed consent. Participating states were subject to state-specific Institutional Review Board requirements.

During 2006–2009, 39 states, DC and Puerto Rico administered the Asthma Call-back Survey. For this analysis, we excluded 2009 preliminary data from North Carolina and Puerto Rico because data were not comparable at the time of analysis. Not all 38 states conducted the ACBS in each year, and information on states administering the ACBS by year can be found at [http://www.cdc.gov/brfss/acbs/2009/ACBS\\_06-09.rtf](http://www.cdc.gov/brfss/acbs/2009/ACBS_06-09.rtf).

We identified adults with current asthma who had ever been employed and were not homemakers, students or retirees at the time of the interview. Participants with current asthma responded "Yes" to the question "Do you still have asthma?" We considered Asthma Call-back Survey participants to be ever-employed if they indicated that they were currently "employed full-time" or "employed part-time" or that they have ever been employed outside the home.

We determined current employment status based on responses to the question "Are you currently...employed for wages, self-employed, out of work for more than 1 year, out of work for less than 1 year, a homemaker, a student, retired, or unable to work?" Among individuals who were not currently employed (i.e. not employed for wages or self-employed), we examined reason for unemployment based on responses to the question "What is the main reason you are not now employed?" Responses included in this analysis were "keeping house", "going to school", "retired", "disabled", "unable to work for other health reasons", "looking for work", "laid off" and "other". Because individuals who were retired, homemakers, students did not provide other reasons for unemployment, we restricted the sample population to adults with current asthma who had ever been employed and were not currently a homemaker, student or retiree.

Participants with work-related asthma included adults who responded "Yes" to the question "Were you ever told by a doctor or other health professional that your asthma was related to any job you ever had?" Some individuals who responded "No" to the question on work-related asthma indicated an association between their asthma and work by answering "Yes" to one of the following questions on the potential role of workplace exposures in the onset and exacerbation of asthma: (1) "Was your asthma caused by chemicals, smoke, fumes or dust in your current job?" (2) "Was your asthma caused by chemicals, smoke, fumes or dust in any previous job you ever had?" (3) "Is your asthma made worse by chemicals, smoke, fumes or dust in your current

job?" and (4) "Was your asthma made worse by chemicals, smoke, fumes or dust in any previous job you ever had?" and were determined to have possible work-related asthma. Respondents had non-work-related asthma if they answered "No" to the question on work-related asthma and "No" to all four additional questions that addressed the potential role of workplace exposures in the onset and exacerbation of asthma.

Definitions for asthma-related characteristics including participants' asthma symptom frequency, level of asthma control and asthma-related health care utilization have previously been described [9,17].

We used SAS<sup>®</sup> software version 9.3 (SAS Institute Inc., Cary, NC) survey procedures and SUDAAN<sup>®</sup> Release 10.0.1 software (Research Triangle Institute, Research Triangle Park, NC) for analyses to account for the complex sample design. Data were weighted to account for non-response differences in the sample and the unequal probability of sample selection. For the 36 states and DC participating in the Asthma Call-back Survey during multiple years, weights were calculated by multiplying the proportion of subjects in each survey year by the corresponding weight for that survey year. For the two states participating in the Asthma Call-back Survey during one year only, unaltered weights for that year were used.

Among adults with current asthma who had ever been employed and were not homemakers, students or retirees at the time of the interview, we examined the current employment status of individuals with work-related asthma, possible work-related asthma and non-work-related asthma. For comparison, we used BRFSS data collected during 2006–2009 from the same 38 states and DC to describe the current employment status in the adult population  $\geq 18$  years.

Using multivariable logistic regression models to calculate adjusted prevalence ratios (PRs) [18], we examined associations between work-related asthma and current employment status. We also calculated adjusted PRs to examine the associations between 1) work-related asthma and reasons for unemployment among those who were not employed at the time of the interview and 2) being unable to work and select asthma-related characteristics. We adjusted for age (continuous), sex, race/ethnicity (four categories: non-Hispanic white, non-Hispanic black, Hispanic, non-Hispanic other), education (two categories: high school or less, more than high school) and annual household income (five categories:  $< \$15\,000$ ,  $\$15\,000$ – $\$24\,999$ ,  $\$25\,000$ – $\$34\,999$ ,  $\$35\,000$ – $\$49\,999$ ,  $\geq \$50\,000$ ) because findings from previous research have shown associations with work-related asthma [11,19,20].

## Results

Using BRFSS data, we found that in the general population of adults in 38 states and DC who were not currently homemakers, students or retirees, 84.3% were currently employed and 6.8% were unable to work (Table 1). The proportion of currently employed individuals was lower among those with current asthma (72.1%) than those with former asthma (82.6%) or no asthma history (85.6%). Using Asthma Call-back Survey data, we found that among ever-employed adults with current asthma, 58.2% of those with work-related asthma were currently employed compared to 78.2% of those with non-work-related asthma. The proportion of individuals

Table 1. Current employment status among select population groups, Behavioral Risk Factor Surveillance System and Asthma Call-back Survey, 38 states and District of Columbia, 2006–2009.

	Employed	Out of work more than 1 year	Out of work less than 1 year	Unable to work
Population (Survey, sample size)	% <sup>a</sup> (95% CI)	% (95% CI)	% (95% CI)	% (95% CI)
Adults (BRFSS, <i>N</i> = 687 934)	84.3 (84.1–84.5)	3.4 (3.3–3.5)	5.5 (5.4–5.7)	6.8 (6.7–6.9)
Current asthma <sup>b</sup> ( <i>N</i> = 65 076)	72.1 (71.3–72.8)	4.9 (4.4–5.4)	6.3 (5.8–6.7)	16.8 (16.2–17.3)
Former asthma <sup>c</sup> ( <i>N</i> = 28 947)	82.6 (81.6–83.6)	3.7 (3.2–4.2)	6.8 (6.1–7.6)	6.9 (6.3–7.4)
No asthma <sup>d</sup> ( <i>N</i> = 589 608)	85.6 (85.4–85.8)	3.2 (3.1–3.3)	5.4 (5.2–5.5)	5.8 (5.7–5.9)
Ever-employed adults <sup>e</sup> with current asthma (ACBS, <i>N</i> = 25 680)	73.5 (72.3–74.8)	4.8 (4.1–5.5)	6.3 (5.4–7.2)	15.4 (14.6–16.2)
WRA <sup>f</sup> ( <i>N</i> = 12 256)	58.2 (54.2–62.2)	6.4 (4.2–8.7)	6.9 (4.7–9.1)	28.5 (24.9–32.1)
Possible WRA <sup>g</sup> ( <i>N</i> = 10 560)	70.5 (68.4–72.7)	5.2 (4.0–6.4)	7.0 (5.3–8.7)	17.3 (15.9–18.7)
Non-WRA <sup>h</sup> ( <i>N</i> = 2773)	78.2 (77.2–80.5)	4.2 (3.3–5.1)	5.6 (4.5–6.8)	11.4 (10.4–12.4)

<sup>a</sup>Results presented as weighted average annual estimate.

<sup>b</sup>BRFSS participants who answered “Yes” to the questions “Were you ever told by a doctor or other health professional that you had asthma?” and “Do you still have asthma?”

<sup>c</sup>BRFSS participants who answered “Yes” to the question “Were you ever told by a doctor or other health professional that you had asthma?” and “No” to the question “Do you still have asthma?”

<sup>d</sup>BRFSS participants who answered “No” to the question “Were you ever told by a doctor or other health professional that you had asthma?”

<sup>e</sup>ACBS participants who described current employment status as “employed full-time” or “employed part-time” or responded “Yes” to the question “Have you ever been employed outside the home?”

<sup>f</sup>ACBS participants who answered “Yes” to the question “Were you ever told by a doctor or other health professional that your asthma was related to any job you ever had?”

<sup>g</sup>ACBS participants who answered “No” to the question “Were you ever told by a doctor or other health professional that your asthma was related to any job you ever had?” and “yes” to any of the following four questions: “Was your asthma caused by chemicals, smoke, fumes, or dust in your current job?”, “Was your asthma caused by chemicals, smoke, fumes, or dust in any previous job you ever had?”, “Is your asthma made worse by chemicals, smoke, fumes, or dust in your current job?”, and “Was your asthma made worse by chemicals, smoke, fumes, or dust in any previous job you ever had?”

<sup>h</sup>ACBS participants who answered “No” to all of the following five questions: “Were you ever told by a doctor or other health professional that your asthma was related to any job you ever had?”, “Was your asthma caused by chemicals, smoke, fumes, or dust in your current job?”, “Was your asthma caused by chemicals, smoke, fumes, or dust in any previous job you ever had?”, “Is your asthma made worse by chemicals, smoke, fumes, or dust in your current job?”, and “Was your asthma made worse by chemicals, smoke, fumes, or dust in any previous job you ever had?”

ACBS = Asthma Call-back Survey

BRFSS = Behavioral Risk Factor Surveillance System

CI = Confidence interval

WRA = Work-related asthma

who were unable to work was greatest among those with work-related asthma (28.5%) and lowest among those with non-work-related asthma (11.4%) (Table 1).

Overall, an estimated 12 million adults in 38 states and DC had current asthma, had ever been employed and were not homemakers, students or retirees at the time of the interview. Of these, most were 18–44 years old (55.4%), female (60.1%), non-Hispanic white (74.9%), had greater than a high school education (67.5%), had health insurance (86.2%), had never been smokers (54.1%), were currently employed (73.5%) and had non-work-related asthma (50.6%) (Table 2). The estimated proportion of individuals with work-related asthma was 9.7% and the proportion with possible work-related asthma was 39.8% (Table 2).

After adjusting for covariates, individuals with work-related asthma were significantly less likely to be employed for wages ( $PR = 0.89$ ) and significantly more likely ( $PR = 1.44$ ) to be unable to work than individuals with non-work-related asthma (Table 3).

Among adults with current asthma who were unemployed at the time of the interview, adults with work-related asthma did not differ from those with non-work-related asthma in naming disability as reason for unemployment ( $PR = 1.09$ ; 95% CI = 0.94–1.26). However, those with work-related asthma were more likely to be unable to work for health reasons other than disability ( $PR = 1.46$ ; 95% CI = 1.01–2.12) than adults with non-work-related asthma (Table 4).

Being unable to work was associated with multiple asthma-related characteristics including less time since last asthma symptom, greater number of days with asthma, having asthma symptoms all the time, greater number of days with trouble sleeping because of asthma, having very-poorly controlled asthma, having an asthma attack, having urgent treatment for worsening asthma, having an asthma-related emergency room visit and having an asthma-related overnight hospital stay (Table 5). Associations between being unable to work and less than 1 day since last asthma symptom and between being unable to work and 15–30 days with asthma symptoms in the past 30 days were stronger among individuals with non-work-related asthma than among individuals with possible work-related asthma. For all other characteristics examined, being unable to work remained associated with adverse asthma-related characteristics in individuals with work-related asthma, possible work-related asthma and non-work-related asthma and the stratum-specific adjusted PRs were similar with overlapping 95% CIs (Table 5). Associations with dependent variables from multivariate analyses for possible work-related asthma were consistently weaker than associations with dependent variables for work-related asthma (Tables 3–5).

## Discussion

The results of this study indicate that unemployment is higher among adults with current asthma (27.9%) and work-related asthma (41.8%) when compared with adults without asthma



Table 2. Characteristics of adults with current asthma who were ever-employed, Asthma Call-back Survey, 38 states and District of Columbia, 2006–2009 (*N* = 25 680).

Characteristics	<i>n</i> <sup>a</sup>	Weighted <i>N</i> (in thousands) <sup>b</sup>	% <sup>c</sup>	(95% CI)
Age (year)				
18–44	8070	6579	55.4	(54.0–56.8)
45–64	15 224	4772	40.2	(38.9–41.5)
65+	2284	524	4.4	(4.0–4.8)
Sex				
Male	7113	4752	39.9	(38.4–41.5)
Female	18 567	7151	60.1	(58.5–61.6)
Race/Ethnicity				
White, non-Hispanic	20 863	8874	74.9	(73.5–76.3)
Black, non-Hispanic	1482	1050	8.9	(8.0–9.7)
Hispanic	1202	1112	9.4	(8.3–10.5)
Other, non-Hispanic	1963	811	6.8	(6.0–7.7)
Education level				
≤High school	8402	3870	32.5	(31.1–33.9)
>High school	17 262	8027	67.5	(66.1–68.9)
Household income				
<\$15 000	3965	1470	13.5	(12.5–14.5)
\$15 000–\$24 999	3775	1549	14.2	(13.1–15.4)
\$25 000–\$34 999	2377	979	9.0	(8.2–9.8)
\$35 000–\$49 999	3386	1457	13.4	(12.3–14.4)
≥\$50 000	10 258	5439	49.9	(48.4–51.4)
Health insurance				
Yes	22 891	10248	86.2	(85.0–87.4)
No	2721	1636	13.8	(12.6–15.0)
Smoking status				
Current	5501	2525	21.3	(20.0–22.5)
Former	7517	2930	24.7	(23.4–25.9)
Never	12 563	6424	54.1	(52.6–55.6)
Current employment status				
Employed	17 874	8754	73.5	(72.3–74.8)
Employed for wages	15 177	7676	64.5	(63.1–65.9)
Self-employed	2697	1078	9.1	(8.3–9.8)
Not Employed	7806	3148	26.5	(25.2–27.7)
Out of work more than 1 year	997	569	4.8	(4.1–5.5)
Out of work less than 1 year	1092	746	6.3	(5.4–7.2)
Unable to work	5717	1833	15.4	(14.6–16.2)
WRA status				
WRA	2773	1147	9.7	(8.9–10.4)
Possible WRA	10 560	4719	39.8	(38.3–41.2)
Non-WRA	12 256	6003	50.6	(49.1–52.1)
Total	25 680	11902		

<sup>a</sup>Unweighted sample size. The numbers may not add to total because of missing values.

<sup>b</sup>Weighted to the state population using the survey sample weights for each Asthma Call-back Survey participant.

<sup>c</sup>Results presented as weighted average annual estimate.

CI = confidence interval

WRA = Work-related asthma

(14.4%). These findings are consistent with research by Sullivan et al. that found that adults with current asthma were less likely to be employed than adults with no asthma [21]. Likewise, a review of data by Vandenplas et al. showed that 25–41% of individuals with occupational asthma were not working one to six years after occupational asthma diagnosis [5]. The high proportion of unemployment among individuals with occupational asthma may partially be explained by severity of the disease [22]. We have previously found that individuals with work-related asthma have more severe disease including decreased asthma control and more frequent asthma symptoms than adults with asthma that is not work related [11,17].

Table 3. Multivariable associations of work-related asthma with current employment status among ever-employed adults with current asthma – Asthma Call-back Survey, 2006–2009.

	WRA versus Non-WRA	Possible WRA versus Non-WRA
Current employment status	PR <sup>a</sup> (95% CI)	PR <sup>a</sup> (95% CI)
Employed	0.91 (0.86–0.95)	0.99 (0.96–1.02)
Employed for wages	0.89 (0.84–0.95)	0.98 (0.94–1.02)
Self-employed	1.02 (0.78–1.32)	1.07 (0.90–1.28)
Unemployed	1.30 (1.16–1.46)	1.04 (0.94–1.14)
Out of work more than 1 year	1.17 (0.75–1.82)	0.87 (0.64–1.18)
Out of work less than 1 year	1.08 (0.72–1.61)	1.10 (0.82–1.48)
Unable to work	1.44 (1.24–1.67)	1.08 (0.97–1.20)

<sup>a</sup>Prevalence ratio adjusted for age, sex, race/ethnicity, education and annual household income.

CI = Confidence interval

WRA = Work-related asthma

While our results are similar to Vandenplas et al.'s, there are some important differences. Vandenplas et al. examined individuals with occupational asthma from countries other than the United States [5]. In addition, the authors included individuals who had retired early or were on chronic sick leave [5]. Although in our data no information on early retirement or chronic sick leave was available, we were able to determine the age of retirees. We found that while there was no difference in the proportion of individuals with work-related asthma and non-work-related asthma who were retired, retired individuals with work-related asthma had a significantly younger mean age (67.0 years) than retired individuals with non-work-related asthma (71.2 years) ( $p < 0.001$ ), indicating that those with work-related asthma may retire at an earlier age (data not shown).

Control of work-related asthma relies heavily on control of the offending workplace exposure. The American College of Chest Physicians recommends that individuals with sensitizer-induced occupational asthma avoid further exposure to the causative agent [2]. A review by Rachiotis et al. found that complete symptomatic recovery occurred in one third of people with sensitizer-induced occupational asthma after cessation of exposure to the offending agent [23]. Exposure avoidance results in a higher likelihood of symptom improvement but also a higher likelihood of unemployment and loss of income [24]. The American College of Chest Physicians recommends that individuals with irritant-induced occupational asthma or work-exacerbated asthma reduce exposure to the offending agent [2,25]. If this is not successful, individuals should change to a workplace with fewer triggers [2]. Lemiere and colleagues found that individuals with work-exacerbated asthma who remained exposed at work did not have significantly different forced expiratory volume per one second than the group of individuals with work-exacerbated asthma who left the workplace [26].

Removal from the job as part of asthma management brings significant social and economic costs [5,13]. Some individuals may choose to remain exposed to the agent at work rather than experience loss of income associated with job change/loss [10]. Factors associated with individuals staying in their jobs include higher education and income, longer tenure with the company, having children to support

Table 4. Reason for unemployment among unemployed populations ( $N = 7806$ ) with current asthma who have ever been employed – Asthma Call-back Survey, 2006–2009.

Reason for unemployment	Total % (95% CI)	WRA % (95% CI)	Possible WRA % (95% CI)	Non-WRA % (95% CI)	WRA versus Non-WRA PR <sup>a</sup> (95% CI)	Possible WRA versus Non-WRA PR <sup>a</sup> (95% CI)
Disabled	47.9 (45.1–50.6)	54.0 (47.5–60.5)	48.9 (44.5–53.4)	44.4 (40.2–48.5)	1.09 (0.94–1.26)	0.99 (0.88–1.11)
Unable to work for other health reasons	16.1 (14.2–18.0)	20.6 (14.7–26.5)	16.5 (13.7–19.3)	14.0 (11.1–16.8)	1.46 (1.01–2.12)	1.18 (0.92–1.52)
Looking for work	9.2 (6.9–11.5)	4.8 (2.4–7.2)	10.2 (5.7–14.7)	9.8 (6.9–12.6)	NR	1.32 (0.84–2.07)
Laid off	7.5 (6.1–8.9)	7.7 (3.9–11.4)	7.1 (5.1–9.0)	7.9 (5.6–12.6)	0.95 (0.53–1.69)	0.96 (0.65–1.42)
Other <sup>b</sup>	19.4 (17.0–21.8)	12.9 (9.5–16.3)	17.3 (14.1–20.5)	24.0 (19.7–28.4)	0.59 (0.43–0.81)	0.82 (0.64–1.05)

<sup>a</sup>Prevalence ratio adjusted for age, sex, race/ethnicity, education and annual household income.<sup>b</sup>Includes keeping house, going to school, retired and other.

CI = Confidence interval

NR = Not reportable because relative standard error  $\geq 30\%$ 

WRA = Work-related asthma

Table 5. Multivariable associations of being unable to work with select asthma-related characteristics by work-related asthma status – Asthma Call-back Survey, 2006–2009.

Select asthma-related characteristics	Total PR <sup>a</sup> (95% CI)	WRA only PR <sup>a</sup> (95% CI)	Possible WRA PR <sup>a</sup> (95% CI)	Non-WRA only PR <sup>a</sup> (95% CI)
Time since last asthma symptom				
1 day or more ago	0.83 (0.78–0.89)	0.85 (0.70–1.02)	0.89 (0.80–0.99)	0.78 (0.70–0.87)
Less than 1 day ago	1.46 (1.29–1.64)	1.31 (0.99–1.73)	1.22 (1.04–1.44)	1.84 (1.51–2.23)
Days with asthma symptoms in past 30 days				
0–14 days	0.78 (0.73–0.84)	0.89 (0.65–0.96)	0.84 (0.75–0.93)	0.73 (0.65–0.82)
15–30 days	1.63 (1.45–1.84)	1.49 (1.11–2.00)	1.35 (1.15–1.59)	2.05 (1.70–2.48)
Asthma symptoms all the time				
No	0.91 (0.88–0.94)	0.91 (0.84–0.98)	0.92 (0.88–0.97)	0.88 (0.83–0.94)
Yes	2.34 (1.84–2.98)	1.94 (1.17–3.20)	1.71 (1.26–2.32)	3.81 (2.44–5.95)
Days with trouble sleeping because of asthma in past 30 days				
0–14 days	0.87 (0.84–0.91)	0.82 (0.71–0.94)	0.89 (0.84–0.93)	0.88 (0.83–0.92)
15–30 days	2.95 (2.33–3.74)	2.47 (1.36–4.48)	2.28 (1.68–3.09)	4.12 (2.85–5.96)
Days symptom-free in past 2 weeks				
8–14 days	0.70 (0.63–0.77)	0.66 (0.50–0.87)	0.76 (0.65–0.89)	0.67 (0.58–0.78)
0–7 days	1.53 (1.39–1.69)	1.45 (1.17–1.80)	1.31 (1.15–1.50)	1.79 (1.53–2.09)
Asthma control				
Well controlled	0.62 (0.55–0.71)	0.40 (0.27–0.58)	0.73 (0.61–0.88)	0.61 (0.51–0.74)
Not-well-controlled	1.06 (0.90–1.24)	1.34 (0.96–1.89)	0.90 (0.70–1.16)	1.13 (0.90–1.42)
Very poorly controlled	2.00 (1.73–2.31)	1.70 (1.25–2.30)	1.65 (1.38–1.98)	2.47 (1.86–3.28)
Asthma attack in past 12 months				
No	0.63 (0.55–0.72)	0.54 (0.36–0.81)	0.68 (0.56–0.84)	0.63 (0.52–0.77)
Yes	1.35 (1.26–1.44)	1.29 (1.12–1.48)	1.22 (1.11–1.34)	1.46 (1.29–1.65)
Urgent treatment in past 12 months				
No	0.84 (0.79–0.90)	0.72 (0.58–0.89)	0.86 (0.79–0.95)	0.88 (0.81–0.96)
Yes	1.55 (1.35–1.78)	1.61 (1.23–2.09)	1.40 (1.16–1.69)	1.55 (1.23–1.96)
Emergency room visit in past 12 months				
No	0.91 (0.88–0.95)	0.85 (0.74–0.96)	0.93 (0.87–0.98)	0.92 (0.87–0.97)
Yes	1.83 (1.46–2.28)	1.83 (1.20–2.79)	1.52 (1.13–2.04)	2.16 (1.48–3.16)
Overnight stay in hospital in past 12 months				
No	0.94 (0.92–0.96)	0.83 (0.71–0.95)	0.96 (0.93–0.98)	0.96 (0.93–0.98)
Yes	5.01 (3.19–7.88)	NR	3.08 (1.75–5.44)	NR

<sup>a</sup>Prevalence ratio adjusted for age, sex, race/ethnicity, education and annual household income.

CI = Confidence interval

NR = Not reportable because relative standard error  $>30\%$ 

WRA = Work-related asthma

and older age [27]. Our results are consistent with findings from Moscato et al. who found that those who ceased exposure had more severe disease [27]. We found that those who were unable to work were more likely to have more frequent asthma symptoms, very poorly controlled asthma and increased health care utilization than their counterparts. However, other studies have not found that individuals with more severe asthma are more likely to be unemployed after diagnosis [10,28].

The findings of this report are subject to some limitations. First, information on asthma is self-reported and thus estimates might be subject to misclassification bias. Moreover, due to the cross-sectional nature of the survey, causality cannot be determined. However, because all individuals in this study were employed at some point and employment was assessed at time of the interview, it is likely that unemployment occurred after work-related asthma diagnosis. Furthermore, due to survey design, we cannot assess

whether the respondents' current unemployment is due to their asthma, work-related asthma or some other medical, social or economic factor. Also, it is possible that individuals with work-related asthma retired early or started school after removal from their job and these individuals were not captured in our study. Additionally, BRFSS only queried individuals with telephone access. People with lower income [29] or who are unemployed may not have telephone access and would not be interviewed. Finally, estimates are limited to the 38 states and DC that conducted the ACBS in 2006–2009 and do not represent non-participating states or the entire U.S. population.

## Conclusions

To our knowledge, this is the first population-based study examining the impact of work-related asthma on employment. Our results suggest that individuals diagnosed with work-related asthma have negative employment outcomes such as being unable to work. Additional studies are needed to determine what health reasons prevent individuals with work-related asthma from working and if the health reasons are asthma-related.

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## Declaration of interest

The authors report no conflicts of interest. The authors alone are responsible for the content and writing of this article.

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