

WORK-RELATED ASTHMA

Asthma Symptoms among Adults with Work-Related Asthma

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Objective. To examine the number of days with asthma symptoms among individuals with work-related asthma (WRA) and non-WRA. **Methods.** We calculated adjusted prevalence ratios and compared mean number of days with asthma symptoms using 2006–2009 Behavioral Risk Factor Surveillance System Asthma Call-back Survey data for ever-employed adults with current asthma from 38 states and District of Columbia. **Results.** Compared with persons with non-WRA, those with WRA had higher mean number of days with asthma symptoms. Regardless of WRA status, individuals with higher number of days with asthma symptoms were more likely to be unable to work or carry out their usual activities due to asthma. Associations between frequency of asthma symptoms and activity limitation due to asthma were weaker among currently employed adults and stronger among adults not currently employed than the observed associations for all ever-employed adults. **Conclusions.** These results suggest higher frequency of asthma symptoms among adults with WRA and underscore the need for optimal asthma management in individuals with WRA.

Keywords asthma, Behavioral Risk Factor Surveillance System, respiratory signs and symptoms, occupational health

INTRODUCTION

Asthma is a chronic inflammatory disease of the airways. It is estimated that current asthma affects over 17.5 million adults in the United States (1,2). Work-related asthma (WRA), a discrete subset of asthma, is a preventable condition that is associated with the workplace environment and includes de novo asthma that is caused by workplace exposures (occupational asthma) and preexisting asthma that is made worse by workplace exposures (work-exacerbated asthma) (3). An estimated 16.9% of adult-onset asthma is attributable to workplace exposures (4). WRA has a negative burden on the worker including adverse socioeconomic impacts, difficulty in sustaining work, frequent health care use, and death (3,5–7). In addition, based on National Asthma Education and Prevention Program guidelines (8), individuals with WRA are more likely to have very poorly controlled asthma when compared with individuals who have non-WRA (9). However, there is limited information on the occurrence, frequency, and severity of symptoms among adults with WRA as compared to individuals with non-WRA.

According to the 2008 American College of Chest Physicians Consensus Statement on the diagnosis and management of WRA, respiratory symptoms of asthma are identical in individuals with and without WRA (3). However, temporal patterns in asthma symptoms may be different in these two groups. Individuals with WRA frequently have asthma symptoms that worsen at or after work, improve on days away from work, or worsen toward

the end of the work week. Temporal patterns of WRA symptoms are sometimes complex and difficult to interpret (10) and the sharing of many clinical and pathological features between asthma with and without relation to work often makes it difficult to determine the work-relatedness of asthma (3,10). Nonetheless, there is limited evidence that individuals with WRA have increased likelihood for asthma attacks, increased number of sick days, and increased asthma-related health care utilization when compared with those who have non-WRA (9,11–13).

To our knowledge, there is limited population-based information on whether the frequencies of asthma symptoms and their impact on activity limitation differ in individuals with WRA and non-WRA. To address this gap, we examined associations between WRA and number of days with asthma symptoms using the 2006–2009 Behavioral Risk Factor Surveillance System (BRFSS) Asthma Call-back Survey data for ever-employed adults with current asthma collected in 38 states and the District of Columbia (DC). To determine the impact the occurrence and frequency of asthma symptoms had on the life of the respondent, we examined the association of the occurrence and frequency of asthma symptoms with activity limitation due to asthma and differences in these associations by employment status.

METHODS

Data Source

BRFSS is an ongoing, state-based, random-digit-dialed telephone survey of the non-institutionalized US civilian population aged ≥ 18 years (14). The Asthma Call-back Survey is administered within 2 weeks of the BRFSS telephone interview to a subset of respondents who have been ever diagnosed with asthma and collects additional asthma-related information. Data from the 2006–2009 Asthma Call-back

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Survey for the 38 states and DC, which provided comparable data at the time of this analysis, were used (15). The 2006–2009 median response rates among the 38 states and DC examined in this report ranged from 47.5% in 2007 to 51.4% in 2009 for BRFSS and from 47.2% in 2009 to 54.3% in 2007 for Asthma Call-back Survey (14,15).

The BRFSS has surveillance exemption from Institutional Review Board review at the Centers for Disease Control and Prevention (CDC). Participating states are subject to state-specific Institutional Review Board requirements. Reports of selected statistical indicators of BRFSS data quality (outcome measures, selection biases, and missing values) are available at http://www.cdc.gov/brfss/technical_infodata/quality.htm.

Study Population and Definitions

For this analysis, the study population included adults with current asthma; those who answered “yes” to both questions: “Have you ever been told by a doctor, nurse, or other health professional that you had asthma?” and “Do you still have asthma?” Because the diagnosis of WRA requires an association of asthma symptoms with work (3), we restricted the study population to ever-employed adults, that is, respondents who described their current employment status as “employed full-time” or “employed part-time” or answered “yes” to the question “Have you ever been employed outside the home?” Respondents were considered currently employed if they described their current employment status as “employed full-time” or “employed part-time” and not currently employed if they described their current employment status as “not employed” Adults not currently employed could include students, homemakers, or retired individuals.

We defined health professional-diagnosed WRA based on a “yes” response 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?” Among respondents who did not have health professional-diagnosed WRA (i.e., responded “no” or “do not know”), we defined possible WRA based on a “yes” response to any of the following four questions: (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?” We defined non-WRA based on a “no” response to all the five questions on asthma work-relatedness.

Respondents were asked a series of questions about the occurrence and frequency of their asthma symptoms: (1) “How long has it been since you last had any symptoms of asthma?” (2) “During the past 30 days, on how many days did you have any symptoms of asthma?” (3) among adults with daily symptoms, “Do you have symptoms all the time? “All the time” means symptoms that continue throughout the day. It does not mean symptoms for a little while each day.” (4) “During the past 30 days, on how

many days did symptoms of asthma make it difficult for you to stay asleep?” (5) “During the past 2 weeks, on how many days were you completely symptom-free, that is, no coughing, wheezing, or other symptoms of asthma?” (6) “During the past 3 months, how many asthma episodes or attacks have you had?” (7) “Compared with other episodes or attacks, was this most recent attack shorter, longer, or about the same?” and (8) “During the past 12 months, how many days were you unable to work or carry out your usual activities because of your asthma?” To examine whether WRA was associated with asthma symptom occurrence, we categorized responses to the question on time since last asthma symptom as non-exclusive categories: less than 1 day ago, less than 1 week ago, less than 3 months ago, less than 1 year ago, less than 3 years ago, and less than 5 years ago; responses to the question on days with asthma symptoms and days with trouble sleeping in the past 30 days were categorized as: 0 days, 1–14 days, and 15–30 days; responses to the question on symptom-free days in the past 2 weeks were categorized as 0 days, 1–7 days, and 8–14 days; responses to the question on activity limitation between 1 and 365 days were categorized as at least 1 day and responses of zero were coded as no days.

We examined frequency of adverse asthma outcomes including asthma-related urgent care visits, asthma-related emergency room visits, and asthma-related overnight hospital stays using previously developed definitions (9). In addition, we examined the frequency that individuals had routine checkups for their asthma in the past 12 months using answers to the question “During the past 12 months, how many times did you see a doctor or other health professional for a routine checkup for your asthma?”

Statistical Analysis

We used SAS[®] software version 9.2 (SAS Institute Inc., Cary, NC, USA) survey procedures and SUDAAN[®] Release 10.0.1 software (Research Triangle Institute, Research Triangle Park, NC, USA) to account for the complex survey design. Data were weighted to account for non-response differences in the sample and the unequal probability of sample selection in order to produce representative estimates. For states/areas participating in the Asthma Call-back Survey during multiple years, weights were established by multiplying the proportion of subjects in each survey year by the corresponding weight for that survey year (information on states participating in the Survey by year can be found at <http://www.cdc.gov/brfss/acbs/2008/2008.htm>). For states/areas participating in the Asthma Call-back Survey during 1 year only, unaltered weights were used.

We estimated the mean (and standard error of the mean) number of days with asthma symptoms, days with activity limitation, routine checkups for asthma, urgent treatment visits for worsening asthma, asthma-related emergency room visits, and asthma-related hospitalizations for individuals with health professional-diagnosed WRA, possible WRA, and non-WRA. We compared means using the *t*-test. Results were considered statistically significant at alpha level of <0.05.

We estimated prevalence ratios (PRs) using separate multivariate logistic regression models (1) to determine associations between WRA and the occurrence and frequency of asthma symptoms and (2) to assess the burden of asthma symptoms on individuals' lives by examining associations between occurrence and frequency of asthma symptoms and activity limitation due to asthma stratified by WRA and employment status. Because age (continuous), race/ethnicity (four categories: non-Hispanic white, non-Hispanic black, non-Hispanic other, and Hispanic), education (two categories: high school or less, more than a high school), and annual household income (three categories: <\$15,000; \$15,000–\$49,999; ≥ \$50,000) were all significantly associated with WRA and asthma symptoms, these independent variables were simultaneously included in the multivariate logistic regression models. Sex (two categories: male and female) and health insurance status (two categories: yes and no) were also included in the models regardless of statistical associations with the independent and dependent variables because findings from previous research have shown associations with WRA (16,17). Because of potential misclassification of WRA status, analyses were repeated using the possible WRA definition (18).

RESULTS

Overall, 38,306 (representing an estimated 16 million) of the 56,097 adults participating in the Asthma Call-back

Survey in 38 states and DC during 2006–2009 were ever-employed adults with current asthma. Detailed descriptions of the study population and differences in WRA by demographic characteristics have been published previously (19). Briefly, 50.1% of the study population was 18–44 years old, 62.8% was female, 76.1% was non-Hispanic white, 65.8% had ≤ a high school education, 46.8% had an annual household income ≥ \$50,000, 87.5% had health insurance, and 57.6% were currently employed (19).

An estimated 9.0% of ever-employed adults with current asthma had health professional-diagnosed WRA and 37.4% had possible WRA. Health professional-diagnosed WRA was associated with middle age (45–64 years), non-Hispanic black race/ethnicity, lower annual household income, and unemployment (19). Possible WRA was associated with middle age (45–64 years), non-Hispanic other race/ethnicity, ≤ high school education, lower annual household income, and current employment (19).

Persons with health professional-diagnosed WRA had significantly higher mean number of days with asthma symptoms, trouble sleeping because of asthma, and activity limitation due to asthma; higher mean number of asthma attacks, routine checkups for asthma, urgent treatment visits for worsening asthma, asthma-related emergency room visits, and asthma-related hospitalizations than adults with non-WRA (Table 1). When compared with persons who have non-WRA, those with health professional-diagnosed WRA were more likely to recently

TABLE 1.—Mean number of days with asthma symptoms, asthma episodes/attacks, and health care use by WRA status.

	Ever-employed adults with current asthma (N = 38,306)	WRA ^a (N = 3808)	Possible WRA ^b (N = 14,812)	Non-WRA ^c (N = 19,563)
Measure	Mean (SE)	Mean (SE)	Mean (SE)	Mean (SE)
Days with asthma symptoms in the past 30 days	9.6 (0.14)	11.2 (0.39)	11.1 (0.24)	8.4 (0.18)
Days with trouble sleeping because of asthma in the past 30 days	3.2 (0.08)	5.5 (0.29)	4.1 (0.16)	2.2 (0.10)
Days symptom-free in the past 2 weeks	8.4 (0.07)	7.3 (0.20)	7.6 (0.13)	9.2 (0.10)
Number of asthma episodes/attacks in the past 3 months	3.2 (0.11)	4.7 (0.32)	4.2 (0.22)	2.3 (0.14)
Days with activity limitation due to asthma ^d	12.2 (0.67)	24.7 (2.74)	15.9 (1.50)	7.6 (0.51)
Routine checkup for asthma ^d	1.8 (0.06)	2.6 (0.15)	2.0 (0.10)	1.5 (0.08)
Urgent treatment visits for worsening asthma ^d	0.8 (0.05)	1.3 (0.10)	0.9 (0.08)	0.6 (0.07)
Asthma-related emergency room visits ^d	0.3 (0.03)	0.5 (0.06)	0.4 (0.05)	0.2 (0.04)
Asthma-related overnight hospitalizations ^d	0.1 (0.01)	0.1 (0.02)	0.1 (0.01)	0.0 (0.01)

Note: SE, standard error; WRA, work-related asthma.

^a “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?”

^b “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: (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?”

^c “No” to all of the following five questions: (1) “Were you ever told by a doctor or other health professional that your asthma was related to any job you ever had?” (2) “Was your asthma caused by chemicals, smoke, fumes, or dust in your current job?” (3) “Was your asthma caused by chemicals, smoke, fumes, or dust in any previous job you ever had?” (4) “Is your asthma made worse by chemicals, smoke, fumes, or dust in your current job?” and (5) “Was your asthma made worse by chemicals, smoke, fumes, or dust in any previous job you ever had?”

^d In the past 12 months.

All differences between WRA and non-WRA and between possible WRA and non-WRA are significant (p -value < .001).

TABLE 2.—Asthma symptoms among ever-employed adults with current asthma by WRA status.

Measure	Ever-employed adults with current asthma			WRA ^a	Possible WRA ^b	Non-WRA ^c	WRA versus non-WRA	Possible WRA versus non-WRA
	N	Weighted N (thousands)	% ^d (95% CI)	% ^d (95% CI)	% ^d (95% CI)	% ^d (95% CI)	PR ^e (95% CI)	PR ^e (95% CI)
Time since last asthma symptom								
Less than 1 day	13,929	4988	31.2 (30.1–32.3)	39.1 (35.8–42.4)	36.6 (34.7–38.5)	26.0 (24.6–27.4)	1.37 (1.23–1.52)	1.30 (1.21–1.40)
Less than 1 week	19,816	7609	47.6 (46.3–48.8)	55.0 (51.4–58.5)	53.6 (51.5–55.6)	42.1 (40.3–43.8)	1.21 (1.12–1.31)	1.20 (1.14–1.27)
Less than 3 months	28,824	11,989	75.0 (73.8–76.1)	80.4 (77.4–83.3)	80.0 (78.4–81.7)	70.5 (68.8–72.1)	1.13 (1.08–1.18)	1.13 (1.09–1.16)
Less than 1 year	33,677	14,291	89.3 (88.6–90.1)	91.6 (89.5–93.7)	92.7 (91.6–93.8)	86.6 (85.4–87.7)	1.06 (1.03–1.10)	1.08 (1.06–1.10)
Less than 3 years	35,965	15,312	95.7 (95.2–96.2)	97.6 (96.9–98.4)	96.8 (95.9–97.8)	94.6 (94.0–95.3)	1.04 (1.02–1.05)	1.03 (1.01–1.04)
Less than 5 years	36,684	15,605	97.6 (97.1–98.0)	98.7 (98.2–99.3)	98.0 (97.1–98.8)	97.1 (96.6–97.6)	1.02 (1.01–1.03)	1.01 (1.00–1.02)
Days with asthma symptoms ^f								
15–30 days	13,742	4935	30.9 (29.8–32.0)	36.1 (32.9–39.2)	35.4 (33.5–37.3)	26.9 (25.5–28.4)	1.18 (1.05–1.31)	1.20 (1.11–1.29)
1–14 days	12,459	4864	36.8 (35.5–38.0)	37.2 (33.7–40.7)	38.7 (36.7–40.8)	35.3 (33.5–37.1)	1.14 (1.02–1.27)	1.15 (1.07–1.27)
0 days	11,305	5153	32.3 (31.1–33.5)	26.8 (23.4–30.1)	25.9 (24.1–27.7)	37.8 (36.0–39.5)	0.74 (0.65–0.85)	0.71 (0.66–0.77)
Asthma symptoms all the time								
Yes	4770	1590	9.9 (9.3–10.5)	14.0 (11.9–16.2)	12.3 (11.1–13.4)	7.5 (6.8–8.2)	1.51 (1.26–1.82)	1.45 (1.26–1.67)
No	33,170	14,493	90.1 (89.5–90.7)	86.0 (83.8–88.1)	87.7 (86.6–88.9)	92.5 (91.8–93.2)	0.96 (0.93–0.98)	0.96 (0.95–0.98)
Days with trouble sleeping because of asthma ^f								
15–30 days	4022	1457	9.2 (8.5–9.8)	17.6 (15.0–20.1)	11.6 (10.4–12.7)	6.2 (5.4–6.9)	2.16 (1.77–2.64)	1.53 (1.30–1.80)
1–14 days	7451	3340	21.1 (20.1–22.1)	27.7 (24.6–30.9)	25.8 (24.0–27.5)	16.7 (15.4–18.0)	1.60 (1.38–1.85)	1.48 (1.33–1.65)
0 days	25,602	11,049	69.7 (68.6–70.8)	54.7 (51.2–58.2)	62.8 (60.7–64.6)	77.1 (75.7–78.6)	0.76 (0.71–0.82)	0.84 (0.81–0.87)
Days symptom-free ^g								
0 days	10,503	3557	22.3 (21.3–23.3)	27.8 (24.9–30.7)	26.4 (24.7–28.2)	18.5 (17.2–19.7)	1.31 (1.15–1.48)	1.30 (1.19–1.43)
1–7 days	7292	3118	19.6 (18.6–20.5)	21.9 (19.1–24.8)	22.1 (20.5–23.6)	17.4 (16.1–18.7)	1.19 (1.02–1.39)	1.19 (1.06–1.32)
8–14 days	19,708	9261	58.1 (56.9–59.3)	50.3 (46.8–53.8)	51.5 (49.5–53.5)	64.1 (62.5–65.8)	0.85 (0.79–0.92)	0.85 (0.82–0.89)
Asthma attack in the past 3 months								
Yes	14,775	6338	40.1 (38.9–41.3)	54.3 (50.7–57.8)	46.9 (44.9–49.0)	32.9 (31.3–34.5)	1.60 (1.47–1.74)	1.38 (1.29–1.47)
No	22,321	9483	59.9 (58.7–61.1)	45.7 (42.2–49.3)	53.1 (51.0–55.1)	67.1 (65.5–68.7)	0.69 (0.64–0.76)	0.81 (0.77–0.85)
How was most recent attack compared to others								
No attack in the past year	18,709	7907	49.0 (47.8–50.3)	35.2 (31.8–38.5)	42.3 (40.3–44.3)	56.0 (54.3–57.8)	0.63 (0.57–0.70)	0.77 (0.72–0.81)
Shorter	4491	1953	12.1 (11.4–12.9)	15.2 (12.7–17.8)	13.8 (12.6–15.0)	10.4 (9.3–11.4)	1.44 (1.17–1.78)	1.34 (1.16–1.54)
Longer	2918	1198	7.4 (6.8–8.0)	12.2 (9.7–14.7)	9.1 (8.1–10.2)	5.5 (4.8–6.1)	2.06 (1.59–2.66)	1.53 (1.28–1.84)
About the same	11,892	5048	31.3 (30.1–32.5)	37.3 (34.0–40.6)	34.6 (32.7–36.6)	27.9 (26.3–29.6)	1.34 (1.20–1.50)	1.22 (1.13–1.33)
Most recent attack was first attack	74	26	0.2 (0.1–0.2)	NR	NR	0.2 (0.1–0.3)	NR	NR
Activity limitation due to asthma ^h								
At least 1 day	11,862	5108	32.7 (31.6–33.9)	53.2 (49.7–56.6)	40.3 (38.3–42.4)	24.2 (22.7–25.7)	2.03 (1.85–2.22)	1.55 (1.43–1.68)
No days	24,668	10,491	67.3 (66.1–68.4)	46.8 (43.4–50.3)	59.7 (57.6–61.7)	75.8 (74.3–77.3)	0.65 (0.61–0.70)	0.81 (0.78–0.85)

Notes: CI, confidence interval; NR, not reportable, relative standard error >30%; PR, Prevalence ratio; WRA, work-related asthma.

^a “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?”

^b “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: (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?”

^c “No” to all of the following five questions: (1) “Were you ever told by a doctor or other health professional that your asthma was related to any job you ever had?” (2) “Was your asthma caused by chemicals, smoke, fumes, or dust in your current job?” (3) “Was your asthma caused by chemicals, smoke, fumes, or dust in any previous job you ever had?” (4) “Is your asthma made worse by chemicals, smoke, fumes, or dust in your current job?” and (5) “Was your asthma made worse by chemicals, smoke, fumes, or dust in any previous job you ever had?”

^d Results presented as weighted average annual estimate.

^e Prevalence ratio adjusted for age, sex, race/ethnicity, education, income, and insurance. For each model, the dependent variable was the measure of the occurrence or frequency of asthma symptoms and the independent variable was WRA/possible WRA. The prevalence ratio shows that individuals with WRA/possible WRA were more/less likely to have the measure of the occurrence or frequency of asthma symptoms than those with non-WRA (referent group).

^f In the past 30 days.

^g In the past 2 weeks.

^h In the past 12 months.

have asthma symptoms, have 15–30 days with asthma symptoms in the past 30 days, have asthma symptoms all the time, have 15–30 days with trouble sleeping in the past 30 days, have fewer symptom-free days, have an asthma attack in the past 3 months, have an asthma attack that lasted longer than previous attacks, and have at least 1 day with activity limitation due to asthma in the past year

(Table 2). Individuals with possible WRA had similar, albeit weaker, associations with asthma symptoms than individuals with health professional-diagnosed WRA (Tables 1 and 2).

Among all ever-employed adults with current asthma, those with higher number of days with asthma symptoms were more likely to be unable to work or carry out their

TABLE 3.—Multivariate association of activity limitation due to asthma^a with asthma symptoms among ever-employed adults.

Measure	All ever-employed adults with current asthma	Subgroup		
		WRA ^b only	Possible WRA ^c only	Non-WRA ^d only
	PR ^e (95% CI)	PR ^e (95% CI)	PR ^e (95% CI)	PR ^e (95% CI)
Time since last asthma symptom				
Less than 1 day ago	1.39 (1.30–1.49)	1.25 (1.11–1.42)	1.33 (1.21–1.46)	1.37 (1.22–1.55)
1 day or more ago	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)
Days with asthma symptoms in the past 30 days				
15–30 days	1.43 (1.33–1.53)	1.24 (1.10–1.41)	1.33 (1.21–1.47)	1.56 (1.38–1.77)
0–14 days	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)
Asthma symptoms all the time				
Yes	1.58 (1.47–1.73)	1.29 (1.14–1.47)	1.41 (1.25–1.59)	1.85 (1.61–2.12)
No	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)
Days with trouble sleeping because of asthma in the past 30 days				
15–30 days	1.89 (1.74–2.06)	1.46 (1.28–1.66)	1.64 (1.46–1.83)	2.18 (1.86–2.56)
0–14 days	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)
Days symptom-free in the past 2 weeks				
0–7 days	1.58 (1.47–1.71)	1.40 (1.22–1.61)	1.46 (1.32–1.63)	1.64 (1.44–1.86)
8–14 days	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)
Asthma attack in the past 3 months				
Yes	2.24 (2.07–2.43)	1.71 (1.46–2.00)	1.97 (1.73–2.23)	2.40 (2.18–2.72)
No	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)

Notes: CI, confidence interval; PR, prevalence ratio; WRA, work-related asthma.

^a Answered 1 day or more to the question “During the past 12 months, how many days were you unable to work or carry out your usual activities because of your asthma?”

^b “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?”

^c “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: (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?”

^d “No” to all of the following five questions: (1) “Were you ever told by a doctor or other health professional that your asthma was related to any job you ever had?” (2) “Was your asthma caused by chemicals, smoke, fumes, or dust in your current job?” (3) “Was your asthma caused by chemicals, smoke, fumes, or dust in any previous job you ever had?” (4) “Is your asthma made worse by chemicals, smoke, fumes, or dust in your current job?” and (5) “Was your asthma made worse by chemicals, smoke, fumes, or dust in any previous job you ever had?”

^e Prevalence ratio adjusted for age, sex, race/ethnicity, education, income, and insurance. For each of the 24 models, the dependent variable was the inability to work or carry out usual activities and the independent variable was the specific measure of the occurrence or frequency of asthma symptoms. The prevalence ratios show that individuals with the higher frequency of asthma symptoms/asthma attack were more likely to be unable to work or carry out their usual activities due to their asthma at least 1 day in the past year than those with lower frequency of asthma symptoms/no asthma attack (referent group).

usual activities due to their asthma at least 1 day in the past year than those with lower number of asthma symptoms and those with fewer symptom-free days were more likely to be unable to work or carry out their usual activities due to their asthma at least 1 day in the past year than those with more symptom-free days. The associations remained across all WRA strata and the stratum-specific adjusted PRs were similar between strata with overlapping 95% confidence intervals (CIs) for asthma symptoms less than 1 day ago, 15–30 days with asthma symptoms in the past 30 days and 0–7 days symptom-free. The associations between activity limitation due to asthma and having asthma symptoms all the time, 15–30 days with trouble sleeping due to asthma symptoms in the past 30 days, and an asthma attack in the past 3 months were higher among individuals with non-WRA than among individuals with WRA (Table 3).

In general, the associations of activity limitation due to asthma with asthma symptoms were weaker among currently employed adults with current asthma (Table 4) and stronger among adults not currently employed with current asthma (Table 5) than the observed associations for all ever-employed adults (Table 3). Among currently employed adults with current asthma, the stratum-specific adjusted PRs were similar between strata with overlapping 95% CIs (Table 4). Among adults not currently employed

with current asthma, associations between activity limitation due to asthma and having 15–30 days with asthma symptoms in the past 30 days, asthma symptoms all the time, 15–30 days with trouble sleeping due to asthma symptoms in the past 30 days, and an asthma attack in the past 3 months were greater among individuals with non-WRA than among individuals with WRA or possible WRA (Table 5).

DISCUSSION

In this population-based, cross-sectional study of ever-employed adults with current asthma, we found that 39% of individuals with health professional-diagnosed WRA had asthma symptoms less than 1 day prior to being interviewed. In general, adults with health professional-diagnosed WRA experienced more frequent asthma symptoms than individuals with non-WRA. This article provides more information on symptom occurrence, frequency, and severity among individuals with WRA than did previous studies on asthma control among adults with WRA (9).

We also found that individuals with asthma symptoms were more likely to be unable to work or carry out their usual activities because of their asthma. When stratified

TABLE 4.—Multivariate association of activity limitation due to asthma^a with asthma symptoms among currently employed adults.

Measure	All ever-employed adults with current asthma PR ^c (95% CI)	Subgroup		
		WRA ^b only PR ^c (95% CI)	Possible WRA ^c only PR ^c (95% CI)	Non-WRA ^d only PR ^c (95% CI)
Time since last asthma symptom				
Less than 1 day ago	1.36 (1.22–1.51)	1.14 (0.92–1.40)	1.41 (1.22–1.62)	1.20 (0.99–1.45)
1 day or more ago	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)
Days with asthma symptoms in the past 30 days				
15–30 days	1.33 (1.19–1.49)	1.22 (0.99–1.51)	1.33 (1.15–1.53)	1.27 (1.04–1.56)
0–14 days	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)
Asthma symptoms all the time				
Yes	1.50 (1.28–1.77)	1.09 (0.83–1.44)	1.39 (1.12–1.72)	1.68 (1.25–2.25)
No	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)
Days with trouble sleeping because of asthma in the past 30 days				
15–30 days	1.67 (1.40–2.00)	1.33 (1.02–1.75)	1.47 (1.19–1.80)	1.86 (1.30–2.68)
0–14 days	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)
Days symptom-free in the past 2 weeks				
0–7 days	1.46 (1.31–1.64)	1.34 (1.08–1.67)	1.39 (1.20–1.62)	1.43 (1.18–1.73)
8–14 days	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)
Asthma attack in the past 3 months				
Yes	2.09 (1.85–2.36)	1.89 (1.47–2.42)	1.91 (1.58–2.30)	2.08 (1.74–2.50)
No	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)

Notes: CI, confidence interval; PR, prevalence ratio; WRA, work-related asthma.

^a Answered 1 day or more to the question “During the past 12 months, how many days were you unable to work or carry out your usual activities because of your asthma?”

^b “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?”

^c “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: (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?”

^d “No” to all of the following five questions: (1) “Were you ever told by a doctor or other health professional that your asthma was related to any job you ever had?” (2) “Was your asthma caused by chemicals, smoke, fumes, or dust in your current job?” (3) “Was your asthma caused by chemicals, smoke, fumes, or dust in any previous job you ever had?” (4) “Is your asthma made worse by chemicals, smoke, fumes, or dust in your current job?” and (5) “Was your asthma made worse by chemicals, smoke, fumes, or dust in any previous job you ever had?”

^e Prevalence ratio adjusted for age, sex, race/ethnicity, education, income, and insurance. In each of the 24 models, the dependent variable was the inability to work or carry out usual activities and the independent variable was the specific measure of the occurrence or frequency of asthma symptoms. The prevalence ratios show that individuals with the higher frequency of asthma symptoms/asthma attack were more likely to be unable to work or carry out their usual activities due to their asthma at least 1 day in the past year than those with lower frequency of asthma symptoms/no asthma attack (referent group).

by WRA status, the associations between asthma symptoms and activity limitation were stronger among individuals with non-WRA. Hypothesizing that these findings were the result of healthy worker effect, we then repeated analyses among individuals who were currently employed and among those who were not currently employed. We found that associations between asthma symptoms and activity limitation were stronger for those who were not currently employed than for those who were currently employed. These findings might be attributed to healthy worker effect where individuals with more severe asthma symptoms leave the workforce because of their symptoms (20). Future research should longitudinally examine the impact of WRA diagnosis and management on employment.

These results are consistent with previous studies (13,14,21,22). Lemiere et al. have shown that WRA is associated with increased likelihood of having asthma symptoms daily, having activity limitation, and being awakened at night due to asthma symptoms (11). In a study of adult health maintenance organization (HMO) members, Henneberger et al. found that individuals with work-exacerbated asthma had asthma symptoms more frequently than those with non-WRA (22).

Increased frequency of asthma symptoms can result in poor clinical outcomes such as higher rates of missed work

days, increased health care utilization, poorer self-rated health, and decreased quality of life (23,24). Appropriate asthma management can reduce the burden of disease for individuals suffering from frequent asthma symptoms through education, ongoing monitoring, use of appropriate medications, and control or elimination of environmental/occupational triggers (8,23).

The diagnosis of occupational asthma, a subset of WRA, offers the opportunity for primary prevention (preventing new asthma development) and secondary prevention (preventing the progression of subclinical physiological or immunological indicators to disease) in other workers (3). Among individuals with occupational asthma, continued workplace exposure is associated with worsening asthma symptoms and it is recommended that adults with occupational asthma be removed from the contributing exposure (tertiary prevention) (3,10,25–28). Moreover, among individuals with increasingly severe occupational asthma, symptoms may persist after removal from the offending exposure (10,25).

The presence of asthma symptoms is also associated with higher health care costs (24,25). In a study of individuals with asthma in the United Kingdom, the average asthma health care cost among those who had an asthma attack was 3.5 times more than among those without an asthma attack (29). Proper asthma management to control

TABLE 5.—Multivariate association of activity limitation due to asthma^a with asthma symptoms among not currently employed adults.

Measure	All ever-employed adults with current asthma PR ^c (95% CI)	Subgroup		
		WRA ^b only PR ^c (95% CI)	Possible WRA ^c only PR ^c (95% CI)	Non-WRA ^d only PR ^c (95% CI)
Time since last asthma symptom				
Less than 1 day ago	1.39 (1.28–1.51)	1.30 (1.15–1.48)	1.22 (1.09–1.36)	1.50 (1.30–1.75)
1 day or more ago	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)
Days with asthma symptoms in the past 30 days				
15–30 days	1.49 (1.37–1.63)	1.19 (1.03–1.37)	1.31 (1.18–1.47)	1.84 (1.59–2.13)
0–14 days	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)
Asthma symptoms all the time				
Yes	1.59 (1.47–1.73)	1.29 (1.14–1.46)	1.36 (1.21–1.53)	1.87 (1.62–2.16)
No	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)
Days with trouble sleeping because of asthma in the past 30 days				
15–30 days	1.93 (1.78–2.10)	1.39 (1.23–1.58)	1.66 (1.47–1.87)	2.27 (1.97–2.62)
0–14 days	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)
Days symptom-free in the past 2 weeks				
0–7 days	1.71 (1.55–1.88)	1.39 (1.18–1.65)	1.53 (1.35–1.74)	1.91 (1.63–2.25)
8–14 days	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)
Asthma attack in the past 3 months				
Yes	2.42 (2.19–2.66)	1.56 (1.29–1.87)	2.04 (1.79–2.32)	2.87 (2.45–3.37)
No	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)

Notes: CI, confidence interval; PR, prevalence ratio; WRA, work-related asthma.

^a Answered 1 day or more to the question “During the past 12 months, how many days were you unable to work or carry out your usual activities because of your asthma?”

^b “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?”

^c “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: (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?”

^d “No” to all of the following five questions: (1) “Were you ever told by a doctor or other health professional that your asthma was related to any job you ever had?” (2) “Was your asthma caused by chemicals, smoke, fumes, or dust in your current job?” (3) “Was your asthma caused by chemicals, smoke, fumes, or dust in any previous job you ever had?” (4) “Is your asthma made worse by chemicals, smoke, fumes, or dust in your current job?” and (5) “Was your asthma made worse by chemicals, smoke, fumes, or dust in any previous job you ever had?”

^e Prevalence ratio adjusted for age, sex, race/ethnicity, education, income, and insurance. In each of the 24 models, the dependent variable was the inability to work or carry out usual activities and the independent variable was the specific measure of the occurrence or frequency of asthma symptoms. The prevalence ratios show that individuals with the higher frequency of asthma symptoms/asthma attack were more likely to be unable to work or carry out their usual activities due to their asthma at least 1 day in the past year than those with lower frequency of asthma symptoms/no asthma attack (referent group).

and prevent asthma symptoms is costly but not nearly as costly as treatment of asthma exacerbations (29).

The findings of this report are subject to some limitations. First, BRFSS and Asthma Call-back Survey rely on self-reported measures and may be subject to recall bias. It is possible that respondents recalled an event in the distant past as happening recently (30). Moreover, because Asthma Call-back Survey is a cross-sectional survey, causality or the temporal relationship of asthma symptoms to work could not be assessed. For example, we could not assess when an event occurred within the given question timeframe, whether the increased occurrence and frequency of asthma symptoms among individuals with health professional-diagnosed WRA was experienced prior to or after the diagnosis of WRA, or the temporal pattern of asthma symptoms in relation to work such as symptoms worsening on days at work or improving on days away from work. In addition, studies suggest that it is difficult to determine whether the severity of WRA contributes to increased symptoms of asthma or if WRA is more likely to be diagnosed in individuals who have more severe asthma (22,31). For example, a health care professional may be more likely to correctly diagnose asthma as work-related if the patient has increased frequency of asthma symptoms (e.g., frequent asthma attacks). Lastly,

estimates are limited to 38 states and DC that were included in this analysis and do not represent other states or the entire US population.

CONCLUSIONS

These results provide additional information on asthma symptoms among adults with WRA and underscore the need for optimal asthma management in individuals with WRA. Early recognition and diagnosis of WRA is an essential step in preventing exacerbation of asthma symptoms (10,25,32,33). Proper management of WRA is important for decreasing the use of medical resources and improving long-term prognosis (11).

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DECLARATION OF INTEREST

The authors report no conflicts of interest.

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