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OCCUPATIONAL ASTHMA

Prevalence of COPD among workers with work-related asthma

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ABSTRACT

Objective: Concurrent asthma and chronic obstructive pulmonary disease (COPD) diagnoses occur in 15%–20% of patients, and have been associated with worse health outcomes than asthma or COPD alone. Work-related asthma (WRA), asthma that is caused or made worse by exposures in the workplace, is characterized by poorly controlled asthma. The objective of this study was to assess the proportion of ever-employed adults (≥18 years) with current asthma who have been diagnosed with COPD, by WRA status.

Methods: Data from 23 137 respondents to the 2012–2014 Behavioral Risk Factor Surveillance System Asthma Call-back Survey from 31 states and the District of Columbia were examined. Logistic regression was used to calculate adjusted prevalence ratios (PRs), examining six disjoint categories of WRA-COPD overlap with non-WRA/no COPD as the referent category.

Results: An estimated 51.9% of adults with WRA and 25.6% of adults with non-WRA had ever been diagnosed with COPD. Adults with WRA/COPD were more likely than those with non-WRA/no COPD to have an asthma attack (PR = 1.77), urgent treatment for worsening asthma (PR = 2.85), an asthma-related emergency room visit (PR = 4.21), overnight stay in a hospital because of asthma (PR = 6.57), an activity limitation on 1–13 days (PR = 2.01) or ≥14 days (PR = 5.02), and very poorly controlled asthma (PR = 3.22).

Conclusions: COPD was more frequently diagnosed among adults with WRA than those with non-WRA, and adults diagnosed with both WRA and COPD appear to have more severe adverse asthma outcomes than those with non-WRA and no COPD.

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Introduction

Asthma and chronic obstructive pulmonary disease (COPD) are both pulmonary disorders characterized by various degrees of airflow limitation, inflammation, and tissue remodeling. Both are associated with significant morbidity among adults in the United States, with asthma affecting 20.4 million adults in 2016 and COPD affecting 15.5 million adults in 2015 (1,2). Asthma and COPD have typically been regarded as two separate disease entities. Asthma is characterized by chronic airway inflammation and variable airflow limitation with symptoms such as wheeze, shortness of breath, chest tightness, and cough (3,4). Conversely, COPD is characterized by persistent and progressive airflow limitation and a chronic inflammatory response in the airways and lungs (5).

In clinical practice, however, 15%–20% of patients with asthma or COPD can present with symptoms of both asthma and COPD (6). Consensus on a formal definition of asthma-COPD overlap has not been reached; however, key features include persistent airflow limitation, history of cigarette smoking or exposure to noxious particles and gases, and physician diagnosis of asthma (6,7). Asthma-COPD overlap has been associated with more symptoms and worse outcomes than asthma or COPD alone (8–10). Patients with overlapping asthma and COPD have been shown to experience more frequent exacerbations, more rapid decline in lung function, poorer health-related quality of life, higher mortality, and greater health care utilization than adults with COPD or asthma alone (10–14).

Work-related asthma (WRA) is asthma that is caused or made worse by exposures in the workplace (15). Adults with WRA have more severe asthma than those with non-WRA and are characterized by poorly controlled asthma, more asthma attacks, and more frequent asthma-related health care utilization (15,16). Recurrent exacerbations may result in accelerated

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decline in lung function and fixed air-flow obstruction in asthma patients; therefore, adults with WRA may be more likely to have COPD than adults with non-WRA (17). Knoeller et al. found that 52% of adults with WRA had a diagnosis of COPD (16), which is greater than the proportion of physician-diagnosed COPD observed among adults with active asthma (35%) in a study by Mirabelli et al (18).

The Behavioral Risk Factor Surveillance Survey (BRFSS) provides unique, population-level data to examine disease prevalence. In this study, we estimated the proportion of COPD among ever-employed adults with asthma and WRA, using the 2012–2014 BRFSS Asthma Call-back Survey (ACBS). In addition, we assessed the demographic characteristics, asthma control, health care utilization, and medication use among adults with current asthma by WRA-COPD overlap status.

Methods

The BRFSS is a state-based, random digit-dialed landline and cellular telephone survey of the non-institutionalized U.S. adult population (19). The ACBS is an optional follow-up survey of BRFSS respondents with asthma conducted within 2 weeks of the initial interview and designed to collect detailed information on asthma (20). Based on the American Association for Public Opinion Research guidelines, the median response rate was 45.0% in 2012, 44.0% in 2013, and 46.0% in 2014 for BRFSS and was 47.3% in 2012, 46.0% in 2013, and 46.3% in 2014 for ACBS. The Institutional Review Board at CDC has granted a surveillance exemption for BRFSS; however, states participating in BRFSS are subject to the Institutional Review Board requirements of their state.

Data were assessed from the 2012–2014 ACBS from 31 states (California, Connecticut, Georgia, Hawaii, Illinois, Indiana, Iowa, Maine, Maryland, Michigan, Mississippi, Missouri, Montana, Nebraska, Nevada, New Hampshire, New Jersey, New Mexico, New York, North Carolina, Ohio, Oklahoma, Oregon, Pennsylvania, Rhode Island, Texas, Utah, Vermont, Washington, West Virginia, Wisconsin) and the District of Columbia (DC) conducting landline and cellular telephone household surveys. New methodology to improve the coverage and representativeness of the ACBS was introduced in 2012; therefore, data collected prior to 2012 were not considered (21,22).

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?" Respondents were considered to be ever-employed if they described their current employment status as "employed full time" or "employed part-time" or answered "yes" to the question "Have you ever been employed?" Adults with current asthma were then classified as having either 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?" Ever-employed adults with current asthma who did not meet definitions for WRA or possible WRA were classified as non-WRA.

Respondents were defined as having COPD if they responded "yes" to any of the following questions: "Have you ever been told by a doctor or health professional that you have chronic obstructive pulmonary disease also known as COPD?", "Have you ever been told by a doctor or other health professional that you have emphysema?", or "Have you ever been told by a doctor or other health professional that you have chronic bronchitis?"

Survey participants were asked about their prescription medication use during the 3 months preceding the interview. Medications were classified as long-acting β-agonist, inhaled corticosteroid, oral corticosteroid, cromolyn/nedocromil, leukotriene pathway inhibitor, methylxanthine, anti-cholinergic, or short-acting β-agonist (SABA) according to previously reported methods (23). Cigarette smoking status was defined as current (i.e., smoked $\geq$ 100 cigarettes during lifetime, and currently smoke every day or some days), former (i.e., smoked $\geq$ 100 cigarettes during lifetime, and currently do not smoke at all), and never (i.e., never smoked or smoked $<$ 100 cigarettes during lifetime).

Asthma control was defined according to the Expert Panel Report 3 Guidelines for the Diagnosis and Management of Asthma and categorized into well controlled, not well controlled, and very poorly

controlled based on the category with the most severe impairment using responses to questions on asthma symptoms, nighttime awakenings, and SABA medication use for symptom control (3,16). Adverse asthma outcomes, including asthma attacks, emergency room visits for asthma, hospital stays, and urgent treatment for worsening asthma in the last 12 months, were classified using previously developed definitions (16,24). The number of days adults were unable to work or carry out their usual activities because of their asthma in the year prior to the interview was categorized based on their responses as 0 days, 1–13 days, and ≥14 days with an activity limitation.

Analyses were done in SAS version 9.3 and SUDAAN release 11.0.1. Data for 31 states and DC collected during 2012–2014 were combined and weighted to increase the reliability and precision of estimates and produce estimates representative of the state populations. Weights for analyses were established by multiplying the survey sample weight provided for each survey participant by the percentage of subjects in each state and survey year. Estimates based on a sample of <50 respondents or with a relative standard error (i.e., standard error divided by the estimate) >30% were not reported.

The demographic and adverse asthma outcomes of ever-employed adults with current asthma were examined by WRA-COPD overlap status. The prevalence of COPD among ever-employed adults with current asthma by select characteristics and WRA status was also examined. The predicted marginal risk ratio method of multivariate logistic regression was used to calculate adjusted prevalence ratios (PRs) to assess the association of WRA-COPD overlap categories with adverse asthma outcomes, asthma control, and asthma medication use. Age, sex, race/ethnicity, education, household income, current employment status, smoking status, and age of asthma onset were independently associated with WRA status or COPD at a p value of <0.2, and were simultaneously included in the multivariate logistic regression models. Using backward selection, non-significant covariates were removed from the model. Associations were compared across six disjoint categories of WRA-COPD overlap, and significance was assessed by comparing 95% confidence intervals (CIs). Results were considered statistically significant at $p < 0.05$.

Results

In the 31 states and DC during 2012–2014, a sample of 866 613 adults participated in BRFSS. Respondents with missing information on current asthma ($n = 5887$) or COPD ($n = 3871$) were excluded, leaving 856 855 (representing a weighted estimate of 172.6 million adults) respondents for analyses. Overall, 9.0% and 6.1% of adults in these 31 states and DC had current asthma and COPD, respectively. Among adults with current asthma, an estimated 25.4% had COPD (Table 1). The proportion of adults with COPD was lower (4.2%) among adults with no current asthma.

Among the persons participating in BRFSS in these 31 states and DC, a sample of 32 470 adults participated in ACBS. Respondents who were never employed ($n = 462$), those with no current asthma ($n = 8053$), and with missing information on employment, current asthma, COPD, or WRA status ($n = 818$) were excluded, leaving 23 137 ever-employed respondents with current asthma for analyses. An estimated 34.5% of ever-employed adults with current asthma had COPD, 13.9% had WRA, 39.0% had possible WRA, and 47.1% had non-WRA (Table 1). Among adults with WRA, 51.9% (representing a weighted estimate of 1.1 million adults) had ever been diagnosed with COPD. The proportion of adults with COPD was lower among persons with possible WRA (38.9%) and non-WRA (25.6%). Age, sex, race/ethnicity, education, household income, current employment status, smoking status, and age of asthma onset were independently associated with WRA-COPD overlap (Table 2).

COPD prevalence among ever-employed adults with current asthma by select characteristics and WRA status is shown in Table 3. After adjusting for other covariates, adults with WRA were significantly more likely to have been diagnosed with COPD than adults with non-WRA. Among non-Hispanic black and non-Hispanic white adults, those with WRA were significantly more likely to have been diagnosed with COPD than adults with non-WRA. Similar results were observed among adults with possible WRA

Multivariate associations between WRA-COPD overlap categories with adverse asthma outcomes and asthma control among ever employed adults with current asthma are shown in Table 4. Adults with WRA/no COPD were significantly more likely than those with non-WRA/no COPD to have adverse asthma outcomes in the last 12 months including an asthma attack (PR = 1.60), urgent treatment for worsening asthma (PR = 2.25), an asthma-related emergency room visit (PR = 2.24), an activity limitation on 1–13 days (PR = 1.83) or ≥14 days (PR = 2.74), and very poorly controlled asthma (PR = 1.96). Associations were stronger among adults with WRA/COPD for asthma-related emergency room visits

Table 1. Proportion of COPD[a] among select population groups, Behavioral Risk Factor Surveillance System (BRFSS) and Asthma Call-back Survey (ACBS), 31 states, and District of Columbia, 2012–2014.

					COPD Proportion	
Population	Sample N[b]	Weighted N (in thousands)[c]	%[c]	95% CI	%[c]	95% CI
Adults (BRFSS)	856 855	172 632			6.1	6.0–6.2
Current asthma[d]	79 706	15 468	9.0	8.8–9.1	25.4	24.9–26.0
No current asthma[e]	777 149	157 164	91.0	90.9–91.2	4.2	4.1–4.3
Ever-employed adults with current asthma (ACBS)	23 137	15 546			34.5	33.0–35.9
WRA[f]	3495	2155	13.9	12.8–14.9	51.9	47.7–56.1
Possible WRA[g]	9471	6067	39.0	37.5–40.6	38.9	36.6–41.2
Non-WRA[h]	10 171	7323	47.1	45.4–48.8	25.6	23.5–27.8

Abbreviation: ACBS = Asthma Call-back Survey; BRFSS = Behavioral Risk Factor Surveillance System; CI = confidence interval; COPD = chronic obstructive pulmonary disease; WRA = work-related asthma.

[a]"Yes" to any of the following questions: "Have you ever been told by a doctor or health professional that you have chronic obstructive pulmonary disease also known as COPD?", "Have you ever been told by a doctor or other health professional that you have emphysema?", or "Have you ever been told by a doctor or other health professional that you have chronic bronchitis?".

[b]Unweighted sample size.

[c]Weighted to the state population using the survey sample weights for each BRFSS or ACBS participant.

[d]"Yes" 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?".

[e]"No" response to the either the question "Have you ever been told by a doctor or other health professional that you have asthma?" or "Do you still have asthma?".

[f]"Yes" 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?".

[g]"No" 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?" and "Yes" response 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?".

[h]"No" response to the following questions "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?", "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?".

(PR = 4.21) and an activity limitation on ≥14 days (PR = 5.02); however, these associations had overlapping 95% CIs and, thus, were not considered significantly different.

Similar results were observed for adults with possible WRA/no COPD and those with possible WRA/COPD. When the 95% CIs were compared, stronger associations were observed among adults with possible WRA/COPD for very poorly controlled asthma (PR = 2.71), urgent treatment for worsening asthma (PR = 2.12), and no activity limitation (PR = 0.67) compared to those with possible WRA/no COPD.

Multivariate associations between WRA-COPD overlap categories with asthma medication use among ever employed adults with current asthma are shown in Table 4. Adults with WRA/no COPD were significantly more likely than those with non-WRA/no COPD to have taken inhaled corticosteroid (PR = 1.26), oral corticosteroid (PR = 1.81), leukotriene pathway inhibitor (PR = 1.48), and short-acting β agonist (PR = 1.27) medications in the three months prior to the interview. Associations were elevated among adults with WRA/COPD for oral corticosteroid (PR = 2.94) and anti-cholinergic (PR = 4.79) medications compared to those with non-WRA/COPD and those with WRA/no COPD; however, all associations had overlapping 95% CIs and, thus, were not considered significantly different. Additionally, adults with WRA/COPD were more likely than those with non-WRA/no COPD to have taken methylxanthine (PR = 10.40) medications. Similar results were observed for adults with possible WRA/no COPD and those with possible WRA/COPD.

Discussion

The current study findings indicate that an estimated 34.5% of ever-employed adults with current asthma had COPD, which was similar to the findings among adults with active asthma in a study by Mirabelli et al. (18). However, the estimated COPD prevalence among patients with asthma has ranged from 16% to 30% in other studies and was as high as 61% among adults aged 65–84 years (25–27). The differences in findings between this and the other studies might be explained, in part, by the differences in methodologies. Although this study relied on self-reported physician diagnoses and health outcomes, the study by Tommola et al. (27) found that 18% of 188 clinical patients with adult-onset asthma had asthma-COPD overlap based on objective pulmonary testing and symptoms evaluated by a respiratory physician. In a population-based study by Mannino et al. (25), an estimated 28% of U.S. adults with current asthma had

Table 2. Characteristics of ever-employed adults with current asthma, by WRA-COPD overlap status, 2012–2014.

		WRA/COPD		Possible WRA/COPD		Non-WRA/COPD		WRA/no COPD		Possible WRA/no COPD		Non-WRA/no COPD	
Characteristics	Weighted no. (in thousands)[a]	%[a]	95% CI	%[a]	95% CI	%[a]	95% CI	%[a]	95% CI	%[a]	95% CI	%[a]	95% CI
Age[b]													
18–44	7084	24.1	18.9–29.2	24.4	20.6–28.1	27.1	21.9–32.4	47.0	40.4–53.6	54.6	51.4–57.9	59.4	56.7–62.2
45–64	5725	55.8	50.6–61.1	49.2	45.7–52.6	36.1	31.9–40.3	43.7	37.1–50.4	34.2	31.4–37.0	28.5	26.1–30.9
≥65	2706	20.1	16.6–23.6	26.5	23.8–29.1	36.8	32.6–41.0	9.3	7.1–11.4	11.2	9.7–12.6	12.1	10.8–13.3
Sex[b]													
Male	5387	37.4	32.5–42.4	34.8	31.5–38.2	24.2	20.6–27.7	37.3	30.6–44.1	36.5	33.2–39.9	35.7	32.8–38.7
Female	10 172	62.6	57.6–67.5	65.2	61.8–68.5	75.8	72.3–79.4	62.7	55.9–69.4	63.5	60.1–66.8	64.3	61.3–67.2
Race/ethnicity[b]													
Non-Hispanic, White	10 682	67.7	62.2–73.1	67.5	63.8–71.2	72.5	67.5–77.5	65.4	57.9–72.9	68.5	64.9–72.1	71.3	68.0–74.6
Non-Hispanic, Black	1970	15.5	11.2–19.8	14.8	12.4–17.2	11.0	8.1–14.0	10.6	6.6–14.6	13.2	10.5–15.9	12.2	10.0–14.5
Hispanic	1642	8.9	5.2–12.6	11.0	7.4–14.5	6.2	3.6–8.7	12.5	7.8–17.1	12.0	9.1–14.9	11.3	8.4–14.1
Other	1069	8.0	4.7–11.2	6.8	5.0–8.5	10.4	5.9–14.8	–		6.3	4.4–8.2	5.2	3.8–6.6
Education[b]													
≤High school	5748	45.5	40.4–50.7	53.3	49.9–56.8	48.6	43.9–53.3	29.5	24.2–34.9	35.2	31.9–38.5	26.7	24.0–29.4
Some college	5615	39.7	34.3–45.0	31.0	28.0–34.0	34.5	30.2–38.9	40.3	33.2–47.3	38.8	35.3–42.2	35.6	32.5–38.6
College graduate	4186	14.8	11.8–17.8	15.7	13.1–18.3	16.8	13.8–19.9	30.2	24.9–35.5	26.0	23.6–28.5	37.7	34.9–40.5
Household income[b]													
<$15 000	2484	25.6	21.2–29.9	32.4	28.6–36.2	22.4	18.3–26.4	14.1	10.1–18.1	14.0	11.4–16.5	11.4	9.0–13.9
$15 000–$24 999	2511	25.4	20.4–30.4	25.6	22.5–28.6	20.4	17.4–23.5	19.0	14.0–24.1	16.0	13.7–18.3	13.3	11.1–15.5
$25 000–$34 999	1378	13.6	10.0–17.1	11.4	9.2–13.5	13.9	9.5–18.3	10.1	6.9–13.3	10.7	8.1–13.3	6.4	5.2–7.7
$35 000–$49 999	1680	13.4	9.6–17.2	9.6	7.8–11.4	12.8	9.4–16.1	12.1	8.3–15.8	13.7	11.6–15.7	11.3	9.5–13.1
≥$50 000	5952	22.1	17.1–27.0	21.1	18.4–23.8	30.5	26.1–34.9	44.7	37.7–51.8	45.7	42.1–49.2	57.5	54.4–60.7
Current employment[b]													
Employed	8030	32.5	27.5–37.5	30.6	27.3–33.8	34.2	29.6–38.9	59.6	53.7–65.6	60.2	56.9–63.5	63.6	60.7–66.4
Not employed	7506	67.5	62.5–72.5	69.4	66.2–72.7	65.8	61.1–70.4	40.4	34.4–46.3	39.8	36.5–43.1	36.4	33.6–39.3
Smoking[b]													
Current	3021	31.4	26.5–36.3	31.1	28.1–34.1	28.6	24.4–32.8	14.5	9.4–19.6	15.4	12.8–18.1	12.5	10.1–14.8
Former	4216	32.5	27.9–37.1	35.8	32.7–39.0	38.9	34.3–43.4	23.1	18.6–27.7	24.0	21.3–26.7	21.2	19.1–23.4
Never	8280	36.1	30.9–41.3	33.1	29.4–36.7	32.5	28.1–37.0	62.3	56.2–68.5	60.6	57.2–63.9	66.3	63.5–69.2
Age of asthma onset[b]													
Child	6911	34.9	29.6–40.1	33.3	29.8–36.8	32.0	26.9–37.1	49.4	42.6–56.2	52.4	49.0–55.9	56.1	53.1–59.1
Adult	7788	65.1	59.9–70.4	66.7	63.2–70.2	68.0	62.9–73.1	50.6	43.8–57.4	47.6	44.1–51.0	43.9	41.0–46.9

Abbreviation: CI = confidence interval; COPD = chronic obstructive pulmonary disease; WRA = work-related asthma.
[a]Weighted to the state populations using the survey sample weights for each BRFSS or ACBS participant.
[b]Characteristic significantly associated with WRA–COPD overlap status; Rao-Scott chi-square test $p < 0.05$.

spirometric-confirmed COPD. Moreover, because the ACBS is a voluntary follow-up survey of BRFSS respondents with asthma, survey respondents with more severe asthma may be more likely to participate than those with less severe asthma.

An estimated 52% (1.1 million) of adults with WRA had a physician diagnosis of COPD, which is higher than that reported by Ojanguren et al. among persons with occupational asthma (28). In their study, the authors found that 13.8% of 304 subjects with occupational asthma had asthma-COPD overlap. However, Ojanguren et al. assessed asthma-COPD overlap only among those who had smoked ≥10 pack-years. Research has shown that nonsmokers can develop COPD and patients with asthma may develop features of COPD (29,30). Accelerated decline in lung function and fixed air-flow obstruction may be a result of recurrent exacerbations characteristic of WRA, and may explain the elevated proportion of COPD found among adults with WRA in this study (17). The pathology of this disease progression is unknown, however (31).

The results of this study indicate that never-smokers with WRA were twice as likely to have COPD as adults with non-WRA, suggesting that some occupational exposures may place individuals at greater risk for asthma-COPD overlap. Although cigarette smoking is the primary cause of COPD, as much as 15% (range 0%–37%) of COPD can be attributable to workplace exposures (32). The proportion attributable to workplace exposure among nonsmokers is higher at 31% (range 27%–53%) (33). Workplace exposures including dusts, gases, minerals, metals, grain, wood, cotton, vapors, welding fumes, and isocyanates have been associated with COPD (34–36). Moreover, workplace exposures, such as irritant chemicals, dusts, secondhand smoke, allergens, cleaners, disinfectants, welding fumes, and isocyanates, have been associated with new-onset and work-exacerbated asthma (37–39). Several of these workplace exposures are causative agents for both WRA and COPD. Exposure to these agents may explain the presence of overlapping asthma and COPD in some workers, and should be considered in managing patients with asthma-COPD overlap. Primary preventive measures should focus on exposure avoidance or reduction for both WRA and COPD (15,40); however, limited

Table 3. COPD prevalence among ever-employed adults with current asthma, by select characteristics and WRA status, 2012–2014.

	COPD Prevalence									
	WRA		Possible WRA		Non-WRA		WRA vs Non-WRA		Possible WRA vs Non-WRA	
Characteristics	%[a]	95% CI	%[a]	95% CI	%[a]	95% CI	PR[b]	95% CI	PR[b]	95% CI
Age										
18–44	35.6	28.1–43.1	22.1	18.3–25.9	13.6	10.5–16.7	**2.06**	**1.48–2.88**	**1.35**	**1.00–1.83**
45–64	57.9	51.8–64.0	47.8	44.8–50.8	30.4	27.1–33.7	**1.58**	**1.38–1.81**	**1.25**	**1.11–1.41**
≥65	70.1	64.2–75.9	60.2	56.3–64.0	51.3	47.4–55.1	**1.26**	**1.12–1.42**	**1.10**	**1.00–1.21**
Sex										
Male	52.0	44.6–59.4	37.8	33.9–41.8	18.9	16.0–21.8	**1.84**	**1.52–2.24**	**1.40**	**1.16–1.68**
Female	51.9	46.8–56.9	39.6	36.7–42.4	28.9	26.1–31.7	**1.50**	**1.31–1.72**	**1.16**	**1.03–1.30**
Race/ethnicity										
Non-Hispanic, White	52.6	48.4–56.8	38.4	36.0–40.8	25.9	23.7–28.2	**1.54**	**1.37–1.72**	**1.21**	**1.09–1.34**
Non-Hispanic, Black	61.0	49.1–73.0	41.6	34.7–48.5	23.7	17.4–29.9	**2.08**	**1.53–2.81**	**1.38**	**1.02–1.86**
Hispanic	43.3	28.6–58.0	36.7	26.3–47.0	15.8	9.0–22.7	1.86	0.95–3.62	**1.71**	**1.01–2.88**
Other	42.6	21.7–63.5	40.4	30.6–50.2	40.6	27.4–53.8	1.14	0.79–1.65	0.79	0.57–1.11
Education										
≤High school	62.4	56.7–68.0	49.1	45.2–53.0	38.5	34.0–43.0	**1.38**	**1.19–1.60**	1.10	0.96–1.26
Some college	51.4	43.3–59.5	33.7	30.0–37.4	25.1	21.5–28.6	**1.67**	**1.38–2.03**	**1.22**	**1.04–1.42**
College graduate	34.5	28.3–40.7	27.8	23.7–31.8	13.3	10.9–15.8	**2.04**	**1.60–2.61**	**1.66**	**1.33–2.07**
Household income										
<$15 000	66.4	58.7–74.2	59.7	53.7–65.7	39.6	32.2–47.1	**1.48**	**1.24–1.77**	**1.33**	**1.10–1.60**
$15 000–$24 999	59.3	50.3–68.3	50.6	45.5–55.6	34.0	28.8–39.2	**1.51**	**1.26–1.81**	**1.32**	**1.13–1.54**
$25 000–$34 999	59.5	49.3–69.8	40.5	32.5–48.5	42.1	32.3–51.9	**1.39**	**1.03–1.87**	0.95	0.69–1.30
$35 000–$49 999	54.8	43.9–65.7	31.1	25.8–36.4	27.4	20.9–34.0	**1.67**	**1.27–2.20**	0.96	0.74–1.23
≥$50 000	35.0	26.9–43.1	22.8	19.7–25.9	15.1	12.6–17.6	**1.84**	**1.41–2.40**	**1.31**	**1.09–1.59**
Current employment										
Employed	37.0	30.7–43.4	24.4	21.5–27.4	15.7	13.1–18.2	**2.00**	**1.58–2.51**	**1.38**	**1.14–1.67**
Not employed	64.4	59.8–68.9	52.6	49.3–56.0	38.4	35.0–41.8	**1.41**	**1.26–1.59**	**1.16**	**1.04–1.30**
Smoking										
Current	69.9	60.8–79.0	56.1	50.8–61.5	44.2	37.5–50.8	**1.46**	**1.23–1.74**	1.08	0.92–1.27
Former	60.2	54.1–66.3	48.7	44.7–52.7	38.7	34.4–43.1	**1.36**	**1.16–1.60**	**1.16**	**1.01–1.33**
Never	38.4	32.3–44.5	25.8	22.5–29.0	14.5	12.2–16.8	**2.04**	**1.62–2.57**	**1.46**	**1.19–1.79**
Age of asthma onset										
Child	42.2	34.9–49.4	27.6	24.1–31.1	16.4	13.2–19.5	**1.87**	**1.48–2.37**	**1.33**	**1.07–1.64**
Adult	57.1	52.3–61.9	45.7	42.8–48.6	34.6	31.7–37.6	**1.47**	**1.32–1.65**	**1.18**	**1.08–1.30**

Abbreviation: CI = confidence interval; COPD = chronic obstructive pulmonary disease; WRA = work-related asthma.
[a]Weighted to the state population using the survey sample weights for each BRFSS or ACBS participant.
[b]Prevalence ratio adjusted for age, sex, education, household income, current employment status, smoking status, and age of asthma onset.
Bold text indicates significance; "–" indicates relative standard error >30%, estimate not reportable.

guidance is available on the management of asthma-COPD overlap (6).

Currently, there is no clinical definition of work-related COPD. The American Thoracic Society indicates that work-related COPD can be considered in a worker with COPD caused or exacerbated by occupational exposures (33). However, the BRFSS has not been designed to collect information on the work-relatedness of COPD. Further studies are needed to examine the surveillance case definition for identification of work-related COPD and the occupational burden of asthma-COPD overlap.

Previous studies have indicated that WRA is associated with poorer asthma control in addition to more frequent asthma attacks, emergency department visits, asthma-related hospitalizations, and urgent treatment for worsening asthma (15,16). In this study, while adults with WRA/no COPD were more likely to have adverse asthma outcomes and poor asthma control than adults with non-WRA/no COPD, stronger associations with adverse asthma outcomes were observed among adults with WRA/COPD. These results suggest that adults with both WRA and COPD may have more frequent and severe symptoms than those with WRA alone, resulting in greater health care utilization. These patients may require initial therapy tailored to the dominant phenotype (4–6).

A previous report found that adults with WRA were more likely to be taking anti-cholinergic medications, a bronchodilator indicated for the treatment of COPD, than adults with non-WRA (23). In this study, we found that adults with WRA/COPD were more likely than those with non-WRA/no COPD to have taken long-acting β agonist, inhaled corticosteroid, oral corticosteroid, leukotriene pathway inhibitor, methylxanthine, anti-cholinergic, and short-acting β agonist medications. Results were similar among adults with WRA/no COPD, suggesting that the treatment of adults with WRA did not differ among adults with COPD compared to those without. However, adults with WRA/COPD were more likely to be taking oral corticosteroid and anti-cholinergic medications

Table 4. Multivariate associations between WRA-COPD overlap status and adverse asthma outcomes among ever-employed adults with current asthma, 2012–2014.

	WRA/COPD		Possible WRA/COPD		Non-WRA/COPD		WRA/no COPD		Possible WRA/no COPD	
	PR[a]	95% CI	PR[a]	95% CI	PR[a]	95% CI	PR[a]	95% CI	PR[a]	95% CI
Asthma control										
Well controlled	**0.56**	**0.46–0.67**	**0.56**	**0.50–0.64**	**0.74**	**0.65–0.84**	**0.72**	**0.61–0.85**	**0.84**	**0.77–0.91**
Not well controlled	0.96	0.75–1.21	**1.21**	**1.01–1.44**	1.03	0.83–1.28	1.20	0.96–1.51	1.13	0.96–1.34
Very poorly controlled	**3.22**	**2.63–3.94**	**2.71**	**2.25–3.28**	**2.18**	**1.77–2.68**	**1.96**	**1.37–2.81**	**1.54**	**1.25–1.89**
Adverse asthma outcomes[b]										
Asthma attack	**1.77**	**1.59–1.97**	**1.54**	**1.39–1.72**	**1.28**	**1.12–1.47**	**1.60**	**1.41–1.82**	**1.27**	**1.14–1.41**
Urgent treatment for worsening asthma	**2.85**	**2.36–3.44**	**2.12**	**1.78–2.53**	**1.79**	**1.44–2.23**	**2.25**	**1.80–2.82**	**1.29**	**1.07–1.57**
Asthma-related emergency room visit	**4.21**	**3.17–5.59**	**3.03**	**2.31–3.98**	**3.00**	**2.12–4.26**	**2.24**	**1.54–3.25**	**1.78**	**1.35–2.35**
Overnight stay in hospital because of asthma	**6.57**	**3.70–11.66**	**3.82**	**2.19–6.66**	**4.39**	**2.24–8.60**	–		1.46	0.70–3.06
Activity limitation[b]										
0 days	**0.58**	**0.51–0.67**	**0.67**	**0.61–0.73**	**0.84**	**0.77–0.91**	**0.74**	**0.66–0.82**	**0.82**	**0.77–0.88**
1–13 days	**2.01**	**1.58–2.56**	**2.01**	**1.64–2.46**	**1.55**	**1.21–1.98**	**1.83**	**1.43–2.35**	**1.64**	**1.34–2.01**
≥14 days	**5.02**	**3.53–7.14**	**3.43**	**2.42–4.86**	**1.96**	**1.34–2.85**	**2.74**	**1.85–4.06**	**1.87**	**1.25–2.81**
Asthma medication										
Long-acting β agonist	**1.37**	**1.13–1.66**	**1.26**	**1.08–1.46**	**1.24**	**1.04–1.48**	1.22	0.97–1.54	1.05	0.89–1.23
Inhaled corticosteroid	**1.23**	**1.05–1.44**	**1.18**	**1.04–1.34**	**1.18**	**1.01–1.38**	**1.26**	**1.04–1.54**	**1.14**	**1.00–1.30**
Oral corticosteroid	**2.94**	**1.74–4.97**	**1.71**	**1.04–2.80**	1.55	0.93–2.60	**1.81**	**1.01–3.25**	0.85	0.50–1.45
Cromolyn/nedocromil	–		–		–		–		–	
Leukotriene pathway inhibitor	**2.01**	**1.50–2.70**	**1.34**	**1.06–1.70**	1.08	0.82–1.42	**1.48**	**1.08–2.02**	1.25	1.00–1.57
Methylxanthine	**10.40**	**4.48–24.14**	**3.70**	**1.65–8.30**	2.02	0.90–4.51	–		–	
Anti-cholinergic	**4.79**	**3.02–7.61**	**3.69**	**2.44–5.58**	**3.14**	**1.94–5.07**	–		**1.64**	**1.04–2.58**
Short-acting β agonist	**1.39**	**1.24–1.55**	**1.35**	**1.22–1.48**	**1.23**	**1.10–1.38**	**1.27**	**1.12–1.45**	1.09	0.98–1.20

Abbreviation: CI = confidence interval; COPD = chronic obstructive pulmonary disease; WRA = work-related asthma.
[a]Prevalence ratio adjusted for age, sex, education, household income, current employment status, smoking status, and age of asthma onset. PR examining six disjoint categories of WRA-COPD overlap with non-WRA/no COPD as the referent category.
[b]In the 12 months prior to the interview.
Bold text indicates significance; "–" indicates relative standard error >30%, estimate not reportable.

than those with WRA/no COPD, although this difference was not significant. Further research is needed to develop more precise recommendations on pharmaceutical interventions for individuals with asthma-COPD overlap (41,42). In addition, adults with WRA/COPD may benefit from non-pharmacological intervention such as elimination or reduction of workplace exposures (6,15,31).

The findings in this report are subject to several limitations. First, information on asthma and COPD was self-reported and not validated by medical records, follow-up with health care providers, or objective pulmonary testing; thus, estimates might be subject to misclassification. A study by Sator et al. found that 62% of adults with self-reported COPD diagnoses had unobstructed lung function, and 10% of adults without a COPD diagnosis demonstrated airflow limitation, suggesting that self-reported COPD diagnoses are subject to both under- and overestimation (43). Moreover, in a population-based study by Mannino et al., while self-reported COPD and current asthma yielded similar estimates of disease burden compared to spirometry-confirmed COPD and current asthma, several clinical characteristics and outcomes differed between the two groups (25). In their study, the authors found that individuals with self-reported COPD and current asthma had significantly greater health care utilization than those with spirometry-confirmed COPD and current asthma (25). This may be explained, in part, by the fact that spirometry tests were not conducted on individuals with known severe lung impairment and may suggest that self-reported COPD and current asthma could capture individuals with more severe disease in population-based studies. Second, the ACBS did not collect information on medication dose or duration of treatment; therefore, we were unable to assess asthma severity. Third, the data are cross-sectional, and no information was available to determine the timing of asthma and COPD diagnoses. Fourth, small sample sizes for some subgroups resulted in unreliable estimates. Finally, because data are limited to 31 states and DC, the results might not be nationally representative or representative of non-participating states.

Conclusions

In these 31 states and DC, an estimated 1.1 million adults had both WRA and COPD. Results suggest that asthma-COPD overlap prevalence may be elevated among adults with WRA compared to those with non-WRA. Adults with WRA-COPD overlap have increased health care utilization and activity limitations compared to those with WRA alone or non-WRA-COPD overlap. Studies are needed to better

characterize the disease and identify optimal WRA-COPD overlap management.

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Declaration of interest

The authors report no conflicts of interest. The findings and conclusions in this report are those of the authors and do not necessarily represent the official views of the National Institute for Occupational Safety and Health, Centers for Disease Control and Prevention (CDC).

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