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Prevalence and burden of asthma among US working adults by industry and occupation—United States, 2020–2021

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ABSTRACT

Objectives: Assess the prevalence of current asthma, asthma attacks/episodes, and asthma-related emergency room (ER) visits by industry and occupation and estimate the proportion of current asthma cases associated with employment during 2020–2021.

Methods: The 2020–2021 National Health Interview Survey data for persons aged ≥18 years who were employed at any time during the 12 months prior to the interview were analyzed.

Results: An estimated 12.7 million US working adults had current asthma. Of those, 40% had an asthma attack/episode and 8.6% had an asthma-related ER visit. Prevalence varied by sociodemographic characteristics, industry, and occupation. Highest asthma prevalence was among workers in the administrative, support, waste management, and remediation industry and the community and social services occupation. Nearly half of workers with current asthma in the arts, entertainment, and recreation industry and arts, design, entertainment, sports, and media occupations reported having an asthma attack/episode. Workers in the accommodations and food services industry and food preparation and serving related occupation had the highest asthma-related ER visits. The proportion of current asthma cases attributable to employment was estimated to be 9.2% by industry and 12.2% by occupation.

Conclusion: An estimated 1.2–1.5 million asthma cases among workers might be attributable to employment by industry and occupation. Disparities in asthma prevalence, asthma attacks/episodes and asthma-related ER visits among workers exist. These findings underscore the importance of early identification of asthma cases in relation to work and implementation of targeted interventions (including, training and education, personal protective equipment use, health surveillance, workplace policies), especially among workers employed in industries and occupations with elevated asthma prevalence.

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Introduction

Asthma prevalence and trends

Asthma, a chronic respiratory disease, is a major public health concern, affecting millions of people worldwide (1,2). In 2021, an estimated 20 million US adults had current asthma, with 41% of them reporting one or more asthma attacks in the past 12 months (2). Asthma is characterized by inflammation and narrowing of the airways, leading to symptoms such as wheezing, coughing, chest tightness, and shortness of breath (1). During 2011–2016, an estimated (average annual) 11 million US adults who were working at any time in the previous 12 months reported having current asthma (3). Among them, an estimated 44.7% reported an asthma attack and 9.9% had an asthma-related emergency room (ER) visit (3). Asthma prevalence varied across industries and occupations, with over 8% among workers in the healthcare and social assistance, and education services industries (3,4). Additionally, half of the workers with asthma in the hospital industry and education services, reported an asthma attack/episode (3,4). Asthma significantly impacts workers' health, affecting their ability to perform job duties (4–7). Furthermore, workplace exposures to environmental risk factors can trigger asthma and asthma attacks (1,4).

Work-related asthma

Work-related asthma (WRA) includes both occupational asthma (new-onset asthma caused by workplace

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exposures) and work-exacerbated asthma (preexisting asthma that is made worse by workplace exposures) (1,8,9). Among workers with asthma, an estimated 6.9% reported that their asthma was associated with their job (10). Workers with WRA may experience reduced income due to absenteeism, fewer work hours, or lower wages (11). Vandenplas et al. reported the estimated average annual lost income attributed to WRA was approximately $4,000 to $6,000 in 2003 (11). Additionally, asthma is associated with a significant health and economic burden. During 2011–2015, an estimated 8 million US workers had at least one asthma-related medical event (i.e. inpatient visit, prescribed drug, physician office visit, ER visit, or hospital stay) (12). The total average annual medical cost associated with these events was estimated at $7 billion ($901 per-person) in 2017-US dollar value (12). Managing asthma effectively is essential not only for individual well-being but also for maintaining a productive workforce and reducing economic burden.

Occupational burden of asthma

Workplace exposures can significantly impact worker health, especially among workers with asthma. Workers in certain industries and occupations have high asthma prevalence, asthma attack rates or ER visits, and may also be exposed to potential asthma triggers (3–5,7). For example, healthcare workers have high asthma prevalence and are exposed to asthma triggers including cleaning and disinfecting agents, latex proteins from gloves, aerosolized medications, and allergens, which have been associated with new onset asthma (4,5). Approximately, 23%–49% of adults with asthma report occupational exposures to various hazards (13). Adults exposed to vapors, dust, fumes, dampness, mold, and strenuous job conditions have significantly higher odds of severe asthma exacerbations (13). In a previous study examining the risk of developing or worsening asthma based on the level of asthma trigger exposures, authors reported that workers in the high risk occupations were 60% more likely to report asthma during their working life, and were four times more likely to report asthma and three times more likely to report new asthma diagnosis (14). Higher risk occupations included in the study were healthcare support, health aides, nurses, cooks, bartenders, entertainers, artists, personal care services, mechanics, machinists, and protective services (14).

The association between workplace exposures and asthma is complex. Findings from previous studies reporting on the proportion of adult asthma that might be associated with work varied based on the methodology used, population samples, and other factors (8,9,15,16). Blanc et al. identified and reviewed nine longitudinal population-based studies estimating incident asthma prevalence and occupational risk factors (8). The authors reported that 16.0% (pooled population attributable fraction across all studies; range 7%–44% of all adult asthma cases are associated with work-related factors (8). The occupational contribution to the burden of asthma using self-reported physician diagnosis asthma data from seven population-based studies was estimated at 19% (15). Groenewold et al. estimated that 11%–26% of incident asthma cases are attributable to occupational exposures among US adults aged ≥20 years (17). Using the Behavioral Risk Factor Surveillance System (BRFSS) Asthma Call-Back Survey data from 31 U.S. states and the District of Columbia, Dodd et al. reported 13.9% of ever-employed adults with current asthma had WRA during 2012–2014 (17). Limited information is available on asthma cases attributable to employment among currently working adults based on their industry and occupation. Continued surveillance for early identification and management of asthma cases among workers, is essential for minimizing its impact on worker health and well-being. The current study (1) estimates the prevalence of current asthma, asthma-related episodes/attacks and ER visits among US working adults employed in the 12 months prior to the survey, and (2) identifies the proportion of asthma cases attributable to employment by industry and occupation.

Methods

The National Health Interview Survey (NHIS) is a nationally representative annual cross-sectional household interview survey of the noninstitutionalized U.S. civilian population. The NHIS sample adult component included 31,568 respondents in 2020, and 29,482 respondents in 2021 (18,19). To improve the precision and reliability of estimates, NHIS data collected during 2020–2021 were combined (18,19). The analysis was restricted to survey respondents aged ≥18 years, who were employed at any time during the 12 months prior to the survey interview (37,725; 67%).

Adults who reported "working at a job or business," "with a job or business but not at work," or "working, but not for pay, at a family-owned job or business" at any time during the 12 months prior to the survey interview were considered employed. Self-reported information on respondents' current industry (21 groups) and occupation (23 groups) were used for

analyses (18,19). Survey respondents who had ever been told by a doctor or other health professional that they had asthma and reported that they still have asthma were considered to have current asthma (18,19). Respondents with at least one asthma attack/episode or one asthma-related ER visit in the past year were identified by affirmative responses to questions "During the past 12 months, have you had an episode of asthma or an asthma attack?" and "During the past 12 months, have you had to visit an ER or urgent care center because of asthma?," respectively. Respondents with depression were those who reported (1) they ever had depression or felt depressed daily, weekly, monthly or a few times a year, or (2) they felt depressed a little, a lot or somewhere in between, or (3) they took any medications for depression. Respondents' physical health was described as "excellent/very good/good" or "poor/fair" based on responses to the question "Would you say your health in general is excellent, very good, good, fair, or poor?"

NHIS data were weighted to produce nationally representative estimates using sample weights (18,19). Estimates with a relative standard error (standard error of the estimate divided by the estimate) ≥30% were not reported. Survey procedures were used to account for complex survey design. All analyses were done using SAS® 9.4 Software (SAS Institute Inc. Cary, NC) and SUDAAN 11.0.4 (Research Triangle Institute, Research Triangle Park, NC). The study was exempted from IRB approval under the Common Rule (45 CFR §46) because deidentified and publicly available data were used for analyses.

Statistical analysis

The estimated average annual prevalence of current asthma, asthma attacks/episodes and asthma-related ER visits among employed persons aged ≥18 years during 2020–2021, by selected demographic characteristics, physical and mental health status, and industry and occupation was assessed. Estimated frequencies, standard errors, and prevalence rates with 95% confidence intervals (CIs) were calculated. To assess the association between current asthma and specific sociodemographic characteristics, industry, and occupation, multivariable logistic regression was used. Adjusted prevalence ratios (PRs) were calculated using the predicted marginal risk ratio method. The variables age, sex, education, and insurance status were identified as confounders and adjusted in the multivariable regression models. The final model was assessed for collinearity among the covariates. Given the cross-sectional study design, PRs were calculated instead of odds ratios (ORs) because ORs may overestimate prevalence when the disease outcome is common and may not accurately represent the excess fraction of cases attributable to the exposure (20). PRs directly relate to prevalence and accurately represent the excess fraction of cases attributable to the exposure of interest (20). Population attributable fractions (PAFs) for asthma among all workers, were estimated by industry and occupation groups (21). The PAF or fraction of cases with asthma that are associated with employment by industry and occupation was calculated using the following equation (15,21):

$$PAF = \sum_{i=1}^{K} Pci \frac{\left(PRi - 1\right)}{PRi}$$

where k is the number of industry or occupation groups (21 and 23 groups, respectively).

Pci is the asthma cases/total cases, cases represent the estimated number of asthma cases in the ith industry or occupation group, and total cases represent the total estimated number of asthma cases summed across in the ith industry group/ith occupation group. PR_i is the adjusted PR for current asthma estimated for the ith industry/occupation. Attributable cases (ACs) were calculated using the following equation (21):

$$AC = Ni * Pi\left(PRi - 1\right) / PRi$$

where Ni is the estimated number of US working adults in the ith industry or occupation group; and Pi is the estimated current asthma prevalence in the ith industry or occupation. No cases were attributed to industries/occupations where $PR \leq 1$.

In the current analysis, the information industry and computer and mathematical occupation groups were selected as reference categories based on current asthma prevalence. Previous study (4) findings indicate that during 2011–2016, current asthma prevalence among workers in both (6.6% and 5.8%, respectively) these groups were lower than the national average (6.8%) (4). In addition, both computer and mathematical occupation and information industry typically involve indoor work environments or office-based tasks and interactions with clients, with minimal exposure to respiratory irritants (21,22).

In a study by Calvert et al. (22) 5% of workers in the "computer and the mathematical occupation" and 14% of workers in the information industry self-reported vapor, dust, gas, and fumes (VGDF)

exposures, which was significantly lower than the national average (25% self-reported VDGF exposures in the longest held job.

Results

During 2020–2021, of an estimated 169 million US workers aged ≥18 years who were employed at any time during the previous 12 months, 12.7 million (7.5%) had current asthma (Table 1). The current asthma prevalence was highest among workers aged 18–24 years (9.3%), females (9.6%), non-Hispanic American Indian Alaskan Natives (AIAN; 12.9%), those with health insurance (7.8%), and those living below the federal poverty level (10.2%) (Table 1). Female workers were more likely to report current asthma as compared with male workers (PR = 1.7). Workers with depression (PR = 1.6), poor physical health (PR = 2.3) and those with BMI ≥30% (obese; PR = 1.9) were approximately two times as likely to report current asthma as compared with workers with no depression, excellent health and workers with a BMI of 18.5 ≤ 25 (healthy weight), respectively.

By industry, workers in the administrative support, waste management, remediation and management of companies (9.6%), education services (9.1%), and healthcare and social assistance (9.1%), industries had the highest current asthma prevalence. By occupation, current asthma prevalence was highest among community and social services workers (11.1%), legal (10.2%) and education, training and library (9.5%) workers (Table 2).

By sex, female workers in the finance and insurance industry (11.9%) and males in the arts, entertainment, and recreation industry (9.3%) had the highest current asthma prevalence. By occupation, female workers in the protective services (16.0%) and males in the legal occupations (9.1%) had the highest current asthma prevalence (Table 2).

Among workers with current asthma, 40.0% (an estimated 5.1 million) had at least one asthma attack/episode, and 8.6% (1.1 million) had at least one asthma-related ER visit in the past 12 months (Table 1). The proportion of workers with current asthma who had at least one asthma attack/episode was highest among workers aged 45–64 years (43.2%), females (43.7%), non-Hispanic AIAN (47.7%), and those with poor/fair physical health (54.2%), workers in the arts, entertainment, and recreation (47.3%) industry and arts, design, entertainment, sports, and media (50.8%) occupations (Tables 1 and 3).

The proportion of workers with current asthma who had at least one asthma-related ER visit in the 12 months prior to the interview was highest among workers aged 18–24 years (10.0%), females (10.4%), non-Hispanic AIAN (25.4%), those with less than high school education (11.5%), those categorized as poor (13.7%), current smokers (14.0%), those with no health insurance (9.9%), workers reporting poor/fair physical health (14.0%) or depression (10.4%) and workers in the accommodation and food services (19.2%) industry and food preparation and serving related (16.1%) occupations (Tables 1 and 3).

By industry, of the estimated 12.7 million workers with current asthma, 1.2 million asthma cases were attributable to workplace risk factors, and the attributable fraction was estimated at 9.2%. By occupation, an estimated 1.5 million asthma cases were attributable to workplace risk factors, and the attributable fraction was estimated at 12.2% (Table 2). Highest number of asthma cases attributed to employment by industry were among retail trade (n = 258,500; 17%) followed by administrative & support and waste management & remediation services and management of companies (n = 231,200; 29%) and health care and social assistance (n = 187,100; 9%). Highest number of asthma cases associated with employment by occupation were among office and administrative support (n = 239,400; 15.3%) followed by sales and related (n = 224,400; 17.6%) and education, training, and library (n = 167,800; 17.9%) (Table 2).

Discussion

Asthma prevalence among US workers

During 2020–2021, an estimated 12.7 million US workers had current asthma. Among workers with asthma, approximately, half experienced an asthma attack/episode in the past 12 months and 1 in 12 had an asthma-related ER visit. The estimated current asthma prevalence among workers has increased from 6.8% (11 million workers) during 2011–2016 (3) to 7.5% (12.7 million) in 2020–2021. However, the current study findings indicate that the prevalence of asthma attack/episode and asthma-related ER visits among workers with current asthma have declined (from 44% to 40% and 9.9% to 8.6%, respectively). The lower prevalence of asthma attack/episode and asthma-related ER visits among workers during 2020–2021 may be partially explained by changes in the work arrangements from workplace to telework/remote work (i.e. working at home offices) during the Coronavirus Disease 2019 (COVID-19) pandemic,

Table 1. Prevalence of current asthma*, asthma attack† and asthma-related ER visits§ and prevalence ratio by selected characteristics—National Health Interview Survey, 2020–2021.

Selected characteristics	Total working adults¶ weighted $N \times 1{,}000$	$N \times 100$	Current asthma			
			Overall *P* (95%CI)	PR**	Asthma attack *P* (95%CI)	ER visits *P* (95%CI)
Total	169,393	12,684	7.5 (7.2–7.8)	NC	40.0 (37.8–42.3)	8.6 (7.3–10.0)
Age group						
18–24	23,596	2,179	9.3 (8.0–10.5)	1.5 (1.2–1.8)	34.0 (27.7–40.2)	10.0 (5.5–14.4)
25–44	72,515	5,443	7.5 (7.0–8.0)	1.2 (1.1–1.4)	41.4 (38.0–44.8)	9.5 (7.4–11.7)
45–64	60,591	4,266	7.1 (6.6–7.5)	1.1 (1.0–1.3)	43.2 (39.7–46.7)	7.3 (5.6–9.1)
≥65	12,691	795	6.3 (5.4–7.1)	Ref	30.0 (23.4–36.5)	5.4 (2.6–8.2)
Sex						
Females	88,379	4,905	9.6 (9.1–10.2)	1.7 (1.6–1.9)	43.7 (40.8–46.6)	10.4 (8.4–12.4)
Males	80,988	7,779	5.6 (5.1–6.0)	Ref	34.1 (30.5–37.8)	5.8 (4.2–7.4)
Race/Ethnicity						
Hispanic	30,284	1,927	6.4 (5.6–7.2)	1.6 (1.2–2.1)	40.6 (34.1–47.1)	16.2 (10.9–21.5)
NH Whites	104,829	7,951	7.6 (7.2–8.0)	1.8 (1.5–2.9)	41.1 (38.4–43.8)	6.0 (4.6–7.3)
NH Blacks	19,224	1,836	9.6 (8.4–10.7)	2.2 (1.7–2.8)	34.7 (28.7–40.7)	10.9 (7.4–14.4)
NH Asian	10,432	438	4.2 (3.3–5.1)	Ref	42.1 (30.6–53.6)	§§
NH AIAN and others††	2,176	279	12.9 (9.4–16.4)	3.1 (2.2–4.4)	47.7 (32.1–63.3)	25.4 (11.1–39.6)
Multiple	2,447	254	10.4 (6.8–14.0)	2.4 (1.6–3.5)	27.5 (14.1–40.9)	§§
Education						
≤High school, GED	35,279	2,408	6.8 (6.1–7.6)	Ref	39.9 (34.5–45.3)	11.5 (7.7–15.3)
>High school	133,710	10,257	7.7 (7.3–8.1)	1.1 (0.9–1.2)	40.1 (37.7–42.5)	8.0 (6.6–9.3)
Unknown/missing	404					
Poverty index¶¶						
Poor	11,960	1,220	10.2 (8.6–11.8)	1.5 (1.2–1.7)	42.8 (34.1–51.5)	13.7 (7.4–20.0)
Near poor	25,275	2,071	8.2 (7.3–9.1)	1.2 (1.1–1.4)	42.0 (36.2–47.8)	10.5 (6.8–14.2)
Not poor	120,946	8,521	7.1 (6.7–7.4)	Ref	38.7 (36.1–41.4)	7.3 (5.8–8.8)
Unknown	11,212	872	–	–	–	
Health insurance						
Not insured	20,518	1,056	5.1 (4.3–6.0)	Ref	39.5 (30.1–48.9)	9.9 (3.6–16.2)
Insured	148,339	11,586	7.8 (7.5–8.2)	1.5 (1.2–1.8)	40.2 (37.9–42.5)	8.5 (7.1–9.9)
Unknown/missing	536	–	–	–	–	–
U.S. census region* **						
Northeast	29,633	2,302	7.8 (6.8–8.7)	1.1 (0.9–1.2)	38.0 (32.7–43.4)	7.0 (4.6–9.4)
Midwest	36,743	2,875	7.8 (7.1–8.6)	1.1 (1.0–1.2)	36.8 (32.5–41.2)	4.9 (3.2–6.6)
South	61,893	4,371	7.1 (6.5–7.6)	Ref	41.6 (37.3–45.9)	10.8 (8.0–13.6)
West	41,123	3,135	7.6 (7.0–8.3)	1.1 (0.9–1.2)	42.1 (38.1–46.2)	10.2 (7.3–13.2)
Body mass index (BMI)†††						
Underweight (<18.5)	2,166	78	3.6 (1.6–5.7)	0.6 (0.3–1.0)	–	0
Normal18.35–25	52,448	3,168	6.0 (5.5–6.6)	Ref	39.9 (35.7–44.0)	8.9 (6.3–11.4)
Overweight (25–30)	56,694	3,613	3.4 (5.9–6.9)	1.2 (1.1–1.3)	37.6 (33.3–41.8)	7.7 (5.4–10.1)
Obese (≥30)	54,852	5,579	10.2 (9.5–10.9)	1.9 (1.7–2.1)	41.9 (38.5–45.3)	9.3 (7.0–11.5)
Unknown/missing	3,233	245	7.6 (5.4–9.9)		–	
Smoking status						
Current	19,709	1,412	7.2 (6.3–8.1)	1.1 1.0–1.2)	44.8 (38.3–51.4)	14.0 (9.5–18.5)
Former	33,560	2,513	7.5 (6.8–8.2)	1.1 (1.0–1.3)	44.9 (40.0–49.9)	6.4 (4.1–8.8)
Never	115,779	8,734	7.6 (7.1–8.0)	Ref	37.8 (35.2–40.3)	8.4 (6.8–10.1)
Unknown/missing	345	–	–	–	–	–
Physical health§§§						
Excellent/very good/good	156,504	10,774	6.9 (6.6–7.2)	Ref	37.5 (35.2–39.9)	7.7 (6.3–9.1)
Poor/fair	12,841	1,909	14.9 (13.3–16.5)	2.3 (2.1–2.6)	54.2 (48.4–59.9)	14.0 (10.2–17.9)
Depression¶¶¶						
Yes	76,190	7,390	9.7 (9.2–10.3)	1.6 (1.4–1.7)	46.1 (43.1–49.2)	10.4 (8.6–12.2)
No	92,907	5,283	5.7 (5.3–6.1)	Ref	31.5 (28.4–34.7)	6.2 (4.3–8.1)

Abbreviation: CI, confidence interval; ER, emergency room; PR, prevalence ratio; NH, non-Hispanic; AIAN, American Indian Alaskan Natives; GED, General Educational Development; NC, not calculated.

*Defined as a "yes" response to both questions "Have you ever been told by a doctor or other health professional that you had asthma?" and "Do you still have asthma?".

†Defined as a "yes" response to the question "During the past 12 months, have you had an episode of asthma or an asthma attack?" (Question administered only to those identified with current asthma).

§Defined as a "yes" to the question "During the past 12 months, have you had to visit an ER or urgent care center because of asthma?" (Question administered only to those identified with current asthma).

¶Adults who reported "working at a job or business"; "with a job or business but not at work"; or "working, but not for pay, at a family–owned job or business" during the last 12 months of the survey interview. Estimates are weighted to provide national estimates.

**PR adjusted for age sex education and health insurance status.

§§Includes Non-Hispanic American Indian Alaskan Native and any other group.

¶¶Poverty index based on family income and family size using the U.S. Census Bureau's poverty thresholds for the previous calendar year. "Poor"" persons are defined as below the poverty threshold. "Near poor" persons have family incomes of 100% to less than 200% of the poverty threshold. "Not poor" persons have family incomes that is 200% of the poverty threshold or greater. Additional information available at Survey Description, National Health Interview Survey, 2020 (cdc.gov).

***Northeast: Connecticut, Maine, Massachusetts, New Jersey, New Hampshire, New York, Pennsylvania, Rhode Island and Vermont; Midwest: Illinois, Indiana, Iowa, Kansas, Michigan, Minnesota, Missouri, Nebraska, North Dakota, Ohio, South Dakota and Wisconsin; South: Alabama, Arkansas, Delaware, District of Columbia, Florida, Georgia, Kentucky, Louisiana, Maryland, Mississippi, North Carolina, Oklahoma, South Carolina, Tennessee, Texas, Virginia, and West Virginia; West: Alaska, Arizona, California, Colorado, Hawaii, Idaho, Montana, New Mexico, Nevada, Oregon, Utah, Washington, and Wyoming.

†††BMI was classified as follows: underweight is BMI< 18.5; healthy weight is BMI 18.5 to <25; overweight/obese is BMI > = 25.

§§§Physical health was assessed based on responses to the question: "Would you say your health in general is excellent, very good, good, fair, or poor?" and grouped into two categories (1) excellent/very good/good and (2) poor/fair health.

¶¶¶Workers were considered being depressed based on "daily," "weekly," "monthly," "a few times a year" responses to the question: "How often do you feel depressed? Would you say daily, weekly, monthly, a few times a year, or never?" or if they reported taking any medications for depression.

Table 2. Current asthma* prevalence, prevalence ratio, † and attributable cases§ by industry and occupation—National Health Interview Survey, 2020–2021.

Industry/occupation	Total working adults¶ Weighted *N*×1,000	Current asthma Number *N*×1,000	*P* (95%CI)	PR (95%CI)	AC *N* x 1,000	PAF** (%)	Males *P* (95%CI)	Females *P* (95%CI)
Industry								
Agriculture, forestry, fishing, and hunting	2,271	67	3.0 (1.4–4.5)	0.5 (0.3–0.9)	0	0.00	3.1 (1.2–5.0)	–**
Mining	585	43	7.4 (3.2–11.6)	1.2 (0.6–2.3)	8	0.06	7.4 (2.8–11.9)	–
Utilities	1,431	87	6.1 (2.9–9.3)	1.0 (0.5–1.8)	0	0.00	5.4 (1.6–9.2)	8.5 (2.2–14.9)
Construction	12,498	417	3.3 (2.5–4.1)	0.6 (0.4–0.9)	0	0.00	3.3 (2.4–4.1)	4.0 (1.3–6.6)
Manufacturing	15,585	925	6.0 (5.0–6.9)	0.9 (0.6–1.3)	0	0.00	4.7 (3.7–5.7)	8.6 (6.5–10.6)
Wholesale trade	3,431	188	5.5 (3.2–7.8)	0.8 (0.5–1.4)	0	0.00	4.3 (2.2–6.4)	8.5 (2.3–14.6)
Retail trade	16,565	1,489	9.0 (7.8–10.2)	1.2 (0.8–1.7)	258	2.05	6.5 (5.0–8.0)	11.4 (9.6–13.2)
Transportation and warehousing	8,628	584	6.8 (5.3–8.3)	1.1 (0.7–1.6)	38	0.30	5.6 (4.0–7.1)	10.1 (6.7–13.6)
Information	3,326	229	6.9 (4.6–9.2)	Ref	0	0.00	7.4 (4.4–10.5)	6.0 (2.7–9.2)
Finance and insurance	7,767	625	8.1 (6.5–9.6)	1.1 (0.7–1.6)	48	0.38	3.7 (2.2–5.2)	11.9 (9.3–14.4)
Real estate and rental & leasing	3,131	160	5.1 (3.4–6.8)	0.8 (0.5–1.2)	0	0.00	3.2 (1.2–5.1)	7.6 (4.6–10.5)
Professional, scientific and technical services	13,762	1,105	8.0 (6.9–9.1)	1.1 (0.8–1.6)	138	1.09	5.8 (4.5–7.0)	11.3 (9.4–13.1)
Administrative, support, waste management & remediation services and management companies	8,188	787	9.6 (7.9–11.4)	1.4 (1.0–2.1)	231	1.90	8.4 (6.0–10.7)	11.3 (8.3–14.3)
Education services	14,610	1,329	9.1 (7.9–10.3)	1.1 (0.8–1.6)	158	1.25	7.5 (5.7–9.3)	9.9 (8.3–11.4)
Health care and social assistance	22,746	2,077	9.1 (8.2–10.1)	1.1 (0.8–1.6)	187	1.48	7.0 (5.1–8.9)	9.7 (8.6–10.8)
Arts, entertainment, and recreation	3,469	282	8.2 (5.8–10.5)	1.1 (0.7–1.8)	32	0.25	9.3 (5.8–12.7)	6.8 (3.9–9.8)
Accommodation and food services	10,645	776	7.3 (5.8–8.8)	1.0 (0.6–1.4)	0	0.00	5.3 (3.4–7.2)	8.8 (6.6–11.1)
Other services (except public administration)	8,872	690	7.8 (6.2–9.3)	1.1 (0.7–1.6)	43	0.34	7.5 (5.0–9.9)	8.0 (6.0–10.0)
Public administration	8,167	557	6.8 (5.6–8.1)	1.0 (0.7–1.4)	0	0.00	4.7 (3.2–6.1)	9.5 (7.5–11.5)
Armed forces/missing, unknown	3,220	210	6.5 (4.3–8.7)	1.0 (0.6–1.6)	4	0.03	4.2 (1.9–6.5)	9.3 (5.3–13.3)
Total	**168,898**	**12,627**	**7.5 (7.2–7.8)**		**1,145**	**9.15**	**5.6 (5.1–6.0)**	**9.6 (9.1–10.2)**
Occupation								
Management	17,483	1,118	6.4 (5.5–7.3)	1.0 (0.8-1.3)	14	0.11	4.8 (3.8–5.9)	8.8 (7.2–10.3)
Business and financial operations	9,864	817	8.3 (7.0–9.6)	1.2 (0.9-1.6)	129	1.02	6.1 (4.5–7.7)	10.3 (8.3–12.3)
Computer and mathematical	6,674	412	6.2 (4.8–7.6)	ref	0	0.00	4.7 (3.4–6.1)	10.4 (6.9–13.9)
Architecture and engineering	3,434	152	4.5 (2.9–6.0)	0.8 (0.5–1.2)	0	0.00	4.3 (2.5–6.0)	5.5 (2.0–9.0)
Life physical, and social science	1,935	141	7.3 (4.7–9.9)	1.0 (0.7–1.6)	3	0.02	–	10.4 (6.2–14.7)
Community and social services	2,927	324	11.1 (8.2–13.9)	1.5 (1.0–2.1)	105	0.83	–	13.0 (9.6–16.4)
Legal	1,786	182	10.2 (6.4–13.9)	1.5 (1.0–2.3)	63	0.50	9.1 (3.7–14.5)	11.2 (6.2–16.2)
Education, training, and library	9,938	938	9.5 (8.0–10.9)	1.2 (0.9–1.6)	168	1.33	8.0 (5.3–10.7)	10.0 (8.2–11.8)
Arts, design, entertainment, sports, and media	3,435	281	8.2 (6.2–10.2)	1.2 (0.9–1.7)	49	0.39	6.5 (3.8–9.2)	10.1 (7.0–13.2)
Healthcare practitioners and technical	9,661	862	8.9 (7.6–10.3)	1.1 (0.9–1.5)	108	0.86	6.6 (4.1–9.1)	9.7 (8.1–11.3)
Healthcare support	6,009	477	7.9 (6.3–9.6)	1.0 (0.7–1.4)	0	0.00	8.8 (3.3–14.2)	7.8 (6.1–9.5)
Protective service	3,375	254	7.5 (5.3–9.7)	1.2 (0.9–1.8)	46	0.36	4.6 (2.5–6.6)	16.0 (9.9–22.0)
Food preparation and serving related	8,046	526	6.5 (4.9–8.2)	0.9 (0.6–1.2)	0	0.00	4.3 (2.4–6.2)	8.0 (5.7–10.3)
Building and grounds cleaning and maintenance	6,970	593	8.5 (6.6–10.4)	1.4 (1.0–1.9)	167	1.32	6.8 (4.5–9.0)	10.6 (7.3–14.0)
Personal care and service	4,470	344	7.7 (5.6–9.8)	1.0 (0.7–1.4)	0	0.00	8.0 (3.7–12.2)	7.6 (5.2–10.0)
Sales and related	14,892	1,278	8.6 (7.3–9.9)	1.2 (0.9–1.6)	224	1.78	6.1 (4.7–7.5)	10.9 (9.0–12.8)
Office and administrative support	17,755	1,569	8.9 (7.7–10.1)	1.2 (0.9–1.5)	239	1.90	7.8 (5.6–10.1)	9.3 (7.9–10.6)
Farming, fishing, and forestry	1,282	–	–	0.7 (0.2–2.3)	0	0.00	–	–
Construction and extraction	8,891	307	3.5 (2.4–4.5)	0.7 (0.5–1.0)	0	0.00	3.2 (2.2–4.1)	–
Installation, maintenance, and repair	5,001	255	5.1 (3.5–6.7)	1.0 (0.7–1.4)	0	0.00	5.0 (3.4–6.6)	–

(*Continued*)

Table 2. Continued.

Industry/occupation	Total working adults[¶] Weighted *N*×1,000	Current asthma Number *N*×1,000	*P* (95%CI)	PR (95%CI)	AC *N* x 1,000	PAF[**] (%)	Males *P* (95%CI)	Females *P* (95%CI)
Production	8,742	655	7.5 (5.9–9.1)	1.2 (0.9–1.6)	112	0.89	6.8 (5.0–8.7)	9.0 (6.0–11.9)
Transportation and material moving	13,186	887	6.7 (5.5–7.9)	1.1 (0.9–1.5)	106	0.84	5.5 (4.2–6.8)	11.0 (8.0–14.0)
Military/missing, unknown	3,136	207	6.7 (4.4–8.9)	1.0 (0.7–1.5)	8	0.06	–	–
Total	**168,898**	**12,627**	**7.5 (7.2–7.8)**		**1,541**	**12.20**	**5.6 (5.1–6.0)**	**9.6 (9.1–10.2)**

Abbreviation: CI, confidence interval; POR, prevalence ratio; PAF, population attributable fraction; AC, attributable cases.
Note: The overall totals may not add up due to rounding.
[*]Defined as a "yes" response to the questions "Have you ever been told by a doctor or other health professional that you had asthma?" and "Do you still have asthma?".
[†]Adjusted prevalence ratio, adjusted for age, sex, education, and health insurance status. Reference group for industry: information industry, and for occupation: computer and mathematical occupation.
[§]Number of current asthma cases attributable to employment by industry and occupation.
[¶]Adults who reported "working at a job or business"; "with a job or business but not at work"; or "working, but not for pay, at a family–owned job or business" during the last 12 months of the survey interview. Estimates are weighted to provide national estimates for current employment.
[**]provides an estimate in percent of the overall burden of asthma among working adults associated with workplace risk factors by industry/occupation.
–Represent relative standard error > 30%, data not reported.

likely resulting in lower frequency of occupational exposures (23). Also, during the early COVID-19 pandemic due to concerns of potential exposure to the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) there was a 42% overall decline in ER visits, and persons with asthma might have avoided ER in-person visits and utilized virtual visits and triage help lines instead (22). Similar to the previous findings, workers aged 18–24 years, females, non-Hispanic AIAN, those with insurance, workers living below the federal poverty level, who reported poor physical health, and those with depression were significantly more likely to report current asthma (3,5,24,25).

Asthma burden by industry and occupations

Higher prevalence of asthma attacks and ER visits among workers in certain industries and occupations has been associated with various factors, including presence of potential exposures/controls, number of workers employed in each industry or occupation and workplace environment (3,26,27). Nearly, half of the workers with asthma in arts, design, entertainment, sports, and media occupation reported an asthma episode/attack and could have been associated with work-place exposures (including irritant chemicals, dusts, physical exertion, etc.) (14,25). In addition, an estimated 19% of workers with asthma in the accommodation and food services industry reported an ER Visits. Workplace exposures, second hand smoke, stress and poor ventilation or exhaust systems have been associated with chronic respiratory symptoms (3,26–29). For example, a Taiwanese study found that in a bakery with no ventilation there was an increased concentration of inhalable flour dust in the oven and baking areas compared with a bakery with a local exhaust ventilation (30). Furthermore, an estimated 30% of all workers in the accommodation and food services industry used some form of tobacco (31). Cigarette smoke is a common trigger for asthma. Both smoking and secondhand smoke exposures can irritate the airways, leading to airway narrowing and exacerbations of asthma symptoms (28,32). Long-term exposure and asthma symptoms can lead to serious implications on disease progression into chronic respiratory illnesses, which might subsequently cause poor quality of life, disability, increase in work lost days, and reduce productivity (9,30).

Asthma cases attributed to work

Current findings indicate that, an estimated 9.2%–12.2% of all current asthma cases were associated with employment by industry and occupation. The overall proportions of asthma cases attributable to employment by industry were lower than those for the occupation. This can be partially explained by reference groups selected to assess workplace risk factors, and the fact that the industry group can include workers from several occupations and some of the occupations with increased risk for asthma may not be represented by the industry categories with increased risk. The highest number of asthma cases associated with employment by occupations were in the office and administrative support, followed by sales and related, and education training and library occupations and by industry, retail trade, administrative & support and

Table 3. Prevalence of asthma attack* and asthma-related ER visits among working† adults with current asthma§ by industry and occupation—National Health Interview Survey, 2020–2021.

	Current asthma§		
Industry/Occupation	Weighted $N \times 1{,}000$	Asthma attack P (95%CI)	ER visits % (95% CI)
Agriculture, forestry, fishing, and hunting	67	–	–
Mining	43	–	–
Utilities	87	–	–
Construction	417	42.6 (31.0–54.2)	–
Manufacturing	925	35.9 (28.1–43.7)	–
Wholesale trade	188	42.8 (19.2–66.4)	
Retail trade	1,489	40.1 (33.5–46.7)	7.3 (4.3-10.4)
Transportation and warehousing	584	31.7 (22.1–41.3)	–
Information	229	26.8 (12.6–41.0)	–
Finance and insurance	625	40.6 (31.0–50.1)	–
Real estate and rental and leasing	160	41.9 (25.4–58.4)	–
Professional, scientific and technical services	1,105	38.0 (31.3–44.8)	6.3 (2.8-9.8)
Administrative & support and waste management & remediation services, & management of companies	787	39.2 (29.6–48.9)	–
Education services	1,329	41.9 (35.4–48.5)	12.1 (7.3-16.8)
Health care and social assistance	2,077	44.9 (39.6–50.1)	9.9 (6.6-13.2)
Arts, entertainment, and recreation	282	47.3 (32.8–61.8)	
Accommodation and food services	776	36.4 (26.7–46.1)	19.2 (10.9-27.5)
Other services (except public administration)	690	46.7 (36.4–57.0)	–
Public administration	557	33.2 (24.1–42.4)	–
Armed forces/unknown/missing	210	–	–
Occupation			
Management	1,118	37.8 (30.4–45.1)	9.7 (4.9-14.5)
Business and financial operations	817	38.5 (30.5–46.5)	–
Computer and mathematical	412	37.5 (26.2–48.7)	–
Architecture and engineering	152	42.7 (25.2–60.2)	–
Life physical, and social science	141	50.4 (32.5–68.3)	–
Community and social services	324	41.5 (28.9–54.1)	–
Legal	182	30.7 (15.7–45.7)	–
Education, training, and library	938	38.7 (31.0–46.3)	8.3 (3.8-12.8)
Arts, design, entertainment, sports, and media	281	50.8 (37.7–63.9)	–
Healthcare practitioners and technical	862	45.4 (38.4–54.3)	8.4 (4.4-12.3)
Healthcare support	477	46.5 (35.4–57.6)	11.2 (4.6-17.9)
Protective service	254	39.4 (24.4–54.4)	–
Food preparation and serving related	526	35.1 (23.5–46.8)	16.1 (6.8-25.4)
Building and grounds cleaning and maintenance	593	41.9 (29.8–53.9)	–
Personal care and service	344	41.8 (27.1–56.6)	–
Sales and related	1,278	41.2 (33.9–48.6)	7.3 (3.4-11.1)
Office and administrative support	1,569	42.7 (36.0–49.5)	10.0 (6.0-14.0)
Farming, fishing, and forestry	47	–	–
Construction and extraction	307	36.2 (22.4–50.0)	–
Installation, maintenance, and repair	255	36.4 (20.4–52.5)	–
Production	655	36.1 (25.6–46.5)	–
Transportation and material moving	887	29.0 (20.5–37.5)	7.6 (3.1-12.1)
Military/unknown/missing	209	–	

Abbreviations: CI, confidence interval; POR, prevalence odds ratio; ER, emergency room.

*Defined as a "yes" response to the question "During the past 12 months, have you had an episode of asthma or an asthma attack?" (Question administered only to those identified with current asthma).

†Reported "working at a job or business"; "with a job or business but not at work"; or "working, but not for pay, at a family–owned job or business" during the last 12 months of the survey interview. Estimates are weighted to provide national estimates for current employment.

§Defined as a "yes" response to both questions "Have you ever been told by a doctor or other health professional that you had asthma?" and "Do you still have asthma?".

–represent relative standard error > 30%; data not reported.

waste management & remediation services and management of companies and healthcare and social assistance industry. Workers in these industries and occupations often are exposed to environmental indoor allergens, cleaning agents, aerosolized medications (e.g., pentamidine, ribavirin), anesthetic agents, glutaraldehyde, enzymes, latex, metal dusts, adhesives, dyes, wood dusts, indoor dampness, mold, among others (25–27,33), all of which have been associated with WRA.

Asthma care and management

Identifying and minimizing exposure to these triggers is important for managing asthma effectively (14,34). In addition, high asthma prevalence among workers in certain industries and occupations underscores the

importance of implementation of targeted interventions, including improved access to healthcare and asthma management resources, as well as addressing underlying social determinants of health that may contribute to asthma disparities. Workers have the right to a safe workplace, free of known hazards such as triggers that can cause or exacerbate asthma (34,35). This can be achieved by reducing or eliminating exposure to WRA triggers; substituting agents causing asthma triggers with less harmful products and materials, implementation of engineering controls (e.g. isolating or enclosing processes or improve ventilation) and implementation of appropriate administrative controls (including smoke free policies), work practices, policies, worker training and personal protective equipment use (14,29,30,33–35).

Strengths and limitations

The current study has several key strengths. First, it utilizes NHIS data, which is a nationally representative sample with a large sample size, enhancing its generalizability to the working population. Second, it provides the most recent national estimates on prevalence and burden of asthma among working adults, and also provides the proportion of asthma cases associated with employment by industry and occupation. Lastly, the standardized industry and occupational classification used in the study ensures consistency and comparability when assessing asthma among working adults. However, the findings in this report are subject to some limitations. First, NHIS data are self-reported and may be subject to recall bias. The asthma data were not validated by pulmonary function tests, medical records review or follow-up with health-care providers. However, previous studies have found self-report of adult asthma to be reliable compared with reviews of medical records (36).Only adults who were employed at some time in the past 12 months were included in this study. Workers with severe asthma might have left employment because of workplace exposures that might have exacerbated their asthma and could not be included in this study. Moreover, the industry and occupation might not accurately identify workers' industry and occupation where exposures might have occurred. The asthma attributable cases calculated varied by industry and occupation and can be sensitive to the choice of reference group. An industry group can include workers from several occupations. Therefore, it is also possible that some of the occupation groups with higher PRs may not represent the industry categories with increased risk. Additionally, sample size in certain groups was small for some groups resulting in unreliable estimates. Finally, lack of detailed information on asthma episodes/attack events was not available, therefore, it was not possible to determine their association with work.

Conclusions

An estimated 9.2% to 12.2% of all asthma cases among employed adults could be attributed to work or workplace risk factors, consistent with other cross-sectional studies (14,15,28). Moreover, disparities in current asthma, asthma attacks/episodes, and asthma-related ER visits by sociodemographic characteristics, industry, and occupations continue to exist. These findings can guide public health policies and workplace safety regulations to reduce the burden of WRA (37), and can assist clinicians in identification of workers who should be evaluated for asthma in relation to work, especially in industries and occupations with a high prevalence of asthma, asthma attacks, and asthma-related ER visits. Work is a social determinant of health, collection of detailed industry and occupation data during physician office visits, in other clinical settings and in surveys are essential for implementation of targeted workplace interventions and to improve overall worker health and safety.

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Authors' contributions

Girija Syamlal: Conceptualization, Methodology, Data Analyses, interpretation and writing- Original draft preparation. **Katelynn Dodd:** Conceptualization, reviewing and editing of the manuscript. **Jacek Mazurek:** Supervision, Writing- reviewing and editing of the manuscript.

Institution and ethics approval and informed consent

The National Health Interview Survey (NHIS) data was approved by the Research Ethics Review Board of the National Center for Health Statistics. For this study, a secondary data analysis, publicly available NHIS data were used, and National Institute for Occupational Safety and Health Internal Review Board approval was not required.

Disclosure of interest

The authors report there are no competing interests to declare.

Disclaimer

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