Prevalence of Lifetime Asthma and Current Asthma Attacks in U.S. Working Adults: An Analysis of the 1997–2004 National Health Interview Survey Data

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Objective: *To estimate national prevalences of lifetime asthma and asthma attacks among workers by age, sex, race, occupation and industry, and estimate population attributable fraction to employment for asthma attacks in the United States.* ***Methods:*** *The 1997–2004 National Health Interview Survey data for currently working adults aged ≥18 years were analyzed.* ***Results:*** *Lifetime asthma prevalence was 9.2%; the social services religious and membership organizations industry and the health service occupation had the highest asthma prevalence. Asthma attack prevalence among workers with asthma was 35.4%; the primary metal industry and the health assessment and treating occupation had the highest attack prevalence. Approximately, 5.9% of cases reporting an asthma attack were attributed to employment when considering industries and 3.8% when considering occupations.* ***Conclusions:*** *Future studies and intervention strategies should address the higher prevalence of asthma in certain industries and occupations.* (J Occup Environ Med. *2009;51:1066–1074*)

Asthma is one of the most prevalent work-related respiratory diseases in the U.S. and other industrialized nations. Among adults aged ≥18 years in the U.S. self-reported asthma cases doubled from approximately 6.8 million (3.1%) in 1980 to 13.8 million (6.7%) in 2004.[1] Occupational exposures can trigger asthma exacerbations in asthmatic workers or induce asthma in a previously healthy worker.[2] An estimated 11 million workers are exposed to at least one of the 350 biological and chemical agents that are known to be associated with work-related asthma (WRA).[3–5]

WRA is generally classified into three categories: 1) occupational asthma, also known as sensitizer induced or immunologic asthma, is a new-onset asthma caused by sensitization to a substance at the workplace after a period of exposure at work; 2) reactive airways dysfunction syndrome, also known as irritant-induced or non-immunologic asthma, is new-onset asthma occurring immediately because of high levels of exposure to irritants at the workplace; and 3) work-aggravated asthma that includes existing asthma worsened by irritants or physical stimuli in the workplace.[6,7] A detailed work history, job duties, exposures information, industry, and onset of asthma symptoms or worsened at work will provide suggestive evidence of a workplace association.[2,7]

Studies have shown that 2% to 26% of all adult asthma cases may be

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associated with work-related factors.[8–10] Furthermore, in a recent analysis of population attributable risk estimates for occupational exposures (ie, proportion of adult asthma attributed to workplace exposures) for WRA in the U.S. and other countries, the attributable risk for WRA was 16.9%.[10] These estimates include both occupational and work-aggravated asthma.

WRA is associated with considerable socioeconomic consequences.[11,12] Based on the population attributable risk of 15% in 2002, the cost for WRA was estimated to be $1.6 billion in 2002 (74% were direct and 26% indirect).[12] Unemployment and financial burden associated with WRA can be high, in particular for industrial, woman, and older workers.[12,13]

The prevalence of WRA depends on the presence of exposure agents, levels of exposure, and host susceptibility factors such as atopy and cigarette smoking. A few population-based epidemiologic studies have investigated the relationship between long-term environmental and workplace exposures and the risk for developing asthma.[7–10] Exposure to contaminants in the air, such as dust, smoke, chemicals (eg, isocyanates, natural rubber latex, platinum salts), vapors, gases and fumes, allergens (eg, molds, animal dander, pollen), environmental tobacco smoke, irritants, cold temperature, and other occupational agents have been shown to initiate or aggravate asthma.[14,15]

The current study is based on a large sample of cross-sectional data from the National Health Interview Survey (NHIS), which is a multipurpose health survey conducted by the National Center for Health Statistics (NCHS), Centers for Disease Control and Prevention. The survey is one of the principal sources of information on the health of the U.S. civilian, non-institutionalized, household population. We aimed to identify industries and occupations associated with high prevalence of asthma and asthma attacks; to estimate the proportion of current asthma attack cases in the population which are attributable to occupational exposures; and to identify occupations or industries that place workers with asthma at greater risk for attacks.

Methods

Data Source

The NHIS is an annual survey conducted continuously since 1957.[16] Data are collected annually from approximately 38,000 households including 98,000 persons. Each year, a representative sample of households across the country is selected for NHIS, using a multistage cluster sample design. Details on sample design can be found in Design and Estimation for the NHIS 1995–2004.[17] Participation in the survey is voluntary. A single randomly selected adult household member is interviewed in person. Basic information on health status, health care services, and behavior are collected. For this study, we used data collected from 1997 to 2004. Multiyear data were used to improve precision and reliability of the estimates. The overall response rate varied annually from 70% to 74% for sample adults.

Case–Ascertainment

Data from adult participants aged 18 years and older were analyzed. Lifetime asthma and asthma attack prevalences were estimated based on positive responses to the questions: "Has a doctor or other health professional ever told you that you had asthma?" (Lifetime asthma), and "During the past 12 months, have you had an episode of asthma or an asthma attack?" (Asthma attack).

Current smokers were those who had smoked at least 100 cigarettes during their entire life and currently smoke every day or some days, former smokers were those who had smoked at least 100 cigarettes in their entire life and do not currently smoke, and never smokers were those who had never smoked or those who smoked less than 100 cigarettes during their entire life.

Currently employed adults were those 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 job or business" during the week prior to their interview.[16] Responses were obtained from each respondent regarding his or her industry and occupation. These were subsequently recoded into two two-digit industry or occupation recodes (41 industry and 43 occupation groupings), that are consistent with the 1995 revisions to the Standard Industrial Classification (SIC) and Standard Occupational Classification systems.[16]

Data Analysis

Estimated prevalences of lifetime asthma and asthma attacks among those with asthma were calculated by age, gender, race or ethnicity, smoking status, industry, and occupation. Sample weights provided by NCHS were used to take into account the complex sampling design and nonresponse. Cases with unknown, missing or unreliable estimates (ie, when the coefficient of variance was $\geq$30% for continuous variables) were excluded from the analysis.

We used multivariate logistic regression to estimate asthma attack prevalence odds ratios (PORs) adjusted for age, gender, race or ethnicity, and smoking status by industry and occupation, with corresponding 95% confidence intervals (CIs). The reference groups used for POR calculation were the insurance, real estate and other finance for industry, and the secretaries, stenographers, and typists, and other administrative support for occupations. This choice was based on the assumption that workers in these industries and occupations have minimal risk for asthma.[1,18–20] We used SAS 9.1 software (SAS Institute Inc., Cary, NC) to analyze data.

Population attributable fraction (PAF) of asthma attacks potentially attributable to employment was calculated using the formula:

TABLE 1
Estimated Number, Percent, Prevalence of Lifetime Asthma and Asthma Attacks by Demographic Characteristics—U.S. Working Adults (≥18 yr), 1997–2004

Characteristics	Working Adults		Lifetime Asthma Prevalence, % (95% CI)	Asthma Attack in Workers With Asthma Prevalence, % (95% CI)
	N	% (95% CI)		
Age group				
18–24	16,982,970	13.4 (13.1–13.6)	13.0 (12.3–13.6)	32.6 (30.1–35.0)
25–44	61,606,539	48.4 (48.1–48.7)	8.9 (8.7–9.1)	37.0 (35.7–38.3)
45–64	42,145,734	33.1 (32.8–33.4)	8.2 (8.0–8.5)	35.1 (33.4–36.7)
≥65	6,532,856	5.1 (5.0–5.3)	9.1 (8.4–9.8)	31.7 (28.0–35.5)
Sex				
Male	68,179,379	53.5 (53.3–53.8)	8.0 (7.7–8.2)	27.4 (26.0–28.7)
Female	59,088,719	46.5 (46.2–46.7)	10.7 (10.4–10.9)	42.2 (41.0–43.5)
Race/ethnicity				
All Hispanics	14,055,829	11.0 (10.9–11.2)	6.8 (6.4–7.1)	34.0 (31.2–36.7)
Non-Hispanic whites	94,274,334	74.1 (73.9–74.4)	9.7 (9.4–9.9)	36.0 (34.9–37.1)
Non-Hispanic blacks	13,588,972	10.7 (10.5–10.8)	9.4 (9.0–9.9)	32.9 (30.4–35.4)
Others	5,340,246	4.2 (4.1–4.3)	7.9 (7.1–8.7)	31.4 (26.7–36.2)
Smoking status				
Current	31,012,027	24.5 (24.2–24.7)	9.4 (9.0–9.7)	33.2 (31.5–35.0)
Former	25,292,870	20.0 (19.7–20.2)	10.0 (9.6–10.4)	35.1 (33.1–37.0)
Never	70,438,863	55.6 (55.3–55.9)	8.9 (8.7–9.1)	36.4 (35.1–37.7)
Total*	127,268,099		9.2 (9.1–9.4)	35.4 (34.4–36.3)

*Numbers may not add up to total because of missing values.

$$\mathrm{PAF} = \sum_{i=1}^{k} P_{\mathrm{ci}}(\mathrm{OR}_i - 1)/\mathrm{OR}_i$$

where k = number of industries (occupations); P_{ci} = cases_i/total cases, where cases_i represents the estimated number of asthma attack cases in the ith industry or occupation; OR_i is the odds ratio for asthma (adjusted for age, sex, race or ethnicity, and smoking status) estimated in the ith industry or occupation. Attributable cases (AC) are cases attributable to employment. AC was calculated according to the following formula:

$$\mathrm{AC} = N_i \times P_i(\mathrm{OR}_i - 1)/\mathrm{OR}_i$$

where N_i = estimated respondents in the ith industry or occupation; P_i = estimated prevalence in the ith industry or occupation.

Results

Of all workers, 48.4% were 25 to 44 years of age, 53.5% were males, 74.1% were non-Hispanic whites, and 55.6% were never smokers (Table 1). The estimated prevalence of lifetime asthma among all workers was 9.2%. Young workers (18–24 years), women, non-Hispanic whites, and former smokers had a higher prevalence of lifetime asthma (Table 1). The highest prevalences of lifetime asthma were associated with the social services religious and membership organizations (11.2%) and the health services, except hospitals (10.9%) industries, and the health service (11.5%) and health technologist and technicians (11.5%) occupations (Table 2).

Among workers with asthma, the prevalence of having an asthma attack was 35.4%. The asthma attack rate was highest among those aged 25 to 44 years (37.0%), non-Hispanics whites (36.0%), and never smokers (36.4%) (Table 1). Workers in the primary metal (47.1%) and social services, religious and membership organizations (44.7%) industries had the highest asthma attack prevalence (Table 3). Workers with asthma in the health assessment and treating (44.7%) and health service (44.2%) occupations had the highest asthma attack prevalence (Table 4). Overall 15 industries and 19 occupations had higher adjusted POR compared with the reference group (Tables 3 and 4). Of all adults with asthma who had an asthma attack, 5.9% were attributed to employment when considering industries and 3.8% when considering occupations (Tables 3 and 4). The social services, religious and membership organizations industry and the teachers, librarians and counselors occupation had the highest number of asthma attack cases attributed to employment (50,000 and 25,000, respectively) (Tables 3 and 4). The prevalence of an asthma attack among never smokers with asthma was approximately 50% in the furniture, lumber and wood and primary metal industries and the architects and surveyors and health assessment and treating occupations (Fig. 1a, b). The estimated numbers of asthma attack cases potentially attributable to employment after adjusting for age, sex, race or ethnicity, and smoking status among workers with asthma, was 239,000 considering industries and 156,000 considering occupations (Tables 3 and 4).

Discussion

WRA is the most common occupational lung disease affecting almost 5% to 15% of the population worldwide.[16–19] In this study, over-

TABLE 2
Top 20 Industries and Occupations With Highest Estimated Lifetime Asthma Prevalence—U.S. Working Adults (≥18 yr), 1997–2004

Industry	Prevalence, % (95% CI)	Occupation	Prevalence, % (95% CI)
Social services, religious and membership organizations	11.2 (10.2–12.1)	Health service	11.5 (10.3–12.7)
Health services, except hospitals	10.9 (10.2–11.7)	Health technologist and technicians	11.5 (10.0–13.0)
Eating and drinking places	10.9 (10.0–11.8)	Other professional specialty	11.2 (10.0–12.4)
Banking and credit agencies	10.7 (9.5–11.9)	Personal service	11.1 (9.8–12.3)
Elementary and secondary schools and colleges	10.5 (9.9–11.1)	Teachers, librarians, and counselors	10.9 (10.2–11.7)
Other educational services	10.4 (8.0–12.7)	Food service	10.8 (9.8–11.7)
Legal, engineering, and other professional services	10.1 (9.3–11.0)	Other administrative support	10.6 (10.0–11.1)
Food, bakery, and dairy stores	10.1 (8.9–11.3)	Architects and surveyors	10.5 (6.6–14.4)
Business services	10.0 (9.2–10.7)	Financial records processing	10.4 (9.0–11.9)
Entertainment and recreation services	9.8 (8.5–11.2)	Other sales	10.4 (9.6–11.2)
Transportation equipment	9.8 (8.5–11.1)	Secretaries, stenographers, and typists	10.4 (9.2–11.5)
Communications	9.7 (8.3–11.0)	Writers, artists, entertainers, and athletes	10.3 (9.1–11.5)
General merchandise stores	9.7 (8.4–11.0)	Health assessment and treating	10.0 (8.9–11.0)
Other and not specified retail trade	9.5 (8.8–10.3)	Technologist and technicians except health	9.7 (8.6–10.9)
Hospitals	9.5 (8.7–10.4)	Officials and administrators, public administration	9.6 (7.5–11.7)
Other personal services	9.4 (8.4–10.5)	Other protective service	9.4 (7.6–11.2)
Printing, publishing, and allied industries	9.3 (7.9–10.8)	Natural mathematical and computer scientists	9.3 (8.2–10.4)
Public administration	9.3 (8.6–10.0)	Freight, stock, and material handlers	9.1 (8.7–9.8)
Automotive dealers and gasoline stations	9.3 (7.9–10.7)	Cleaning and building service	8.9 (9.1–9.4)
Private households	9.1 (7.1–11.1)	Management related	8.9 (8.0–10.2)
Total	9.2 (9.1–9.4)	Total	9.2 (9.1–9.4)

TABLE 3
Estimated Number, Prevalence, POR, PAF, and AC for Having an Asthma Attack by Selected Industry—U.S. Working Adults (≥18 yr) With Lifetime Asthma, 1997–2004

	Asthma Attack in Workers With Asthma				
Industry	*N**	Prevalence, % (95% CI)	POR (95% CI)†	PAF%	AC*
Primary metal industry	41	47.1 (30.1–64.1)	2.19 (1.1–4.5)	0.26	11
Social services, religious, and membership organizations	535	44.7 (40.3–49.0)	1.27 (1.0–1.6)	1.24	50
Health services, except hospitals	779	42.3 (38.7–45.9)	1.14 (0.9–1.4)	0.98	40
Elementary and secondary schools and colleges	1127	40.4 (37.4–43.3)	1.09 (0.9–1.3)	0.91	37
Hospitals	501	40.2 (35.9–44.6)	1.05 (0.8–1.3)	0.25	10
Entertainment and recreation services	230	39.2 (31.9–46.5)	1.23 (0.9–1.7)	0.42	17
Communications	186	38.9 (31.8–45.9)	1.18 (0.8–1.7)	0.27	11
Business services	706	37.6 (33.9–41.3)	1.15 (0.9–1.5)	0.87	35
Food, bakery, and diary stores	288	36.6 (30.5–42.7)	1.02 (0.8–1.4)	0.05	2
Eating and drinking places	638	36.3 (32.2–40.5)	1.03 (0.8–1.3)	0.17	7
Fabricated metal industries, including ordnance	83	35.6 (23.9–47.3)	1.22 (0.7–2.1)	0.13	5
Other transportation	252	35.4 (29.2–41.5)	1.09 (0.8–1.5)	0.18	7
Printing publishing and allied industries	152	35.1 (27.1–43.2)	1.02 (0.7–1.5)	0.02	1
Other and not specified durable goods	177	33.9 (26.4–41.4)	1.03 (0.7–1.5)	0.04	1
Repair services	146	31.6 (23.2–39.9)	1.09 (0.7–1.7)	0.09	4
Other industries‡	4859	30.7 (29.3–32.0)	0.87 (0.7–1.0)	—	—
Insurance, real estate, and other finance§	801	36.7 (33.1–40.3)	1.00	—	—
Total	11,502	35.4 (34.5–36.3)		5.88	239

*Expressed in 1,000s.
†PORs adjusted for age, sex, race or ethnicity, and smoking status.
‡Other industries include industries with POR ≤1; for these PAF% was not calculated.
§Reference group.
Numbers may not add up to total because of missing values.

Fig. 1. a, Estimated asthma attack prevalence among never smokers with lifetime asthma, by industry—U.S. working adults (≥18 years), 1997–2004. b, Estimated asthma attack prevalence among never smokers with lifetime asthma, by occupation—U.S. working adults (≥18 years), 1997–2004.

all asthma prevalence in the U.S. working population was 9.2% compared with 11.0% among all adults (≥18 years) in 2001.[19] Of all working adults with asthma, 35.4% reported to have an asthma attack in the past year.

The prevalences of lifetime asthma and having an asthma attack were higher among workers in certain industries and occupations. In the primary metal industries nearly half of the workers with asthma reported an attack. Previous studies have shown that workers in this industry are exposed to metal fumes, metal salts, isocyanates, and metal working fluids. These exposures are known to be associated with asthma.[21–24] Furthermore, exposure to metal-rich particles and metal composition of ambient particulate matters has shown to exacerbate existing asthma among individuals.[22,24] In the social services, religious and membership organizations industry that included individual and family social services, child daycare services, business associations, art councils, professional membership organizations, labor unions, political, and religious organizations, approximately 45% of the workers with asthma reported an asthma attack. Although, exact causes of the higher asthma and asthma attack prevalence in this industry is unknown, there is a possibility that they might have previously worked or are currently working in jobs with important exposures or it could be due to self-selection of subjects with asthma into this industry.

In this study, the prevalence of having an asthma attack in the past year among individuals with asthma was highest among health-related occupations (ie, health assessment and treating and health service). This finding is consistent with previous studies reporting high WRA prevalence that was associated with exposure to potential asthmagens in health care settings.[5,25–28] For example, disinfectants and sterilants (eg, glutaraldehyde, formaldehyde), pharmaceuticals (eg, psyllium, antibiotics), sensitizing metals (eg, dental alloys), methacrylates, irritant aerosolized medications, and cleaning products were associated with WRA.[26–28] Delclos et al[29] indicated that there was ~2-fold increased likelihood of asthma among health care workers who were involved in cleaning and disinfecting instruments, used general cleaning products, used powdered latex gloves, or administered aerosolized medications. Furthermore, health care professionals (eg, nurses, physicians, therapists) are more knowledgeable about asthma and other health conditions and have access to health care more easily as compared with other workers.[26,27] Thus, they could be more frequently diagnosed with WRA which could contribute to the higher proportion of WRA among health-related occupations.

The overall lifetime asthma and asthma attack prevalence among the 24-to 44-year-old workers were higher compared with workers in other age groups. Education level and atopy have been associated with asthma among younger workers (23 to 25 years).[30] Lower education level and asthma association have been reported as a consequence of limiting the working options and rendering them more predisposed to work in high risk places.[31] Kogevinas et al[32] reported that the proportion of asthma among young adults attributed to occupation was 5% to 10% and excess risk was associated with

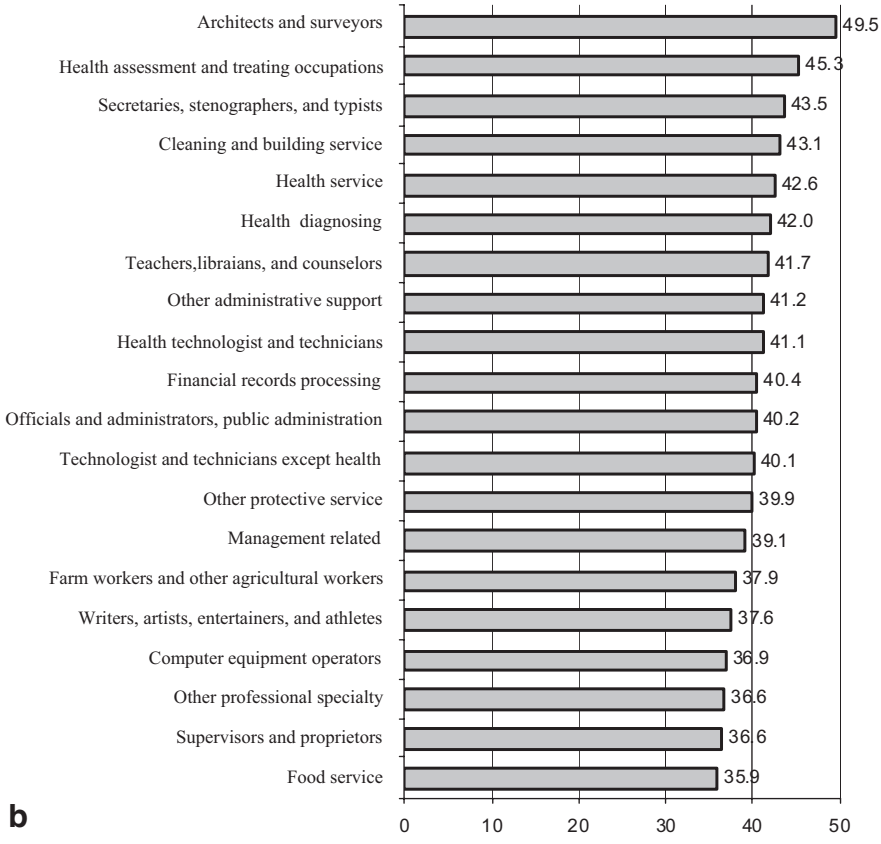

Fig. 1. (*Continued*).

exposure to biological dusts, mineral dusts, gases and fumes.

In this study, the overall prevalence of lifetime asthma in women was almost 2-fold higher than in men. Furthermore, 42.2% of all females with asthma had an asthma attack compared with 27.4% of males. These findings are similar to those previously published.[31,33–35] High WRA prevalence has been reported among female waitresses, cleaners, hair dressers, dental workers, textile workers, and silk workers.[35–39] In these occupations, exposure to hair-dyes, hair sprays, cleaning agents, and dust are the leading causes of wheezing, bronchitis, and asthma.[1,35–38] Also, investigators have shown that WRA is more common in women than it had been previously believed.[33,38,39] Moreover, women may be more sensitive to their health status, more likely to report asthma and more likely to seek medical attention.[38,39] Furthermore, women with asthma are three times more likely to be hospitalized for asthma and have longer hospital stays compared with men even though women on average have less severe episodes.[38] High asthma prevalence rates among females indicates a need for studies to examine the association of occupational exposures with asthma in this group.

Smoking has been shown to increase the overall asthma symptoms in individuals.[40] Both morbidity and mortality from asthma are increased in individuals who are cigarette smokers (current or former) compared with never smokers.[41] Our study shows that former smokers had the highest overall prevalence of lifetime asthma and asthma attacks. Among workers with asthma, never smokers had a higher percent of asthma attacks compared with current and former smokers. Furthermore, in the furniture, lumber and wood, and primary metal industry and in the architects and surveyors, and health assessment and treating occupation nearly 50% of never smokers with asthma reported an asthma attack in the previous year.

The overall PAF%s calculated for asthma attacks (6% considering industries; 4% considering occupations) were lower than those published previously by the American Thoracic Society (15%)[7] or estimated by Toren and Blanc (16.3%).[10] The PAF% calculated in our study was based on the concept of counterfactual risk estimate obtained from the prevalence of occupational categories compared with a reference group. The reference groups were preselected based on previous studies[1,18,19,20] and under the assumption that the exposure in the reference groups was minimal compared with all other comparison groups. The secretaries, stenographers, and typists and other administrative support occupations (occupational reference group) had a high prevalence of asthma and asthma attack compared with all working adults. This may have resulted from higher risk for asthma among these occupations possibly due to poor indoor environmental quality. Asthma and asthma like symptoms have shown to be related to exposure to dampness or mold in workplaces.[42] The other cause could be due to workers transferring from one job to another to avoid aggravation of their symptoms, although it is impossible to asses what proportion of asthma workers in the reference group is due to worker's migration to jobs with lower levels of potential exposures. Because of this possible influx of workers from hazardous jobs to a less hazardous job, counterfactual risk estimates (odds ratios in this study) tend to underestimate the true risk, which could have resulted in the underestimated number of cases that are attributable to their employment.

These results support other reports that have examined contribution of occupational exposures to the overall burden of asthma. Workers in certain industries and occupations may be at an increased risk for asthma attacks. In

TABLE 4
Estimated Number, Prevalence, POR, PAF, and AC for Having an Asthma Attack by Selected Occupations—U.S. Working Adults (≥18 yr) With Lifetime Asthma, 1997–2004

Occupation	Asthma Attack in Workers With Asthma				
	*N**	Prevalence % (95% CI)	POR (95% CI)†	PAF%	AC*
Health assessment and treating occupations	333	44.7 (39.3–50.1)	1.18 (0.92–1.51)	0.55	23
Health service	306	44.2 (38.6–49.7)	1.19 (0.92–1.53)	0.51	21
Other protective service	90	43.5 (33.5–53.5)	1.58 (1.03–2.44)	0.35	14
Health technologist and technicians	214	42.0 (35.2–48.8)	1.08 (0.80–1.46)	0.17	7
Financial records processing	220	41.9 (34.3–49.5)	1.03 (0.74–1.44)	0.07	3
Officials and administrators, public administration	74	41.3 (30.1–52.4)	1.27 (0.80–2.01)	0.16	6
Teachers, librarians, and counselors	759	40.9 (37.3–44.5)	1.09 (0.90–1.31)	0.60	25
Personal service	306	40.6 (34.7–46.4)	1.03 (0.79–1.34)	0.09	4
Computer equipment operators	32	40.1 (22.4–57.8)	1.30 (0.64–2.67)	0.07	3
Management related	455	38.5 (34.0–43.0)	1.08 (0.87–1.35)	0.31	13
Health diagnosing	84	37.9 (26.5–49.3)	1.23 (0.74–2.03)	0.14	6
Cleaning and building service	275	37.4 (31.3–43.5)	1.15 (0.86–1.53)	0.32	13
Managers and administrators, except public administration	1155	34.9 (32.0–37.7)	1.01 (0.85–1.20)	0.13	5
Technologist and technicians except health	259	34.5 (28.5–40.5)	1.06 (0.79–1.41)	0.11	5
Construction laborers	61	33.5 (21.6–45.5)	1.28 (0.74–2.23)	0.11	4
Natural mathematical and computer scientists	246	33.4 (27.4–39.4)	1.02 (0.76–1.37)	0.04	1
Farm operators and managers	48	31.5 (17.1–45.9)	1.12 (0.57–2.22)	0.04	2
Architects and surveyors	24	30.9 (13.1–48.7)	1.06 (0.46–2.44)	0.01	1
Other occupations‡	5266	31.2 (29.8–32.5)	0.91 (0.79–1.03)	—	—
Reference group§	1476	39.2 (36.6–41.7)	1.00	—	—
Total	11,685	35.3 (34.4–36.3)		3.76	156

*Expressed in 1,000s.
†PORs adjusted for age, sex, race or ethnicity, and smoking status.
‡Other occupations include occupations with POR ≤1; for these PAF% was not calculated.
§Reference group: secretaries, stenographers, and typists, and other administrative support.
Numbers may not add up to total because of missing values.

particular, the social services, religious and membership organizations industry, and health care-associated occupations have been found to have high prevalence of lifetime asthma, and asthma attack and may benefit from targeted interventions.

The prevalence of WRA may continue to increase because of the introduction of newer chemicals or agents and the changing workforce. Despite the increasing attention to the association of asthma with work exposures, WRA remains underrecognized and its population burden underestimated. This may be due, in part, to the fact that traditional approaches for studying asthma in working populations cannot adequately take into account the healthy worker effect. Presence of asthma symptoms could have influenced their job selection and sicker and more sensitive individuals could have selected jobs with lesser exposures.

There are some limitations to the study. First, the NHIS data were not designed to be representative of the U.S. employment patterns and are not focused on occupational hazards. Second, cross-sectional study design does not allow for the ascertainment of cause-effect association. Third, asthma diagnosis and asthma attack history were self-reported. There was a lack of objective information on asthma onset, number of asthma attacks, and exposure history. Respondents may have under- or over-reported asthma and asthma attacks, and the accuracy of self-reported physician's diagnosis of asthma collected in NHIS is not known. Fourth, the collected employment information applied only to the week prior to the interview. There is a possibility that occupational exposures associated with the development of asthma or asthma attacks may have occurred in a different occupation or industry, workers could have changed jobs and, thus, be exposed to different agents over time. In addition, the calculated prevalences could be under- or overestimated because of healthy worker effect (ie, ill and disabled persons may be excluded from employment or they may seek employment in work environments in which exposures are low).[43] The extent of underreporting or overreporting of asthma and asthma episodes or attacks cannot be determined. Finally, the PAF underestimates the proportion[44] of asthma attack cases estimated as potentially related to the specified industry or occupation.

Preventing new WRA cases and reducing the work-aggravated asthma by identifying and controlling exposures is the best approach to reducing the burden of work-related asthma. High asthma or asthma attack prevalences among workers in specific industries (occupations) in-

dicate a need for enhanced prevention programs for asthma. One of the examples of past successful interventions was the removal of powdered latex gloves from use in health care settings.[27,28] Employee medical surveillance can detect early disease and help in secondary prevention. Educating and counseling individuals with asthma can help them to avoid or reduce exposures. Additional information on WRA prevention and examples of the possible solutions for hazards associated with WRA can be found at http://www.cdc.gov/niosh/topics/asthma/OccAsthmaPrevention.html and http://www.osha.gov/SLTC/occupationalasthma.

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