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Gender differences in work-related asthma: surveillance data from California, Massachusetts, Michigan, and New Jersey, 1993–2008

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Abstract

Objective—To characterize work-related asthma by gender.

Methods—We analyzed state-based sentinel surveillance data on confirmed work-related asthma cases collected from California, Massachusetts, Michigan, and New Jersey during 1993–2008. We used Chi-square and Fisher’s Exact Test statistics to compare select characteristics between females and males.

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Declaration of interest

The authors report no conflicts of interest.

Results—Of the 8239 confirmed work-related asthma cases, 60% were female. When compared to males with work-related asthma, females with work-related asthma were more likely to be identified through workers' compensation (14.8% versus 10.6%) and less likely to be identified through hospital data (14.2% versus 16.9%). Moreover, when compared to males, females were more likely to have work-aggravated asthma (24.4% versus 13.5%) and less likely to have new-onset asthma (48.0% versus 56.5%). Females were also more likely than males with work-related asthma to work in healthcare and social assistance (28.7% versus 5.2%), educational services (11.8% versus 4.2%), and retail trade (5.0% versus 3.9%) industries and in office and administrative support (20.0% versus 4.0%), healthcare practitioners and technical (13.4% versus 1.6%), and education training and library (6.2% versus 1.3%) occupations. Agent groups most frequently associated with work-related asthma were miscellaneous chemicals (20.3%), cleaning materials (15.3%), and indoor air pollutants (14.9%) in females and miscellaneous chemicals (15.7%), mineral and inorganic dusts (13.2%), and pyrolysis products (12.7%) in males.

Conclusions—Among adults with work-related asthma, males and females differ in terms of workplace exposures, occupations, and industries. Physicians should consider these gender differences when diagnosing and treating asthma in working adults.

Keywords

Gender differences; occupational asthma; reactive airways dysfunction syndrome; surveillance; work-related asthma; work-aggravated asthma

Introduction

Asthma, a chronic inflammatory disease of the airways, affects over 18.7 million adults in the United States [1]. The prevalence of current asthma is higher in adult females (9.7%) when compared to adult males (5.7%) [1]. In addition, females with asthma have more severe and more frequent asthma symptoms, increased activity limitation due to asthma, poorer asthma-related quality of life, and increased healthcare utilization when compared to males [2,3].

Work-related asthma, a subset of asthma, includes newonset asthma (asthma caused by workplace exposures to sensitizers or irritants) and work-aggravated asthma (preexisting asthma worsened by workplace exposures) [4]. An estimated 7% to 51% (median = 17.6%) of adult asthma is caused by occupational exposures such as vapors, gas, dust, and fumes [5] and approximately 13% to 58% (median = 21.5%) of adult asthma is worsened by workplace exposures [6]. Studies with separate estimates of the occupational attributable risk for asthma for males and females found a higher median occupational attributable risk for females (11.5%, range 3.9–20.0%) than for males (9.1%, range 6.0–29.0%) [7–12]. However, other studies have shown that occupational exposures are associated with a higher risk for adult-onset asthma in males than in females [13–15]. Although gender differences in work-related asthma may be due to differences in many factors, including workplace exposures, most work-related asthma surveillance data are not stratified by gender, an issue that was raised in 2007 during the Third Jack Pepys Workshop on Asthma in the Workplace [16].

Males and females tend to have different jobs, different responsibilities within the same occupation, different exposures, and varying exposure levels [17]. For example, males are more likely to work in construction and females are more likely to work in health-related occupations [18]. The characteristics of exposure, even within the same job, and the impact of the exposure on health may also differ by gender [15,19]. Dumas and colleagues found that the frequency and intensity of exposure to cleaning products in hospital workers was higher among females than males [19]. Moreover, in snow crab processing, female workers were significantly more likely than male workers to be exposed to allergens and to receive a diagnosis of work-related asthma [17]. In swine processing operations, asthma was more prevalent among atopic female swine workers than in atopic male swine workers [20].

While gender differences in adult asthma have been well characterized, information on gender differences in work-related asthma in the United States is limited. The objective of this study was to characterize gender differences in work-related asthma using state-based sentinel surveillance data from 1 January 1993 to 31 December 2008 from California, Massachusetts, Michigan, and New Jersey.

Methods

For this study, we used 1993–2008 state-based sentinel work-related asthma surveillance program (formerly referred to as the Sentinel Event Notification System for Occupational Risks, or SENSOR) data from California, Massachusetts, Michigan, and New Jersey [4]. For surveillance purposes, confirmation of work-related asthma requires a healthcare professional's diagnosis consistent with asthma, and an association between symptoms of asthma and work [4]. Surveillance systems in each state identify potential cases of work-related asthma using a combination of healthcare professional reports and workers' compensation, emergency department, hospital discharge, and poison control center data. Massachusetts, Michigan, and New Jersey actively solicit healthcare professional reports while California uses an existing passive healthcare professional-based occupational injury and illness reporting system.

After receiving a report, states attempted to reach individuals with potential work-related asthma for telephone interviews to collect additional information on the interviewee's demographics, asthma symptoms in relation to work, industry and occupation, and asthma-related exposures. Confirmed cases of work-related asthma were classified as new-onset asthma, work-aggravated asthma, or confirmed but unclassified work-related asthma. New-onset asthma was further classified into occupational asthma or reactive airways dysfunction syndrome (RADS); a condition induced by a onetime, high-level irritant exposure at work, with symptoms that occur within 24 hours and persist for at least three months. Further details of the classification schemes have been previously described [4]. Information on industry and occupation was coded using the 2002 North American Industry Classification System (NAICS) and the 2000 Bureau of Census Occupation Codes (COC), respectively. To determine if there were occupational gender differences within the same industry, we examined gender differences in major occupation groups within major industry groups reported. For simplicity, we only examined gender differences in the ten most common major occupation and industry groups reported.

For this analysis, we examined up to three reported putative agents associated with work-related asthma for each individual. Agents were coded using the Association of Occupational and Environmental Clinics (AOEC) exposure codes [21]. Because of the large number of reported putative agents associated with work-related asthma, we grouped them using AOEC categories that contain agents of similar use or chemical nature. We calculated percentages of individuals associated with at least one agent in a specific agent category using the total number of individuals with work-related asthma separately for females and males. For simplicity, this manuscript only reports on the ten most frequently reported exposures by AOEC agent categories. We used SAS[®] version 9.3 (SAS Institute Inc., Cary, NC) for analyses. To compare select characteristics between females and males, chi-square and Fisher's Exact Test statistics were used and considered statistically significant at p value < 0.05.

Results

During 1993–2008, a total of 8239 confirmed cases of work-related asthma were identified through the state-based sentinel surveillance systems in California, Massachusetts, Michigan and New Jersey (Table 1). Two individuals had missing information on gender and were excluded from further analysis. The primary source of case ascertainment was healthcare professional reports (70.3%). Most individuals were classified as having new-onset asthma (51.3%), non-Hispanic (59.7%) and female (60.4%). Approximately one quarter of individuals (27.0%) worked in the manufacturing industry (e.g. fabricated metal product manufacturing, medical equipment and supplies manufacturing, and perishable prepared food manufacturing) and nearly one fifth of individuals (19.2%) worked in a production occupation (e.g. engine and other machine assemblers, bakers, cabinet makers) when their work-related asthma began.

The most frequently reported AOEC agent categories and the most frequent individual agents within each category are shown in Table 2. A total of 10 722 putative agents associated with work-related asthma were reported; 5097 (61.9% of 8237) individuals reported only one agent, 1778 (21.6% of 8237) individuals reported two agents, 694 (8.4% of 8237) individuals reported three agents, and for 670 (8.1%) individuals agents were not known. The three most common reported agent categories were miscellaneous chemicals (18.5%), mineral and inorganic dusts (13.0%), and cleaning materials (12.5%) (Figure 1).

When compared to males, significantly higher proportions of females were ascertained through workers' compensation (14.8% versus 10.6%), had work-aggravated asthma (24.4% versus 13.5%), were 45–54 years old (30.9% versus 24.3%), black (11.9% versus 8.3%), Asian (2.3% versus 1.5%), and non-Hispanic (62.2% versus 55.8%) (Table 1). Significantly lower proportions of females were ascertained through hospital data (14.2% versus 16.9%), had new-onset asthma (48.0% versus 56.5%), and were 16–24 years old (6.3% versus 11.0%) and 25–34 years old (17.1% versus 22.1%) when compared to males.

Females also differed from males in the industries and occupations they worked in when their work-related asthma began. By industry, when compared to males, significantly higher proportions of females worked in healthcare and social assistance (28.7% versus 5.2%),

educational services (11.8% versus 4.2%), and retail trade (5.0% versus 3.9%) industries and significantly lower proportions worked in manufacturing (19.2% versus 38.8%), transportation and warehousing (2.8% versus 4.9%), construction (0.7% versus 7.3%), administrative support and waste management (2.4% versus 4.2%), and other services (except public administration) (1.8% versus 2.8%) industries. By occupation, when compared to males, significantly higher proportions of females worked in office and administrative support (20.0% versus 4.0%), healthcare practitioners and technical (13.4% versus 1.6%), education training and library (6.2% versus 1.3%), healthcare support (5.0% versus 0.6%), and management (3.8% versus 2.0%) occupations and significantly lower proportions worked in production (13.7% versus 27.8%), transportation and material moving (4.1% versus 11.0%), building and grounds cleaning and maintenance (4.4% versus 6.4%), protective service (3.0% versus 8.1%), and construction and extraction (0.7% versus 9.1%) occupations (Table 1). Within industries, occupations associated with work-related asthma differed by gender (Table 3). For example, within the construction industry, females were more likely to work in office and administrative support occupations (21.6% versus 0.4%) and less likely to work in construction and extraction occupations (27.0% versus 68.1%) than males. In addition, within the educational services industry, females were more likely to work in education, training and library occupations (47.4% versus 26.3%) and less likely to work in building and grounds, cleaning, and maintenance occupations (6.7% versus 38.7%) than males. Examples of occupations within each industry group are shown in Appendix 1.

Females and males also significantly differed in the exposures associated with their work-related asthma. Females were significantly more likely than males to have reported exposure to miscellaneous chemicals (20.3% versus 15.7%), cleaning materials (15.3% versus 8.2%), indoor air pollutants (14.9% versus 2.8%), and mold (7.8% versus 3.6%) (Figure 1). Females were significantly less likely than males to report pyrolysis products (10.1% versus 12.7%), plant materials (2.7% versus 7.7%), isocyanates (2.9% versus 6.9%), and metals and metalloids (2.0% versus 7.8%) (Figure 1).

Discussion

In this study of individuals with confirmed work-related asthma from four state-based sentinel surveillance programs, approximately 60% were female. These findings are similar to findings from Washington State where 57.1% of individuals with work-related asthma were females [22] and slightly higher than findings from the New York State Occupational Health Clinic Network where 53.7% of individuals with work-related asthma were females [23]. Moreover, these findings are consistent with 2008 Behavioral Risk Factor Surveillance Survey findings from these four states that an estimated 62.9%–65.3% of adults with current asthma are females [24]. Additionally, data from the Behavioral Risk Factor Surveillance Survey indicate that the proportion of asthma that is diagnosed as work-related asthma by a healthcare professional does not significantly differ by gender [25,26]. Accordingly, the proportion of individuals with work-related asthma that are female may reflect the gender distribution in adult asthma.

Multiple reasons have been hypothesized why among adults with asthma females make up a higher proportion than males. First, sex hormones may influence biological differences in pulmonary and immunological factors associated with asthma [27]. Furthermore, the diagnosis of asthma depends both on the diagnostic practices of healthcare professionals and the healthcare seeking behavior of individuals, particularly those with milder forms of asthma (presumably individuals with more severe asthma have less discretion on whether or not to seek medical care). For example, Schatz and Camargo have reported that females are more likely to have outpatient visits for their asthma than males [28]. Additionally, females with asthma describe more symptoms than males with asthma despite having better or comparable pulmonary function [29,30]. Also, studies 25–30 years ago, found that among adults with similar respiratory symptoms and smoking status, females were more likely to be diagnosed with asthma and chronic bronchitis while males were more likely to be diagnosed with emphysema, suggesting physician bias in diagnostic practices during that time period [31].

In addition to possible gender differences in asthma identification, a review article by Camp et al. suggests that a number of other factors may lead to gender differences in the development of occupational lung diseases including work-related asthma [32]. First, even though males and females may have the same job title, they can have different job tasks that lead to variation in types and levels of exposure. For example, male cleaners may be assigned to mopping floors while female cleaners are assigned to clean toilets [32,33]. Second, in workplaces in which respirators are worn, but fit testing is not done (as required when necessary to prevent overexposure, by OSHA 1910.134 Respiratory Protection Standard), respirators may not fit females' faces, which may lead to increased exposure in females [32,34]. Third, structural differences in adult male and female lungs such as lung size, airway caliber, vital capacity, and expiratory flow rates may impact the volume of inhaled agent per breath and the deposition of the inhaled agent in the lung [32,35].

We found that among individuals with work-related asthma, females were more likely to have work-aggravated asthma and less likely to have new-onset asthma than males. Our findings are consistent with findings from surveillance systems in the United Kingdom [36,37], Canada [38], and France [39] that found that males had more new-onset asthma than females. Lemiere and colleagues found that among adults in an asthma tertiary care center in Quebec, both subjects with work-aggravated-asthma and those with work-related new-onset asthma were less likely to be in females (43% and 34%, respectively) compared to subjects with non-work-related asthma among whom 58% were females [40]. In addition, in a study of health maintenance organization members with asthma in Massachusetts, Henneberger and colleagues found that those with workplace exacerbation of asthma were less likely to be females than those without workplace exacerbation of asthma (55% versus 73%, respectively) [41]. This differs from our findings where 73.3% of individuals with work-aggravated asthma, 56.4% of individuals with work-related new-onset asthma, and 58.4% of individuals with confirmed but unclassified work-related asthma were female (data not shown). The differences may be explained by differences in study populations and methods.

Data from a French voluntary reporting system of occupational and chest physicians has shown that the occupations associated with new-onset asthma differ by gender [39]. Consistent with our results, Ameille and colleagues found that females with new-onset asthma were more likely than males to be healthcare workers when their asthma started (26.4% versus 1.1%, respectively) [39]. We also found that occupations differed by gender within all major industries for individuals with work-related asthma. This is consistent with a 2013 report from the Bureau of Labor Statistics on women in the labor force which indicates that the share of females working in specific occupations varies largely within the United States. For example, females account for 98% of preschool and kindergarten teachers, 74% of cashiers, 43% of bus drivers and 2% of carpenters. Similarly, the proportion of females working in specific industries varies largely within the United States. For example, females account for 79% of workers in the health care and social assistance industry, 49% of workers in the retail trade industry, 25% of workers in the agriculture, forestry, fishing, and hunting industry, and 9% of workers in the construction industry [42].

The reported exposures associated with work-related asthma also differed by gender. In this study of individuals with work-related asthma, females were significantly more likely than males to report that miscellaneous chemicals, cleaning materials, indoor air pollutants, and mold were associated with their work-related asthma. Dimich-Ward et al. found that the risk of asthma and asthma symptoms by gender differed based on the type of occupational exposure (organic/inorganic dusts) and on industry and occupation of the worker [43]. The authors found that males exposed to organic dusts in their jobs had greater risk of asthma symptoms than female coworkers. Among workers exposed to inorganic dusts, the risk of asthma was higher for females than males. The results by Dimich-Ward et al. suggest that the associations between gender, occupation, exposure, and work-related asthma are complex and need to be explored [43].

The strengths and limitations of the state-based sentinel surveillance data have been described elsewhere [4]. Due to under-recognition and under-reporting of work-related asthma by healthcare professionals, the findings from the state-based sentinel surveillance systems are not necessarily representative of the underlying burden of work-related asthma. Asthma-like symptoms in patients might be inadequately diagnosed or the connection between asthma symptoms and the workplace may not be made. In Michigan, it has been reported that only 1.3% of physicians report cases to the state-based sentinel surveillance system [44]. However, even with under-reporting, the state-based sentinel surveillance system for work-related asthma has the ability to capture in-depth industry, occupation, and workplace exposure information. We were unable to draw any conclusions regarding whether the gender differences in industry and occupation in this population of individuals with work-related asthma reflected gender differences in industry and occupation in the general populations in these four states. Factors such as gender differences in asthma prevalence, access to medical care, medical care seeking behaviors, and reporting of work-related asthma to state health departments may all impact the ascertainment of work-related asthma cases by state health departments. Future studies should examine gender differences in the incidence of work-related asthma. Information presented here is limited to four states with sentinel work-related asthma surveillance capabilities. These four states have very

different industry and occupation profiles and are not necessarily representative of other states or the entire country.

Conclusions

To the best of our knowledge, this is the first study done in the United States that describes industries, occupations, and workplace exposures associated with work-related asthma by gender. While we cannot establish that work is responsible for the higher prevalence of asthma among females, our study adds to the increasing evidence that work impacts females with asthma and that gender differences impact work-related asthma. Gender differences in workplace exposures, occupations, and industries of workers may contribute to differential risk of work-related asthma. Healthcare professionals should be cognizant that unlike the classic occupational lung diseases such as asbestosis and silicosis, which are more common in males, work-related asthma is more commonly identified in females. Moreover, healthcare professionals need to consider gender differences in workplace exposure, occupations, and industries when diagnosing and treating adults with asthma.

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Appendix 1

Examples of industry and occupation combinations among adults with work-related asthma
— California, Massachusetts, Michigan, and New Jersey, 1993–2008.

	Top Ten Major Occupations					
Top Ten Major Industry Groups (NAICS 2002)	Production (770–896)	Office and administrative support (500–593)	Healthcare practitioners and technical (300–354)	Transportation and material moving (900–975)	Building and grounds cleaning and maintenance (420–425)	Protective service
Manufacturing (31–33) <i>n</i> = 2,222	Motor vehicle parts manufacturing (336 300)	Motor vehicle parts manufacturing (336 300)	Spring manufacturing (332 612)	Motor vehicle parts manufacturing (336 300)	Motor vehicle parts manufacturing (336 300)	Chemical manufacturing (325 000)
	Miscellaneous assemblers and fabricators (775)	Shipping receiving and traffic clerk (561)	Registered nurse (313)	Hand packers and packagers (963)	Janitors and building cleaners (422)	Security guards and surveillance officers
Healthcare and social assistance (62) <i>n</i> = 1,597	Nursing care facilities (623 110)	Medical and surgical hospitals (622 110)	Ambulatory health care services (621 000)	Ambulance services (621 910)	Medical and surgical hospitals (622 110)	Vocational rehabilitation services (624 310)
	Laundry worker (830)	Secretaries and administrative (570)	Registered nurse (313)	Taxi drivers and chauffeurs (914)	Janitors and building cleaners (422)	Fire fighter (374)
Public administration (92) <i>n</i> = 882	Administration of air and water resource and solid waste management programs (924 110)	Public finance activities (921 130)	Administration of public health programs (923 120)	Regulation and administration of transportation program (926 120)	Other general government support (921 190)	Fire protection (921 190)
	Water and liquid waste treatment plant and systems operator (862)	Office clerk (586)	Registered nurse (313)	Bus driver (912)	Janitors and building cleaners (422)	Fire fighter (374)
Educational services (61) <i>n</i> = 723	Junior colleges (611 210)	Colleges, universities, and professional schools (611 310)	Elementary and secondary schools (611 110)	Elementary and secondary schools (611 110)	Elementary and secondary schools (611 110)	Colleges, universities, and professional schools (611 310)
	Photographic process workers and processing machine operators (883)	Secretaries and administrative (570)	Registered nurse (313)	Bus driver (912)	Janitors and building cleaners (422)	Police and sheriff's officers (385)
Retail trade (44–45) <i>n</i> = 374	Supermarkets and other grocery stores (445 110)	Supermarkets and other grocery stores (445 110)	Pharmacies and drug stores (446 110)	Supermarkets and other grocery stores (445 110)	Supermarkets and other grocery stores (445 110)	Department stores
	Butchers and other meat poultry and fish processing workers (781)	Stock clerks and order fillers (562)	Emergency medical technicians and paramedics (340)	Laborers and freight stock and material movers (962)	Janitors and building cleaners (422)	Security guards and surveillance officers
Transportation and warehousing (48–49) <i>n</i> = 297	Other warehousing and storage (493 190)	Postal services (491 110)	Other nonscheduled air transportation (481 219)	Urban transit systems (485 110)	Support activities for transportation (488 000)	Motor vehicle towing (488 410)
	Extruding forming pressing and compacting machine setters, operators, and tenders (874)	Postal service mail sorters, processors, and processing machine operators (556)	Miscellaneous health technologists and technicians (353)	Bus driver (912)	First line supervisors/managers of housekeeping and janitorial workers (420)	Private detectives and investigators (391)
Construction (23) <i>n</i> = 275	Other specialty trade contractors (238 990)	Highway street and bridge construction (237 310)		Painting and wall covering contractors (238 320)	Highway street and bridge	

							Top Ten Major Occu
							construction (237 310)
		Welding, soldering, and brazing workers (814)	Secretaries and administrative (570)		Material moving workers (975)		Grounds maintenance workers (425)
Administrative and support, waste, management and remediation services (56) <i>n</i> = 255	Carpet and upholstery cleaning services (561 740)	Administrative and support services (561 000)	Employment placement agencies (561 310)		Solid waste collection (562 111)	Janitorial services (561 720)	Investigation, guard armored car service (610)
	Laundry worker (830)	Office clerk (586)	Registered nurse (313)		Driver/sales workers and truck drivers (913)	First line supervisors/managers of housekeeping and janitorial workers (420)	Security guards and surveillance office
Accommodation and food services (72) <i>n</i> = 206	Food services and drinking places (722 000)	Hotels (except casino hotels) and motels (721 110)			Hotels (except casino hotels) and motels (721 110)	Hotels (except casino hotels) and motels (721 110)	Travel accommoda 100)
	Bakers (780)	Hotel motel and resort desk clerks (530)			Service station attendants (936)	Maids and housekeeping cleaners (423)	Lifeguards and oth protective service (395)
Other services (except public administration) (81) <i>n</i> = 181	Photofinishing (812 920)	Religious organizations (813 110)			All other automotive repair and maintenance (811 198)	Private households (814 110)	
	Production workers, all others (896)	Secretaries and administrative assistants (570)			Driver/sales workers and truck drivers (913)	Maids and housekeeping cleaners (423)	
All other major industry categories ^b <i>n</i> = 1,011	Other electric power generation (221 119)	Electric power distribution (221 122)	Medical, dental, and hospital equipment and supplies merchant wholesalers (423 450)		Wholesale trade (420 000)	Lessors of residential buildings and dwellings (531 110)	Fitness and recreat sports center (713)
	Power plant operators distributors and dispatchers (860)	Customer service representatives (524)	Registered nurse (313)		Laborers and freight stock and material movers (962)	First line supervisors/managers of housekeeping and janitorial workers (420)	Lifeguards and oth protective service (395)

COC, Census Occupation Codes; NAICS, North American Industrial Classification System (The numbers in parentheses signify NAICS 2002 codes or COC 2000 codes).

^a All other major occupation categories include business and financial operations (050–095); computer and mathematical (100–124); architecture and engineering (130–156); life, physical, and social services (160–196); community and social services (200–206); legal (210–215); arts, design, entertainment, sports, and media (260–296); food preparation and serving related (400–416); personal care and service (430–465); sales and related (470–496); farming, forestry, and fishing (600–613); installation, repair, and maintenance (700–762); military, rank not specified (983).

^b All other major industry categories include agriculture, forestry, fishing, and hunting (11); mining (21); utilities (22); wholesale trade (42); information (51); finance and insurance (52); real estate and rental and leasing (53); professional, scientific, and technical services (54); management of companies and enterprises (55); arts, entertainment, and recreation (71).

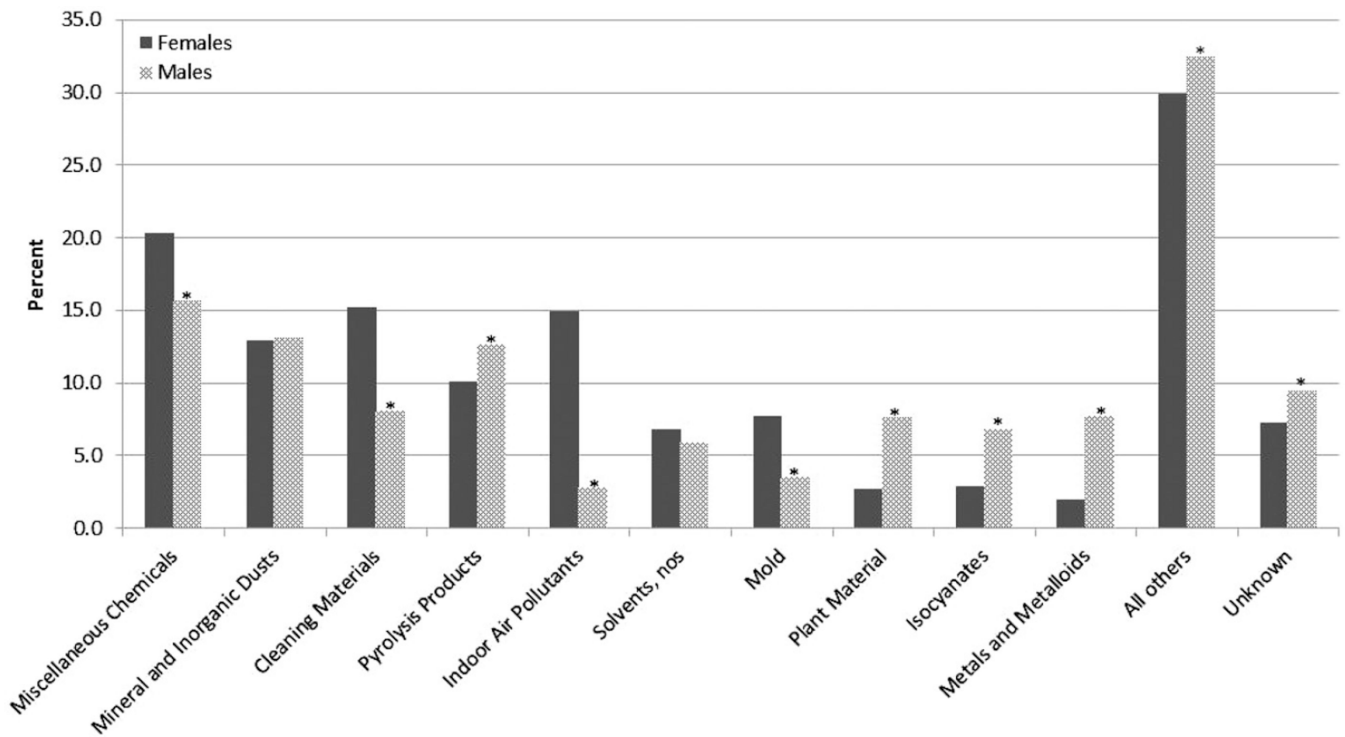


Figure 1.

Major AOEC agent categories for reported exposures associated with work-related asthma by gender—California, Massachusetts, Michigan, and New Jersey, 1993–2008. AOEC, Association of Occupational and Environmental Clinics. **p* Value for gender differences <0.05. AOEC exposure categories as of September, 2012. See AOEC exposure code lookup (<http://www.aoecdata.org/>) for more information. Each case may be associated with up to three putative agents. A total of 10 722 putative agents associated with work-related asthma were reported. In 670 cases (8.1%) agents were not identified. Percentages are based on the number of females (4973) and males (3264). All other major AOEC exposure categories include aldehydes and acetals; aromatic hydrocarbons; animal materials; ergonomics; miscellaneous inorganic compounds; halogens (inorganic); physical factors; epoxy compounds; hydrocarbons, not otherwise specified; polymers; acids, bases, and oxidizing agents; aliphatic and alicyclic hydrocarbons; esters; halogenated aliphatic hydrocarbons; ketones; aliphatic and alicyclic amines; alcohols; aliphatic and miscellaneous nitrogen compounds; organophosphate pesticides/carbamate pesticides; phenols and phenolic compounds; glycol ethers; microorganisms, not including mold; glycols; organic sulfur compounds; aliphatic carboxylic acids; cyanides and nitriles; ethers; halogenated aromatic hydrocarbons; aromatic nitro and amino compounds; organochlorine insecticides.

Select characteristics of work-related asthma by gender — California, Massachusetts, Michigan, and New Jersey, 1993–2008.

Table 1

Characteristics	Total			Females			Males			p Value ^a
	n	%		n	%		n	%		
Total	8237	100.0		4973	100.0		3264	100.0		
State										
California	4638	56.3		2945	59.2		1693	51.9		<0.0001
Massachusetts	787	9.6		502	10.1		285	8.7		0.0396
Michigan	2341	28.4		1265	25.4		1076	33.0		<0.0001
New Jersey	471	5.7		261	5.3		210	6.4		0.023
Reporting Source										
Healthcare professional report	5788	70.3		3470	69.8		2318	71.0		0.228
Hospital data ^b	1257	15.3		706	14.2		551	16.9		0.001
Workers' compensation	1083	13.2		738	14.8		345	10.6		<0.0001
Co-worker	17	0.2		11	0.2		6	0.2		0.715
Poison control centers	66	0.8		37	0.7		29	0.9		0.472
Other ^c	26	0.3		11	0.2		15	0.5		0.059
Work-Related Asthma Classification										
Work-aggravated asthma ^d	1654	20.1		1213	24.4		441	13.5		<0.0001
New-onset asthma ^e	4229	51.3		2386	48.0		1843	56.5		<0.0001
Occupational asthma	3620	43.9		2061	41.5		1559	47.8		0.002
Reactive airways dysfunction syndrome (RADS)	609	7.4		325	6.5		284	8.7		0.004
Confirmed, but unclassifiable ^f	2354	28.6		1374	27.6		980	30.0		0.467
Age										
16–24	670	8.1		311	6.3		359	11.0		<0.0001
25–34	1572	19.1		850	17.1		722	22.1		<0.0001
35–44	2369	28.8		1467	29.5		902	27.6		0.068
45–54	2329	28.3		1537	30.9		792	24.3		<0.0001
55–64	1130	13.7		712	14.3		418	12.8		0.051
65	111	1.4		65	1.3		46	1.4		0.694

Characteristics	Total			Females			Males			p Value ^d
	n	%		n	%		n	%		
Unknown	56	0.7		31	0.6		25	0.8		0.441
Race										
White	4008	48.7		2410	48.5		1598	49.0		0.659
Black	864	10.5		594	11.9		270	8.3		<0.0001
American Indian/Alaskan Native	104	1.3		62	1.3		42	1.3		0.874
Asian	160	1.9		112	2.3		48	1.5		0.012
Other/mixed race	388	4.7		235	4.7		153	4.7		0.937
Unknown	2713	32.9		1560	31.4		1153	35.3		0.0002
Ethnicity										
Hispanic	602	7.8		349	7.5		253	8.2		0.223
Non-Hispanic	4635	59.7		2915	62.2		1720	55.8		<0.0001
Unknown	2530	32.6		1420	30.3		1110	36.0		<0.0001
Major Industry (NAICS 2002)										
Agriculture, forestry, and fishing (11)	156	1.9		49	1.0		107	3.3		<0.0001
Mining (21)	14	0.2		4	0.1		10	0.3		0.015
Utilities (22)	84	1.0		40	0.8		44	1.4		0.016
Construction (23)	275	3.3		37	0.7		238	7.3		<0.0001
Manufacturing (31–33)	2222	27.0		955	19.2		1267	38.8		<0.0001
Wholesale trade (42)	134	1.6		57	1.2		77	2.4		<0.0001
Retail trade (44–45)	374	4.6		247	5.0		127	3.9		0.022
Transportation and warehousing (48–49)	297	3.6		137	2.8		160	4.9		<0.0001
Information (51)	146	1.8		112	2.3		34	1.0		<0.0001
Finance and insurance (52)	140	1.7		126	2.5		14	0.4		<0.0001
Real estate, rental, and leasing (53)	59	0.7		31	0.6		28	0.9		0.217
Professional, scientific, and technical services (54)	159	1.9		113	2.3		46	1.4		0.005
Management of companies and enterprises (55)	2	0.0		2	0.4		0	0.0		0.522
Administrative and support, waste management and remediation services (56)	255	3.1		117	2.4		138	4.2		<0.0001
Educational services (61)	723	8.8		586	11.8		137	4.2		<0.0001
Healthcare and social assistance (62)	1597	19.4		1427	28.7		170	5.2		<0.0001
Arts, entertainment, and recreation (71)	117	1.4		70	1.4		47	1.4		0.903

Characteristics	Total			Females			Males			p Value ^d
	n	%		n	%		n	%		
Accommodation and food services (72)	206	2.5	136	2.7	70	2.1	0.093			
Other services (except public administration) (81)	181	2.2	91	1.8	90	2.8	0.005			
Public administration (92)	882	10.7	527	10.6	355	10.9	0.689			
Unknown	214	2.6	109	2.2	105	3.2	0.004			
Major Occupation (COC 2000)										
Management (001–043)	253	3.1	189	3.8	64	2.0	<0.0001			
Business and financial operations (050–095)	121	1.5	108	2.2	13	0.4	<0.0001			
Computer and mathematical (100–124)	56	0.7	40	0.8	16	0.5	0.090			
Architecture and engineering (130–156)	76	0.9	28	0.6	48	1.5	<0.0001			
Life, physical and social services (160–196)	135	1.6	91	1.8	44	1.4	0.092			
Community and social services (200–206)	105	1.3	88	1.8	17	0.5	<0.0001			
Legal (210–215)	20	0.2	17	0.3	3	0.1	0.024			
Education training and library (220–255)	349	4.2	307	6.2	42	1.3	<0.0001			
Arts, design, entertainment, sports, and media (260–296)	29	0.4	18	0.4	11	0.3	<0.0001			
Healthcare practitioners and technical (300–354)	719	8.7	668	13.4	51	1.6	<0.0001			
Healthcare support (360–365)	271	3.3	250	5.0	21	0.6	<0.0001			
Protective service (370–395)	410	5.0	147	3.0	263	8.1	<0.0001			
Food preparation and serving related (400–416)	177	2.2	121	2.4	56	1.7	0.028			
Building and grounds cleaning and maintenance (420–425)	428	5.2	220	4.4	208	6.4	<0.0001			
Personal care and service (430–465)	111	1.4	94	1.9	17	0.5	<0.0001			
Sales and related (470–496)	219	2.7	165	3.3	54	1.7	<0.0001			
Office and administrative support (500–593)	1122	13.6	993	20.0	129	4.0	<0.0001			
Farming, fishing, and forestry (600–613)	81	1.0	32	0.6	49	1.5	0.0001			
Construction and extraction (620–694)	331	4.0	34	0.7	297	9.1	<0.0001			
Installation repair and maintenance (700–762)	246	3.0	31	0.6	215	6.6	<0.0001			
Production (770–896)	1585	19.2	679	13.7	906	27.8	<0.0001			
Transportation and material moving (900–975)	564	6.9	205	4.1	359	11.0	<0.0001			
Unknown	829	10.1	448	9.0	381	11.7	<0.0001			

COC, Census Occupation Classification; NAICS, North American Industrial Classification System (The numbers in parentheses signify NAICS 2002 codes or COC 2000 codes).

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^a *p* Value for gender differences.

^b Includes hospital discharge and emergency department data.

^c Cases identified through death certificates, self-report, reports from the Mine Safety and Health Administration, and reports from Occupational Safety and Health Administration.

^d Pre-existing asthma aggravated by exposure or condition at work.

^e Includes cases of reactive airways dysfunction syndrome and occupational asthma.

^f Confirmed cases of work-related asthma that lack the necessary information to determine if they are new-onset asthma or work-aggravated asthma. Numbers may not add up to total because of missing values.

Table 2

Ten most frequent major AOEC agent categories reported and examples by gender.

Category	Total	Females	Males
Miscellaneous Chemicals			
	Chemicals, NOS	Chemicals, NOS	Chemicals, NOS
	Perfume, NOS	Perfume, NOS	Pesticides, NOS
	Glues, NOS	Glues, NOS	Glues, NOS
	Pesticides, NOS	Pesticides, NOS	Fire extinguisher discharge
	Odors	Odors	Printing chemicals, NOS
Cleaning Materials			
	Cleaning materials, NOS	Cleaning materials, NOS	Cleaning materials, NOS
	Bleach	Bleach	Bleach
	Floor stripping cleaners	Floor stripping cleaners	Ammonium hydroxide, NOS
	Cleaners, disinfectants, NOS	Cleaners, disinfectants, NOS	Floor stripping cleaners
	Carpet cleaners	Carpet cleaners	Cleaning mixtures (excluding bleach plus acid or ammonia)
Mineral and Inorganic Dusts			
	Dust, NOS	Dust, NOS	Dust, NOS
	Man-made mineral fibers, NOS	Man-made mineral fibers, NOS	Man-made mineral fibers, NOS
	Asbestos, NOS	Asbestos, NOS	Cement dust
	Cement dust	Carbon black	Asbestos, NOS
	Silica, crystalline, NOS	Cement dust	Silica, crystalline, NOS
Pyrolysis products			
	Smoke, NOS	Smoke, NOS	Smoke, NOS
	Diesel Exhaust	Cigarette smoke	Diesel exhaust
	Cigarette smoke	Diesel exhaust	Plastic smoke
	Plastic smoke	Plastic smoke	Exhaust, NOS
	Exhaust, NOS	Exhaust, NOS	Cigarette smoke
Indoor air pollutants			
	Air pollutants, indoor	Air pollutants, indoor	Air pollutants, indoor
	Indoor air pollutants from building	Indoor air pollutants from building	Indoor air pollutants from building
Solvents, NOS			
	Paint, NOS	Paint, NOS	Paint, NOS
	Solvents, NOS	Solvents, NOS	Solvents, NOS
	Paint, oil-based	Paint, oil-based	Paint, oil-based
	Thinner	Thinner	Thinner
	Lacquer	Lacquer	Lacquer
Mold			
	Mold, NOS	Mold, NOS	Mold, NOS
	Aspergillus	Aspergillus	Aspergillus
	Stachybotrys	Stachybotrys	Stachybotrys
	Penicillium	Penicillium	Penicillium
Plant material			

Category	Total	Females	Males
	Plant material, NOS	Capsicum	Wood dust, NOS
	Wood dust, NOS	Plant material, NOS	Plant material, NOS
	Capsicum	Wood dust, NOS	Flour, NOS
	Flour, NOS	Paper dust	Pollen
	Paper dust	Pollen	Paper dust
Isocyanates			
	Diisocyanates, NOS	Diisocyanates, NOS	Diisocyanates, NOS
	Toluene diisocyanate	Toluene diisocyanate	Methylene bisphenyl diisocyanate
	Methylene bisphenyl diisocyanate	Methylene bisphenyl diisocyanate	Toluene diisocyanate
	Hexamethylene diisocyanate	Hexamethylene diisocyanate	Hexamethylene diisocyanate
	Naphthalene diisocyanate	Naphthalene diisocyanate	Naphthalene diisocyanate
Metals and metalloids			
	Welding, NOS	Welding, NOS	Welding, NOS
	Metal dust, NOS	Soldering flux, NOS	Metal dust, NOS
	Cobalt compounds	Soldering, NOS	Cobalt compounds
	Welding fumes, stainless steel	Cobalt compounds	Welding fumes, stainless steel
	Nickel compounds	Welding fumes, stainless steel	Soluble halogenated platinum compounds, NOS

AOEC, Association of Occupational and Environmental Clinics. NOS, not otherwise specified.

AOEC exposure categories as of September, 2012. See AOEC exposure code lookup (<http://www.aoecdata.org/>) for more information.

Table 3

Occupation distribution among industry groups for females and males with work-related asthma — California, Massachusetts, Michigan, and New Jersey, 1993–2008.

Top Ten Major Industry Groups (NAICS 2002)	Sex	Top Ten Major Occupation Groups (COC 2000)										All other major occupation categories ^d %	Unknown %
		Production (770-896) %	Office and administrative support (500-593) %	Healthcare practitioners and technical (300-354) %	Transportation and material moving (900-975) %	Building and grounds cleaning and maintenance (420-425) %	Protective service (370-395) %	Education training and library (220-255) %	Construction and extraction (620-694) %	Healthcare support (360-365) %	Management (001-043) %		
Manufacturing (31-33) <i>n</i> = 2222	F	62.6 ^b	7.3 ^b	0.6 ^b	9.6	2.0	0.1	0.2	0.5 ^b	0	1.8	8.3 ^b	6.9
	M	58.4	2.5	0.8	10.1	2.2	0.3	0	4.0	0.1	0.9	12.2	9.2
Healthcare and social assistance (62) <i>n</i> = 1597	F	0.8 ^b	17.9 ^b	42.1 ^b	0.1	3.9 ^b	0.5 ^b	0.6	0.9 ^b	15.6 ^b	2.8	8.9 ^b	6.0
	M	4.1	3.5	25.3	1.2	12.9	6.5	1.2	11.2	9.4	2.4	15.3	7.1
Public administration (92) <i>n</i> = 88	F	1.1 ^b	39.9 ^b	3.8 ^b	1.1 ^b	1.0 ^b	18.4 ^b	1.5	0.2 ^b	1.0 ^b	5.5 ^b	17.1 ^b	9.5
	M	3.4	6.5	1.1	3.4	5.1	53.2	1.1	4.2	0.3	1.7	10.4	9.6
Educational services (60) <i>n</i> = 723	F	0.2	13.5 ^b	3.2	1.2	6.7 ^b	0.7 ^b	47.4 ^b	0.2 ^b	1.0	4.6	14.5	6.8
	M	0.7	2.9	0.7	2.2	38.7	5.1	26.3	2.9	0.7	2.9	9.5	7.3
Retail trade (44-45) <i>n</i> = 374	F	4.5	16.2 ^b	1.2	9.7	2.8	0.4	0	0 ^b	0.4	0.4	51.8 ^b	12.6
	M	7.1	8.7	0.8	14.2	6.3	1.6	0	3.9	0	0	39.4	18.1
Transportation and warehousing (48-49) <i>n</i> = 297	F	1.5	27.7 ^b	1.5	33.6 ^b	2.9	0.7	0	0	3.7	2.2	16.1	10.2
	M	4.4	10.0	0	60.0	1.9	0.6	0	2.5	0.6	0	10.6	9.4
Construction (23) <i>n</i> = 275	F	8.1	21.6 ^b	0	8.1	2.7	0	0	27.0 ^b	0	2.7	16.2	13.5
	M	8.4	0.4	0	4.2	2.1	0	0	68.1	0	1.7	9.2	5.9
Administrative and support,	F	9.4	25.6 ^b	0.9	5.1 ^b	23.9	9.4	0	0 ^b	0	3.4	10.3	12.0
	M	9.4	25.6 ^b	0.9	5.1 ^b	23.9	9.4	0	0 ^b	0	3.4	10.3	12.0

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Top Ten Major Occupation Groups (COC 2000)

Top Ten Major Industry Groups (NAICS 2002)	Production (770–896) %	Office and administrative support (500–593) %	Healthcare practitioners and technical (300–354) %	Transportation and material moving (900–975) %	Building and grounds maintenance and cleaning (420–425) %	Protective service (370–395) %	Education training and library (220–255) %	Construction and extraction (620–694) %	Healthcare support (360–365) %	Management (001–043) %	Other major occupation categories ^a %	Unknown
waste, management and remediation services (56) <i>n</i> = 255												
M	14.5	5.1	0	21.7	14.5	13.8	0	5.1	0	0.7	10.1	
Accommodation and food services (72) <i>n</i> = 206												
F	1.5	8.1 ^b	0	1.5	25.7 ^b	0.7	0	0 ^b	0	9.6	47.1	
Other services (except public administration) (81) <i>n</i> = 181												
M	5.7	0	0	1.4	12.9	1.4	0	4.3	0	7.1	58.6	
F	11.0 ^b	26.4 ^b	0	1.1	4.4	0	1.1	0 ^b	2.2	1.1 ^b	44.0	
All other major industry categories ^c <i>n</i> = 1011												
M	28.9	0	0	4.4	7.8	0	0	5.6	0	7.8	38.9	
F	3.2 ^b	36.3 ^b	2.2 ^b	1.8 ^b	3.3 ^b	3.8 ^b	1.3 ^b	0.7 ^b	1.5	8.6	28.3	
Unknown <i>n</i> = 214												
M	12.0	6.9	0.3	11.3	7.9	7.1	0	4.2	0.3	5.4	31.0	
F	4.6	7.3 ^b	2.8	4.6	2.8	0.9	1.8	0 ^b	0	0.9	8.3	
M	10.5	1.0	0	8.6	2.9	0	0	4.8	0	0	6.7	

COC, Census Occupation Codes; F, females; M, males; NAICS, North American Industrial Classification System (The numbers in parentheses signify NAICS 2002 codes or COC 2000 codes); Percentages may not sum to 100% due to rounding.

^a All other major occupation categories include business and financial operations (050–095); computer and mathematical (100–124); architecture and engineering (130–156); life, physical, and social services (160–196); community and social services (200–206); legal (210–215); arts, design, entertainment, sports, and media (260–296); food preparation and serving related (400–416); personal care and service (430–465); sales and related (470–496); farming, forestry, and fishing (600–613); installation, repair, and maintenance (700–762); military, rank not specified (983).

^b *p* Value for gender differences <0.05.

^c All other major industry categories include agriculture, forestry, fishing, and hunting (11); mining (10); utilities (22); wholesale trade (42); information (51); finance and insurance (52); real estate and rental and leasing (53); professional, scientific, and technical services (54); management of companies and enterprises (55); arts, entertainment, and recreation (71).