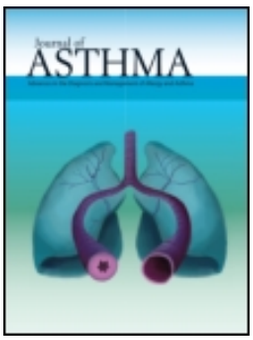

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ORIGINAL ARTICLE

The Proportion of Self-Reported Asthma Associated with Work in Three States: California, Massachusetts, and Michigan, 2001

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Objectives. To assess the proportion of adult asthma at the state level that may be related to work. *Design*. Work-related asthma questions were added to the 2001 Behavioral Risk Factor Surveillance System (BRFSS) questionnaire in California, Massachusetts, and Michigan. *Results*. Findings indicate 7.4–9.7% of those with current asthma reported that their asthma may be work related. These results estimate that approximately 137,000 adults in California, 39,000 in Massachusetts, and 63,000 in Michigan have asthma that may be work related. *Conclusions*. These findings are unique in providing population-based estimates at the state level that illustrate that a substantial portion of adult asthma morbidity is due to exposures in the work environment.

Keywords asthma, occupational disease, health survey, surveillance, prevalence

INTRODUCTION

Asthma is a major public health problem, affecting up to 15.1 million adults in the United States in 2001 (1). The nationwide prevalence among all ages increased 74% from 1980 to 1996 (2). Work-related asthma (WRA) is defined as asthma caused or worsened by work or the work environment. Approximately 250 agents have been associated with asthma among workers (3, 4). It is estimated that the proportion of adult asthma that is work related is 15% (4). Surveillance systems tracking work-related respiratory conditions in developed countries have shown that WRA is one of the most frequently reported of the occupational respiratory conditions (5–7). Such surveillance systems usually rely on physician reports and are case based rather than population based, thereby significantly underestimating the prevalence of WRA (8, 9). The primary sources of population-based data for adult asthma in the United States have been the National Health Interview Survey (NHIS), National Health and Nutrition Examination Survey (NHANES), and Behavioral Risk Factor Surveillance System (BRFSS). Yet, while these surveys have estimated the prevalence of asthma among adults and have examined various risk factors and demographics associated with asthma, none have reported the proportion of adult asthma that is work related. Population-based data are needed to more accurately estimate WRA prevalence at the state level and to provide a foundation for prevention efforts.

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The BRFSS is an annual, nationwide, random-digit–dialed telephone survey of adults 18 years of age and over that assesses prevalence and trends of health-related behaviors, prevention practices, and selected health conditions. It is administered in all 50 states and includes core questions administered to all respondents nationwide, as well as questions added by states on specific topics. We report here the proportion of current asthma that is work related in California, Massachusetts, and Michigan, which was derived from several supplementary questions administered as part of the Behavioral Risk Factor Surveillance System (BRFSS) 2001.

METHODS

The BRFSS is funded and coordinated by the Centers for Disease Control and Prevention (CDC) and data are collected in 54 jurisdictions, including all 50 states, the District of Columbia, and 3 U.S. territories. The system uses a random-digit–dialed telephone design to survey the noninstitutionalized civilian U.S. population 18 years of age and older to collect information about the prevalence and trends of disease and health-related behaviors. Data are collected on an ongoing basis and the survey is administered in several languages, including English, Spanish, and Portuguese, depending on the state. Sample sizes in every state and jurisdiction vary, depending on data needs and the availability of funds.

The BRFSS questionnaire is developed annually by the CDC in collaboration with the states and consists of three components: (1) a core component of questions administered by all states; (2) optional modules consisting of questions on specific topics of interest; and (3) questions added by individual states to address topics of local concern (10). In 2001, the core component included two questions about asthma. Survey

respondents were asked, "Have you ever been told by a doctor, nurse, or other health professional that you had asthma?" and "Do you still have asthma?" The first question was used to assess the proportion of people who have ever had asthma in their lifetime. Those respondents who answered "yes" to this question were asked the second question to assess the proportion of people who currently have asthma. To determine age at asthma onset (childhood versus adult), respondents in Michigan and Massachusetts were also asked, "How old were you when you were first told by a doctor, nurse, or other health professional that you had asthma?"—a question contained in the optional adult asthma history module. To estimate the proportion of people with WRA, respondents in all three states were asked two state-added questions: (1) "Were you ever told by a doctor or other medical person that your asthma was related to any job you ever had?" and (2) "Did you ever tell a doctor or other medical person that your asthma was related to any job you ever had?" The work-related questions were developed by state investigators in consultation with the National Institute for Occupational Health and Safety (NIOSH) and the National Center for Environmental Health (NCEH). The questions were adapted from two WRA questions on the 1988 Occupational Supplement of the National Health Interview Survey (NHIS), the results of which were never published.

Each state analyzed its own data using SAS statistical software (version 8.1; SAS Institute Inc., Cary, NC) and provided summary results for this report. Weighting was performed to compensate for unequal selection probabilities and nonresponse differences in the study sample. In addition to adjusting for variation in selection and sampling probability, weighting also adjusts for variation in the demographic characteristics of each state's sample so that the survey results can be projected to the state's general population as a whole (10). Chi-square tests were used to compare state results.

To estimate the number of people in each state that have WRA, state-specific prevalence results were applied to each state's population as determined by the 2000 U.S. Census. First, the prevalence of people with current asthma was multiplied by the number of people 18 years of age and over as determined by the Census. This result was then multiplied by the proportion of people who responded "yes" to either of the two WRA questions, establishing that the respondent or their health care provider had identified an association between asthma and work. To estimate the national burden of WRA, the nationwide 2001 BRFSS prevalence of current asthma of 7.2% (1) was multiplied by the 2000 U.S. Census number for the U.S. population age 18 and older. This number was then multiplied by our estimate of the proportion of asthma found to be work related. Because only three states asked the work-related questions, no national BRFSS data on WRA as a proportion of adult asthma were available, and instead the range (7.4–9.7%) from the three states was used.

RESULTS

Lifetime Asthma Prevalence

The number of people interviewed in each state was 4,188 in California, 8,628 in Massachusetts, and 3,830 in Michigan (Table 1). Response rates, as defined by the Council of American Survey Research Organizations (CASRO), were 38.0% in California, 36.7% in Massachusetts and 44.2% in Michigan. Demographic characteristics of state participants have been described elsewhere (11). The lifetime prevalence of asthma was similar across the three states, ranging from 12.4 to 13.1%. In all three states, lifetime asthma prevalence differed by gender, with women reporting a prevalence of 14.1 to 15.4% versus 9.9 to 11.0% in men. Massachusetts and Michigan showed very similar results for age of onset of lifetime asthma. The prevalence of childhood-onset (under 16 years of age) lifetime asthma among all respondents was 5.7 to 5.9%, whereas 6.2 to 6.7% of respondents reported lifetime asthma with adult onset. The prevalence of people reporting adult-onset lifetime asthma differed by gender; 8.5 to 8.7% of female respondents reported adult-onset asthma, as compared to 3.5 to 4.7% of male respondents reporting adult-onset asthma.

TABLE 1.—Prevalence of adults with lifetime and current asthma in 3 states: California, Massachusetts, and Michigan, Behavioral Risk Factor Surveillance System (BRFSS) results, 2001.

	California $n = 4{,}188$	Massachusetts $n = 8{,}628$	Michigan $n = 3{,}830$
Lifetime asthma			
All	12.7 ± 1.2	13.1 ± 0.9	12.4 ± 1.2
Males[1]	9.9 ± 1.6	11.0 ± 1.3	10.5 ± 1.8
Females[2]	15.4 ± 1.6	14.9 ± 1.2	14.1 ± 1.6
Childhood-onset			
All	*	5.9 ± 0.7	5.7 ± 0.9
Males[3]	*	5.9 ± 1.0	6.5 ± 1.5
Females[4]	*	5.9 ± 0.9	4.9 ± 1.1
Adult-onset			
All	*	6.7 ± 0.6	6.2 ± 0.8
Males	*	4.7 ± 0.9	3.5 ± 1.0
Females	*	8.5 ± 0.9	8.7 ± 1.3
Current asthma			
All	7.5 ± 0.9	9.5 ± 0.8	8.8 ± 1.0
Males	5.2 ± 1.2	7.4 ± 1.1	6.7 ± 1.5
Females	9.8 ± 1.3	11.4 ± 1.2	10.8 ± 1.5
Childhood-onset			
All	*	4.0 ± 0.6	3.5 ± 0.7
Males	*	3.5 ± 0.8	3.7 ± 1.2
Females	*	4.3 ± 0.8	3.4 ± 0.9
Adult-onset			
All	*	5.2 ± 0.6	5.0 ± 0.7
Males	*	3.7 ± 0.8	2.9 ± 0.9
Females	*	6.7 ± 0.8	7.0 ± 1.2

*Age of onset not asked in California.
[1]Proportion of male adults who reported diagnosis of asthma in their lifetime.
[2]Proportion of female adults who reported diagnosis of asthma in their lifetime.
[3]Proportion of male adults who reported lifetime asthma with childhood onset.
[4]Proportion of female adults who reported lifetime asthma with childhood onset.
Percentages with 95% confidence intervals.

Current Asthma Prevalence

The prevalence of adults with current asthma varied significantly by state, with 7.5% in California, 8.8% in Michigan, and 9.5% in Massachusetts ($\chi^2 = 14$, $p < 0.001$). Women were more likely to report current asthma, with a prevalence ranging from 9.7 to 11.4% compared to men reporting a 5.1 to 7.4% prevalence. Again, age at onset was similar between Michigan and Massachusetts for all respondents with approximately 3.5 to 4.0% in each state reporting current asthma with childhood onset and 5.0 to 5.2% reporting current asthma with adult onset. Current asthma with adult onset was twice as common among women, who reported approximately twice the prevalence compared to men (6.7–7.0% *vs* 2.9–3.7%, $p < 0.001$).

TABLE 2.—Proportion of adults with current asthma reporting an association with work in 3 states: California, Massachusetts, and Michigan, Behavioral Risk Factor Surveillance System (BRFSS) results, 2001.

	California $n = 342$	Massachusetts $n = 817$	Michigan $n = 337$
Q1. Were you ever told by a doctor or other medical person that your asthma was related to any job you ever had?			
All[1]	5.8 ± 3.2	6.1 ± 2.1	5.8 ± 2.3
Male[2]	8.4 ± 6.9	6.3 ± 3.3	6.1 ± 4.0
Female[3]	4.4 ± 3.3	6.0 ± 2.7	5.6 ± 2.8
Childhood-onset[4]	*	2.8†	3.4 ± 2.9
Adult-onset[5]	*	8.5 ± 2.8	7.3 ± 3.3
Q2. Did you ever tell a doctor or other medical person that your asthma was related to any job you ever had?			
All	3.9 ± 2.4	4.7 ± 1.5	7.0 ± 2.9
Male	5.5 ± 5.1	3.8 ± 2.5	10.4 ± 6.4
Female	3.1 ± 2.5	5.2 ± 1.9	5.1 ± 2.8
Childhood-onset	*	1.5 ± 1.2	4.0 ± 3.3
Adult-onset	*	6.6 ± 2.4	9.3 ± 4.6
Possible WRA (yes to either Q1 or Q2)			
All	7.4 ± 3.5	8.5 ± 2.3	9.7 ± 3.2
Male	9.8 ± 7.2	7.9 ± 3.6	12.6 ± 6.8
Female	6.1 ± 3.9	8.8 ± 3.0	8.1 ± 3.3
Childhood-onset	*	3.7 ± 3.3	5.3 ± 3.7
Adult-onset	*	11.8 ± 3.2	12.7 ± 4.9

*Age of onset not asked in California.

†Symmetric confidence intervals could not be generated for this point estimate due to variation in the sample weights in the MA BRFSS. The asymmetric confidence interval for this point estimate is 0.9–8.6.

[1]Proportion of adults with current asthma who reported they were told their asthma was work-related.

[2]Proportion of male adults with current asthma who reported they were told their asthma was work related.

[3]Proportion of female adults with current asthma who reported they were told their asthma was work related.

[4]Proportion of adults with current asthma that was diagnosed in childhood who reported they were told their asthma was work related.

[5]Proportion of adults with current asthma that was diagnosed in adulthood who reported they were told their asthma was work related.

Percentages with 95% confidence intervals.

Proportion of Current Asthma Related to Work

In all three states a substantial proportion of adults with current asthma reported an association with work by answering "yes" to one of the work-related questions (7.4–9.7%) (Table 2). The three states reported nearly identical proportions (approximately 6%) of respondents with current asthma who had been told by a medical care professional that their asthma was related to their work. However, the findings differed by state for the proportion of respondents who recognized the link between work and asthma themselves and told a medical care professional that their asthma was related to their job (3.9–7.0%), with Michigan showing the highest percentage. Proportionately more men than women reported that their current asthma was work related (yes to either Q1 or Q2) in California and Michigan, whereas proportionately more women did so in Massachusetts. Data from Massachusetts and Michigan examining age at onset indicate that the proportion of asthma that is work related is over twice as high among those who developed asthma as adults compared to those who developed asthma as children (12–13% *vs* 4–5%).

Applying these proportions to 2000 U.S. Census data in each state results in an estimate of 137,000 adults in California (95% confidence interval 62,000–228,000), 39,000 in Massachusetts (26,000–54,000), and 63,000 in Michigan (37,000–93,000) with current WRA. Although these data are available for only three states, California, Massachusetts, and Michigan represent geographically diverse regions of the country and together comprise almost one fifth of the U.S. working population. If we assume that these populations are not substantially different from the rest of the nation, the findings can be used to generate a crude estimate of the possible scope of WRA for the country as a whole. National results for the 2001 BRFSS revealed a prevalence of lifetime asthma of 11% and a prevalence of current asthma of 7.2% (1). Using the national estimate of current asthma (7.2%), the range of proportions of asthma that is work related from the three states (7.4–9.7%), and U.S. Census numbers for the U.S. population, we estimate that 1.1 to 1.5 million people in the U.S. may have had WRA in 2001.

DISCUSSION

Lifetime and Current Asthma Prevalence

All three states included in this study reported a higher prevalence of adults with lifetime and current asthma than the national average, with Massachusetts reporting the highest prevalence of current asthma among all 50 states (9.5%) (1). Women had a higher prevalence of both current and lifetime asthma, which is consistent with other studies (2, 12, 13). Also, women were more likely to report adult onset of their asthma than men for both lifetime and current asthma. This reflects the well-documented trend of boys outnumbering girls with asthma in childhood followed by a reversal with women exceeding men with asthma as adults (12–17).

Some results differed among the three states. While still above the national average (7.2%), current asthma was significantly lower in California than in Massachusetts or Michigan (7.5% *vs* 9.5% and 8.8%, $\chi^2 = 14$, $p < 0.001$). Among the possible reasons for state disparities are differences in population demographics, environmental factors, socioeconomic factors, physician diagnostic practices, industry and employment patterns, and data collection procedures.

Proportion of Asthma Associated with Work

These findings show that WRA accounts for a substantial proportion of adult asthma in these three states. Overall, with Q1 and Q2 combined, in California and Michigan, men were more likely to report that their asthma was work-related than women, which is consistent with other studies of asthma associated with work (18–24). In contrast, surveillance systems in these three states plus one other found that 56% of cases of WRA identified during 1993–1995 were female (25). Possible explanations for this discrepancy could be that case finding for the surveillance systems rely on health care provider recognition and reporting of WRA, which may not be representative of cases in the population. Surveillance case confirmation relies on telephone interviews, which in California and Massachusetts are more likely to be completed by women than men. Some studies have suggested that women with asthma use medical care more often than men, but this does not explain the gender discrepancies in the BRFSS findings (26–28).

It is important to remember that WRA includes preexisting asthma exacerbated by conditions in the workplace as

well as new-onset asthma. Overall, previous studies show that among adults with asthma, the proportion with adult onset is approximately 50 to 60%, which is consistent with the BRFSS data from Massachusetts and Michigan (23, 29, 30, 31). In our data, the proportion of asthma that was work related was higher among those reporting adult-onset asthma than those reporting childhood onset. One possible explanation for this finding is that health care providers and workers may be more likely to recognize and report workplace factors as possible triggers in new-onset asthma, as opposed to lifelong asthma exacerbated in the workplace. This finding is consistent with WRA surveillance data showing that approximately 80% of the cases reported by four states (including the three in this survey) were new onset (25–26). Differences in WRA by state may be related to differences in the nature of industry in each state. Michigan, for example, due to its automobile manufacturing industry, has a much larger manufacturing sector than the other two states. Massachusetts and California have a more dominant service industry sector than Michigan. Strong union membership or occupational health programs in industry may affect the awareness of both workers and health care providers around WRA and may in turn increase the recognition of WRA and therefore, its prevalence.

These data are the first population-based survey findings for WRA at the state level in the United States. The American Thoracic Society (ATS) recently conducted a literature review and concluded that a median of 15% is a reasonable estimate of the occupational contribution to the population burden of asthma (4), although other studies estimate that workplace exposures are responsible for up to 21% of all asthma cases among adults in the United States and as much as 29% in other parts of the world (20). In surveillance systems from the industrialized world, occupational asthma is a frequently reported occupational respiratory disorder (32). The annual incidence rate for WRA ranges from 3 per million working people to 710 per million, depending on the country and study (8, 9, 20, 25, 33). Certain occupations are at especially high risk, with up to 30 times the average overall incidence rate (21). The prevalence of asthma in certain high-risk occupational groups ranges from 5% in isocyanate and western red cedar workers (34, 35) to 10% in animal handlers (36) and historically up to 40 to 50% in the detergent industry and platinum refinery workers (37). It is well established that the incidence and prevalence of WRA in various occupational cohorts is dependent on the agents to which workers are exposed and the levels of exposure (4).

The primary remedy for WRA is the identification and prevention of workplace exposures that cause or trigger it. Cessation of these exposures and early diagnosis are the best established predictors of case resolution, suggesting that early identification of cases and immediate elimination of worker exposure to the suspected agent are crucial to long-term prognosis (38, 39). The socioeconomic consequences of WRA are severe. In a follow-up study of workers diagnosed with WRA by Ameille et al., 25% of workers were unemployed, 44% had left the job of exposure, and 32% remained exposed approximately 3 years after diagnosis. Overall, 46% showed a reduction in income (40).

WRA surveillance systems in all three states have been tracking incident cases of WRA for over 10 years, yet have identified a much smaller number of cases than would be expected given the results of this study. A CDC report summarizing 7 years of surveillance data reported 2,526 cases of WRA in 4 states, including the 3 in this study (26). These surveillance data were generated as part of the Sentinel Event Notification System for Occupational Risks (SENSOR), a program funded by the National Institute for Occupational Safety and Health (NIOSH) established to detect priority cases of occupational illness and injury so that interventions and prevention activities can be targeted. Underreporting is acknowledged to be an obstacle for case-based surveillance systems, resulting in a significant undercount of individuals with WRA (6, 8, 9, 41, 42). Case-based surveillance data show the lowest estimates for how much asthma may be work related, most likely because they typically rely on voluntary or passive reporting and require the most definitive proof that the asthma is work related (9).

The findings of this survey are subject to several limitations. Only non-institutionalized civilian adults 18 years of age and older with telephones were included in the survey. While a high proportion of households included in the sample have telephones (over 90%), asthma prevalence could be different in homes without telephones. The Council of American Survey Research Organizations (CASRO) response rate for the BRFSS in these three states was lower than the national median. While the median response rate for the national data was 51.1%, the rate was 38.0% for California, 36.7% for Massachusetts, and 44.2% for Michigan. This could impact the results of the survey and account for some differences between states. Also, the diagnosis and work relatedness of asthma are self-reported in the survey. While previous research suggests that self-reported asthma can provide an accurate measure of asthma prevalence, the validity of self-reported asthma on the BRFSS is unknown (43). A respondent may incorrectly recall a diagnosis of asthma or a physician's diagnosis could be wrong. Similarly, the validity of self-reported association with work has not been determined. It is possible for a respondent to discuss work relatedness with a health care provider when the asthma is not work related. However, it is also possible that the questions used to assess work-relatedness generated an underestimate of prevalence of WRA. It has been documented that WRA is frequently unrecognized and undiagnosed (33). Health care providers frequently do not ask about work exposures and do not appreciate the prevalence of WRA. Milton et al. found that in a large Massachusetts health maintenance organization population, 21% of asthma cases did not remember being told by a physician that they had asthma. Only 15% of the medical records of adults with asthma showed any documentation that a provider inquired about workplace exposures (33). In a more recent study of adult-onset asthma, researchers found that medical charts "included a discussion of work exposures in relation to asthma in only 7% of the cases" (44).

The individual costs as well as costs to society in terms of medical care, lost workdays, and lost income from asthma are severe. It is important to recognize that a substantial portion of adult asthma morbidity is due to exposures in the work environment. Asthma can be effectively prevented in the workplace through interventions and prevention activities. Other states should be encouraged to assess the proportion of WRA in their asthmatic populations utilizing the

BRFSS. It is a low-cost method of estimating the burden of WRA at the state level using an existing survey mechanism. By increasing recognition of WRA by health care providers and public health practitioners, prevention efforts can be targeted to diminish exposures, thus reducing both the overall asthma prevalence and severity and associated human and economic burden.

The findings and conclusions in this report are those of the author(s) and do not necessarily represent the views of the National Institute for Occupational Safety and Health.

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ABBREVIATIONS

BRFSS:	Behavioral Risk Factor Surveillance System
CASRO:	Council of American Survey Research Organizations
CDC:	U.S. Centers for Disease Control and Prevention
NCEH:	National Center for Environmental Health
NHANES:	National Health and Nutrition Examination Survey
NHIS:	National Health Interview Survey
NIOSH:	National Institute for Occupational Safety and Health
SENSOR:	Sentinel Event Notification System for Occupational Risks
WRA:	Work-related asthma.

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