Characteristics of Patients With Work-Related Asthma Seen in the New York State Occupational Health Clinics

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Objective: The objective of this study was to characterize the work-related asthma population seen by the New York State Occupational Health Clinic Network (OHCN) to determine which industries, occupations, and causal agents are associated with work-related asthma in New York State (NYS). **Methods:** *The OHCN patient database was analyzed to identify those patients with a diagnosis of work-related asthma and medical charts were then abstracted for data on demographics, clinical history, disease severity, industry, occupation, and putative agent.* **Results:** *The OHCN patients with work-related asthma were most commonly employed in the service and manufacturing industries. Common occupations included teachers, farm operators/managers, and construction trades. The most frequently reported putative agents associated with work-related asthma were dust, indoor air, mold, and solvents.* **Conclusions:** *Our findings suggest the potential importance of prevention of workplace exposure in reducing adult asthma in NYS.* (J Occup Environ Med. 2006;48:1203–1211)

In the United States, like in other industrialized countries, asthma of occupational etiology has been a largely unrecognized cause of preventable disease and disability.[1] Over the past decade, work-related asthma has become the most frequently diagnosed occupational respiratory disease in developed countries with estimates of the proportion of work-related asthma in the adult population ranging from 2% to 26% with a median of 15%.[2,3] Work-related asthma is asthma that can be attributable to or made worse by exposures in the workplace.[1] It is estimated that in the United States, there are over 20 million workers potentially exposed to occupational asthmagens[4] of which more than 350 have been documented.[5,6] Definitive diagnoses of work-related asthma can be complicated by the difficulty in distinguishing it from asthma caused by nonoccupational etiologies.

In 1987, the National Institute for Occupational Safety and Health (NIOSH) instituted the Sentinel Event Notification System for Occupational Risks (SENSOR) cooperative agreement program with the aim of identifying and characterizing new case reports of targeted occupational diseases. State-based surveillance and intervention programs for work-related asthma are conducted in California, Massachusetts, Michigan, and New Jersey as part of the SENSOR program. From January 1, 1993, through December 31, 1999, a total of 2526 cases of work-related asthma were identified by state SENSOR programs.[7] The SENSOR states worked with NIOSH to

develop a surveillance case definition for work-related asthma. This definition includes: 1) a healthcare professional's diagnosis of asthma and 2) an association between symptoms of asthma and work.[8] Work-related asthma is then classified into categories using case classification criteria. These categories include work-aggravated asthma—a work-related exacerbation of a preexisting asthma condition, and new-onset occupational asthma—asthma induced by workplace exposures. The NIOSH work-related asthma classification system also distinguishes between two types of new-onset work-related asthma—reactive airways dysfunction syndrome (RADS) and occupational asthma. RADS is a condition in which new asthma symptoms develop within 24 hours after a one-time, high-level inhalation exposure to an irritant gas, fume, smoke, or vapor and persist for at least 3 months.[9]

The prognosis of work-related asthma depends on the severity and duration of symptoms at the time of diagnosis and on the timeliness and effectiveness of medical treatment and environmental preventive interventions. The most effective clinical approach is to stop exposure to the offending agent(s).

Although work-related asthma has been documented across a wide variety of industries, occupations, and sociodemographic groups, little is known about the distribution of the disease and its risk factors in New York State (NYS). This can be examined by using data from the NYS Occupational Health Clinic Network (OHCN).[10] These clinics are recognized centers of excellence providing a unique blend of high-quality occupational medicine services specializing in the diagnosis, treatment, and prevention of occupational diseases. Patients are referred to the clinics by their primary care practitioners, employers, attorneys, community groups unions, or as self-referrals.

The NYS OHCN developed and published a series of clinical practice protocols in an effort to contribute to the improved diagnosis, treatment,

and prevention of occupational disease.[11] These protocols are used by the OHCN to guide clinical practice and maintain a high level of quality care and consistent practice. They integrate public health approaches (primary, secondary, and tertiary disease prevention) into the clinical model by emphasizing a team approach to the diagnosis and treatment of occupational diseases.[11] Included among these protocols is one specific to work-related asthma that provides the steps and diagnostic tools for the clinical evaluation of patients with suspected work-related asthma.[1]

This study, the first multicenter study of work-related asthma in the clinic network, was designed to:

- Characterize the work-related asthma population seen at the OHCN,
- determine which industries, occupations, and causal agents are associated with work-related asthma in NYS,
- determine what proportion of cases conform with the Centers for Disease Control and Prevention's (CDC) NIOSH case definition of work-related asthma,[8] and
- compare the work-related asthma cases seen at the OHCN with those work-related asthma cases reported by the SENSOR states.

Materials and Methods

Only those patients seen at one of the OHCN clinics from January 1, 1988, through December 31, 1999, and diagnosed with definite work-related asthma were included in this study. A case of "definite" work-related asthma is defined as one in which a network clinician determined that both the diagnosis of asthma and its workrelatedness conformed to the clinical diagnostic criteria set forth in the NYS OHCN clinical practice review for work-related asthma.[1] All of the network clinics submit patient data to the NYS Department of Health on a monthly basis. Those patients diagnosed with work-related asthma were coded according to the Interna-

tional Classification of Diseases, 9th Revision (ICD-9) using codes 493–493.9. A list of patients meeting the eligibility requirements, by clinic, was generated by medical record number to identify those charts to be reviewed and abstracted. The medical charts were abstracted by NYS Department of Health reviewers for data on demographics, clinical history, disease severity, industry, occupation, and potential etiologic agent. Human subjects research protection approval was secured from the NYS Department of Health Institutional Review Board (IRB) and the corresponding IRB at each clinic in the OHCN before any medical charts were abstracted.

During the period of January 1, 1988, through December 31, 1999, providers at the clinics saw more than 34,000 patients, approximately 21,000 of which were seen as part of group screenings (ie, asbestos screenings, respiratory certifications). The patients with work-related asthma in this study were compared only with the remaining 12,823 symptomatic patients seen individually for medical evaluation.

Data abstracted from the medical charts were analyzed using SAS 8.2[12] to characterize the work-related asthma population seen at the OHCN. The industry and occupation associated with each patient with work-related asthma were classified according to the Standard Industrial Classification and Bureau of Census Occupation Codes. Multiple potential workplace exposures were recorded for each case of work-related asthma.

The data were analyzed in an effort to determine the proportion of cases that conformed with the NIOSH case definition for work-related asthma. Information on SENSOR cases was obtained from recent NIOSH publications to identify similarities and differences between the work-related asthma patient population in New York State and the SENSOR states. χ^2 analysis was used to compare the patients with asthma with the symptomatic OHCN patients

TABLE 1

Characteristics of Patients With Work-related Asthma Seen at the New York State Occupational Health Clinic Network (OHCN) Compared With All Symptomatic Patients Seen at the OHCN

	OHCN Patients With Asthma		All Symptomatic OHCN Patients			
	N	Percent	N*	Percent	χ^2	P Value
Gender					41.8	<0.0001
Male	210	46.3	7862	61.3		
Female	244	53.7	4956	38.6		
Race/ethnicity					4.3	0.40
White	347	76.4	10134	79.0		
Black	59	13.0	1503	11.7		
Hispanic	37	8.2	867	6.8		
Asian	7	1.5	252	2.0		
Native American	4	0.9	58	0.5		
Age					16.1	0.001
<20 yr old	3	0.7	96	0.7		
20–39 yr old	180	39.6	4605	35.9		
40–59 yr old	244	53.7	6572	51.3		
>60 yr old	27	5.9	1548	12.1		
Body mass index (kg/m^2)						
Underweight (<18.5)	5	1.2	N/A†	N/A†	—	—
Normal (18.5–24.9)	110	26.9	N/A†	N/A†	—	—
Overweight (25–29.9)	141	34.5	N/A†	N/A†	—	—
Obese (>30)	153	37.4	N/A†	N/A†	—	—
Missing information	45				—	—
Smoking status						
Current	57	13.1	N/A†	N/A†	—	—
Former	142	32.7	N/A†	N/A†	—	—
Never	235	54.1	N/A†	N/A†	—	—
Missing	20				—	—
Worker's compensation filed						
Yes	358	87.3	N/A†	N/A†	—	—
No	52	12.7	N/A†	N/A†	—	—
Missing	44					
Referral source					194.4	<0.001
Union	77	17.0	3037	23.7		
Employer	13	2.9	2403	18.7		
Physician	179	39.4	2390	18.6		
Lawyer	74	16.3	1289	10.1		
Self	30	6.6	1232	9.6		
COSH	12	2.6	179	1.4		
Other	69	15.2	2293	17.9		

*Total number of patients for each characteristic may vary slightly due to missing data.
†These data were not available from the OHCN database.
N/A indicates the data is not applicable for the category.
COSH indicates Committee for Occupational Safety and Health.

and with cases from the SENSOR states.

Results

Analysis of the OHCN database identified 480 patients who were diagnosed with work-related asthma by an OHCN clinician during the period 1988 through 1999. A total of 454 charts (95%) were abstracted. The remaining charts could not be located at the time of chart abstrac-tion. Patients with work-related asthma represent approximately 4% of the total number of symptomatic patients seen by OHCN physicians.

Table 1 provides a comparison of the patients with work-related asthma to the 12,823 symptomatic OHCN patients. Significantly more of the work-related asthma patients were female (53.7% vs 38.6%). The ethnic distribution of the work-related asthma cases was similar to that of the symptomatic OHCN patients with only slightly more of the patients with work-related asthma being black (13.0% vs 11.7%) and His-panic (8.2% vs 6.8%). Compared with the symptomatic OHCN pa-tients, the patients with work-related asthma tended to be younger (the mean age of the patients with work-related asthma was 42.6, whereas the mean age of the symptomatic OHCN patients was 44.6). Significantly more of

TABLE 2

Indicators of the Severity of Disease at the Time of the First Visit for Patients With Work-Related Asthma Seen at the New York State Occupational Health Clinic Network

	Patients With Work-Related Asthma (N = 454)		New-Onset Occupational Asthma Cases (N = 214)		Reactive Airways Dysfunction Syndrome Cases (N = 144)		Work-Aggravated Asthma Cases (N = 63)		Unclassifiable Patients With Work-Related Asthma (N = 33)	
	N	Percent	N	Percent	N	Percent	N	Percent	N	Percent
Number of asthma medications*										
None	69	15.2	34	15.9	26	18.1	4	6.4	5	15.2
One	90	19.8	45	21.0	31	21.5	8	12.7	6	18.2
Two	110	24.2	54	25.2	35	24.3	13	20.6	8	24.2
Three	97	21.4	45	21.0	25	17.4	20	31.8	7	21.2
Four or more	88	19.4	36	16.8	27	18.8	18	19.1	7	21.2
Steroid use*										
Yes	104	22.9	47	22.0	32	22.2	18	9.5	7	21.2
No	350	77.1	167	78.0	112	77.8	45	71.4	26	78.8
Hospitalization/emergency room visits due to exposure										
Yes	123	27.1	54	25.2	41	28.5	23	36.5	5	15.2
No	331	72.9	160	74.8	103	71.5	40	63.5	28	84.8
Job change due to exposure										
Yes	201	44.3	102	47.7	63	43.8	25	39.7	11	33.3
No	242	53.3	108	50.5	79	54.9	37	58.7	18	54.6
Unknown	11	2.4	4	1.9	2	1.4	1	1.6	4	12.1

*Not necessarily mutually exclusive; a medication can be counted in both "number of asthma medications" and "steroid use" medication categories.

the patients with work-related asthma were referred to the clinics by a physician (39.4% vs 18.6%).

Approximately 65% of the patients with work-related asthma were overweight or obese, whereas 45% indicated that they were current or former smokers.

The most commonly reported symptoms among the patients with work-related asthma included shortness of breath (77.5%), wheezing (64.8%), and cough (62.6%). Only 21.8% of the patients indicated that they had a history of asthma and the majority of patients (55.3%) had no history of respiratory disease or allergies. Less than one fourth of the patients (23.6%) indicated that they had a family history of asthma.

Indicators of the severity of the disease at the time of diagnosis, broken down by type of work-related asthma, are provided in Table 2. At the time of their first visit to the clinics, 85% of the patients were taking some form of asthma medication, 40% were taking three or more asthma medications, and almost one fourth of the patients were using steroids to treat their asthma symptoms. Slightly more than one fourth of the patients with work-related asthma indicated they either went to the emergency room or were hospitalized because of symptoms resulting from their exposure. Almost half of the patients indicated that they had to change their job due to the exposures at their workplace.

Table 3 shows the industries in which patients were employed when their work-related asthma occurred. Almost 62% of the patients diagnosed with work-related asthma at the OHCN were employed in the service and manufacturing industries. Among the service industries, elementary and secondary schools (9.5%), medical and surgical hospitals (7.7%), and colleges and universities (3.5%) were the three most frequent. These industries, along with dairy farms (7.7%) and local and suburban transit (2.4%), accounted for the five most common industries associated with the patients with work-related asthma (data not shown). Overall, the manufacturing, agriculture, and

public administration industries were overrepresented in the work-related asthma population when compared with the employed population of adults in NYS.[13]

The industry distribution for the patients seen at the OHCN was similar to that for cases of work-related asthma identified by other states as part of their SENSOR program, although the OHCN cases were more likely to be associated with the agriculture and transportation industries than the SENSOR cases (Table 3). The most common industries associated with SENSOR work-related asthma cases included manufacturing (41.5%) and services (34.2%). In fact, there were significantly more SENSOR cases employed in the manufacturing industry when compared with the OHCN cases. Similar to NYS, the manufacturing and public administration industries were overrepresented in the SENSOR work-related asthma population when compared with the employed population of adults in these states.[13]

TABLE 3
Industries of Work-Related Asthma Cases Compared With the Number of Employed Adults, New York State (NYS) Occupational Health Clinic Network (OHCN) (1988–1999) and SENSOR Asthma States (1993–1999)

Industry (Standard Industrial Classification)	Employed Adults*		Patients With Work-Related Asthma	
	NYS (N = 8.4 million) (%)	SENSOR States (N = 28 million) (%)	NYS OHCN (N = 454) (%)	SENSOR States†‡ (N = 2526) (%)
Agriculture (01–09)	1.1	2.6	9.3	2.1
Mining (10–14)	0.1	0.1	0.9	0.2
Construction (15–17)	5.4	6.0	4.6	3.0
Manufacturing (20–39)	11.7	15.8	23.1	41.5
Transportation (40–49)	7.8	6.8	7.1	3.8
Wholesale (50–51)	3.5	4.2	1.3	1.4
Retail (52–59)	16.0	16.6	3.5	3.3
Finance, Insurance, Real Estate (60–67)	8.6	6.8	2.4	1.5
Services (70–89)	41.0	37.2	38.8	34.2
Public Administration (91–97)	4.9	4.1	9.0	9.0

*Employment data from the Bureau of Labor Statistics includes persons older than 16 yr of age employed during 1999.
†California, Massachusetts, Michigan, and New Jersey.
‡Includes cases with unclassifiable industries.

TABLE 4
Occupations of Work-Related Asthma Cases Compared With the Number of Employed Adults, New York State (NYS) Occupational Health Clinic Network (OHCN) (1988–1999) and SENSOR Asthma States (1993–1999)

Occupation (Census Occupation Codes)	Employed Adults*		Patients With Work-Related Asthma	
	NYS (N = 8.4 million) (%)	SENSOR States (N = 28 million) (%)	NYS OHCN† (N = 454) (%)	SENSOR States†‡ (N = 2526) (%)
Managerial and professional specialty (003–199)	32.6	32.0	23.1	20.2
Technical, sales, and administrative support (203–389)	29.3	29.4	22.9	19.2
Service (403–469)	16.6	13.2	9.9	11.8
Farming, forestry, and fishing (473–499)	1.4	2.6	9.5	2.1
Precision production, craft, and repair (503–699)	8.8	10.2	14.3	12.3
Operators, fabricators, and laborers (703–889)	11.4	12.7	20.0	32.9

*Employment data from the Bureau of Labor Statistics includes persons older than 16 yr of age employed during 1999.
†Includes cases with unclassifiable and miscellaneous unemployed occupations.
‡California, Massachusetts, Michigan, and New Jersey.

Occupation distributions of the patients with work-related asthma were also similar to the SENSOR cases (Table 4). The OHCN patients were, however, more likely to have farming occupations and were less likely to be operators or laborers due to the differences previously observed with manufacturing. The five most common occupations of the patients with work-related asthma seen at the OHCN included teachers (7.3%), farm operators and managers (6.6%), construction trades (5.7%), administrators and managers (5.5%), and cleaning and building services (5.1%) (data not shown). Farming, forestry and fishing, precision production, craft and repair and operators, fabricators, and laborer occupation categories were overrepresented in the work-related asthma population when compared with the employed population of working adults in NYS.[13] Similarly in the SENSOR states, cases of work-related asthma were overrepresented in the precision production, craft and repair and operators, fabricators, and laborer occupation categories.

The most frequently reported putative agents associated with all work-related asthma cases were dust (33.5%), poor indoor air quality (in-

TABLE 5
Most Frequently Reported Putative Agents Associated With Cases of Work-Related Asthma Seen at the New York State Occupational Health Clinic Network

Agent	Patients With Work-Related Asthma (N = 454) (%)*	New-Onset Occupational Asthma Cases (N = 214) (%)*	Reactive Airways Dysfunction Syndrome Cases (N = 144) (%)*	Work-Aggravated Asthma Cases (N = 63) (%)*	Unclassifiable Patients With Work-Related Asthma (N = 33) (%)*
Dusts	33.5	37.9	31.3	33.3	42.4
Poor indoor air quality	24.0	20.1	26.4	27.0	33.3
Molds	21.3	22.9	19.4	19.0	24.2
Solvents	19.8	28.5	26.4	25.4	18.2
Cleaning Products	10.4	8.9	9.0	17.5	3.0
Paints	10.4	9.8	12.5	11.1	6.1
Smoke, fumes, and vapors	6.6	5.6	4.9	12.7	9.1
Asbestos	6.4	7.0	8.3	1.6	3.0
Welding fumes	5.7	4.7	7.6	6.3	3.0
Irritant gases	5.3	5.6	6.1	3.2	—

*Patient can be exposed to more than one agent.

TABLE 6
Number of Cases of Work-Related Asthma by National Institute of Occupational Safety and Health Case Classification Category

Classification	NYS OHCN		SENSOR States*		χ^2	P Value
	N†	Percent	N	Percent		
Work-aggravated asthma	63	15.0	508	20.1	6.1	0.006
New-onset asthma	358	85.0	2018	79.9		
Reactive airways dysfunction syndrome	144	34.2	238	9.4		
Occupational asthma	214	50.8	1780	70.5		

*California, Massachusetts, Michigan, and New Jersey.
†Information is not presented on 33 patients due to inability to classify these patients.
NYS OHCN indicates New York State Occupational Health Clinic Network.

cluding poor ventilation, odors, construction dust and debris) (24.0%), molds (21.3%), solvents (19.8%), cleaning products (10.4%), and paints (9.3%). Dust, poor indoor air quality, and solvents were the three agents most commonly associated with cases of RADS and work-aggravated asthma, whereas dust, solvents, and molds were the top three reported agents for the occupational asthma cases (Table 5). A case could have multiple putative agents assigned. Work-related asthma among teachers was most commonly attributed to dust, mold, and indoor air, whereas work-related asthma among farm workers was most commonly attributable to dust and mold. Work-related asthma among executives and health techni-

cians was most commonly attributed to poor indoor air quality, whereas work-related asthma among construction workers and machine operators was most commonly attributable to solvents (data not shown).

A designation of work-related asthma cases by NIOSH case classification categories is provided in Table 6. Of the 454 cases of work-related asthma seen at the clinics, 421 cases (92.7%) met the NIOSH case classification of work-related asthma, ie, a healthcare professional's diagnosis consistent with asthma and an association between symptoms and work.[8] Of these 421 cases, 358 (85%) were new-onset cases, including 144 (34.2%) classified as RADS—new asthma symptoms that develop within

24 hours after a one-time high-level inhalation exposure that persist for at least 3 months, and 214 (50.8%) were classified as occupational asthma— classic sensitizer or irritant-induced asthma not meeting the RADS criterion. The other 63 cases (15%) were classified as work-aggravated asthma defined as increased asthma symptoms or increased use of asthma medication (on entering an occupational exposure setting) experienced by a person with preexisting asthma who was symptomatic or treated with asthma medication within the 2 years before entering that new occupational setting. For the cases identified by SENSOR states, 2018 cases (79.9%) were diagnosed with new-onset asthma, including 238 (9.4%) classified as RADS and 1780

(70.5%) classified as occupational asthma. The other 508 SENSOR state cases (20.1%) were classified as work-aggravated asthma.

For the 33 cases that did not meet the NIOSH case definition of work-related asthma, it was found that although the OHCN physicians diagnosed these patients with work-related asthma, their medical charts lacked the adequate documentation of an association between symptoms and work. These charts lacked information on asthma history, the date of first asthma symptoms, or the date of first exposure to a potential asthmagen.

Discussion

Recent studies and public health surveillance activities have led to the recognition that work-related asthma is an important public health issue. A recent study from Massachusetts involving the review of medical records from a Health Maintenance Organization (HMO) reported that 21% of new-onset adult asthma diagnoses among the HMO members could be attributed to occupational exposures.[14] Similarly, the American Thoracic Society reviewed the published literature and concluded that 15% is a reasonable estimate of the occupational contribution to the population burden of adult asthma.[3] The opportunity to investigate work-related asthma in NYS exists through the utilization of data from the NYS OHCN. This is the first multicenter study of work-related asthma in the clinic network. Although it is recognized that clinic-based reporting has problems with referral bias and misclassification, it can also provide clues as to the causes and severity of the disease.

Data from the 1996–2002 NYS Behavioral Risk Factor Surveillance System[15] show that the rate of asthma among women in NYS was nearly double that among men. Yet, among the patients diagnosed with work-related asthma at the OHCN, almost half were male. This suggests that work-related asthma affects a different population than general adult asthma, especially because women made up almost half (47%) of the employed worker population in NYS in 1999.[13]

It appears that the OHCN physicians were rigorous in their diagnosis of work-related asthma because over 92% of the cases met the NIOSH case classification. A substantially higher percent of the clinic population was diagnosed with occupational asthma (including RADS) than the SENSOR population, suggesting that the surveillance case definitions for occupational asthma and RADS used by SENSOR were less rigorous (ie, specific) than the clinical case definition used by the clinics. Comparing other clinical databases with the SENSOR population also shows a higher proportion of RADS among clinic populations.[16,17]

In view of the fact that over 84% of the patients with work-related asthma were taking asthma medication at the time of their first visit to the clinics, and 75% were referred to the clinics from an outside source (physician, union, lawyer), it is likely that this patient population was already experiencing severe symptoms when they were first seen at the clinics. Over 45% of the OHCN patients indicated they changed jobs due to the potential exposure at their workplace, which is consistent with rates of job loss or change seen in other studies.[18,19] Earlier detection of work-related asthma should be encouraged to help improve prognosis and reduce poor socioeconomic and financial outcomes. To enable earlier detection, collaboration with employers in high-risk industrial sectors should be emphasized. These employers should be targeted for outreach activities such as prevention, screening, and surveillance programs to heighten both employer and worker awareness of work-related asthma. Surveillance data could then be used to develop and implement appropriate work-related asthma prevention programs.

Identifying whether asthma is new onset or work aggravated is relevant for the management of the disease, prevention of additional cases, and treatment. The majority of patients diagnosed with work-related asthma in the OHCN were identified as new-onset asthma cases. One of the most important steps in diagnosing work-related asthma is to consider it in all adults who present with new-onset asthma. This condition is often underdiagnosed because many healthcare providers do not inquire about the possible workrelatedness of symptoms.[20] It is important to note that work-related asthma, along with its associated costs, is preventable for many patients. The symptoms and disability associated with the disease can be partially or completely reversible if exposures are identified and controlled or eliminated.[1] Prevention of new-onset asthma among coworkers of affected patients should also be considered a priority.

Although the patients with work-related asthma in this population were employed in a variety of industries and occupations, the majority was employed in service industries or the manufacturing sector. Differences in industries between the OHCN population and SENSOR state populations are reflective of the employment differences in these states.[21] The primary industry and occupation distributions of the OHCN work-aggravated asthma cases and the new-onset asthma cases were consistent with results from a recent report by the SENSOR states, which compared work-related asthma cases and new-onset asthma cases reported during 1993 through 1995.[22] Our results are also consistent with a recent study examining 2001 National Health Interview Survey data, which showed increased prevalence of work-related asthma among workers in service industries.[23] Certain occupational groups are known to be at particularly high risk of developing work-related asthma, including cleaners,[24] healthcare workers,[25] and educational service workers.[26] Cleaning and building service workers, healthcare technicians, and teachers were all common occupations among the patients with work-related asthma seen in the OHCN. Routine surveillance of worker popula-

tions known to be at risk can identify workers who require further evaluation.

Dust and poor indoor air quality represent the most frequent putative causes of work-related asthma in this population. This is similar to what was observed among the SENSOR states and other studies, which have reported an association between high exposure to dusts, gases, and fumes and an excess asthma risk.[27] Workers affected by dust included agriculture workers and teachers, whereas workers affected by poor indoor air quality included health technicians and teachers. Results of two studies examining the school environment suggest that poor indoor air quality in schools is common and adversely affects the performance and attendance of students and may affect asthmatic symptoms in schoolchildren.[28,29] It is therefore likely that the poor indoor air quality in schools also adversely affects the teaching staff, which is consistent with the results of our study.

For some occupations, asthma triggers can be substituted with other products, or work processes can be modified to eliminate or reduce exposures by use of engineering controls (ie, dust extraction equipment and regular maintenance and cleaning of machinery and/or office equipment). For many occupations, personal protective equipment such as respirators is not an effective or practical approach. In these cases, the proper maintenance of heating, ventilation, and air conditioning systems to provide a sufficient volume of clean-filtered air and the elimination or control of known sensitizers should be emphasized for prevention of work-related asthma.

The clinic patient population is not representative of the NYS worker population because the OHCN specifically focuses on patients from high-risk industries. There is increased awareness of the clinics among certain unions and industries creating a potential referral bias in that these groups may be overrepresented among the patient population. For example, the percentage of symptomatic clinic patients who work

on dairy farms is higher than the percent of NYS workers in this industry (1.7% vs 0.4%, respectively). However, it is still important to note that workers in high-risk industries in NYS remain at increased risk for work-related asthma.

Our findings suggest the potential importance of prevention of workplace exposure in reducing adult asthma in NYS. Past and present occupational factors must be included in the assessment of adult-onset asthma. Documenting work-related symptoms and occupational activities is vital in establishing a connection between a patient's workplace and their asthma diagnosis, allowing for faster control of possible workplace exposures. Results from this study also suggest the potential benefits of targeting at-risk industries in NYS for both outreach and educational endeavors.

Acknowledgments

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