Surveillance of Work-Related Asthma in Selected U.S. States Using Surveillance Guidelines for State Health Departments — California, Massachusetts, Michigan, and New Jersey, 1993–1995

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Abstract

Problem/Condition: Cases of work-related asthma (WRA) are sentinel health events that indicate the need for preventive intervention. WRA includes new-onset asthma caused by workplace exposure to sensitizers or irritants and preexisting asthma exacerbated by workplace exposures.

Reporting Period: This report reviews cases of WRA identified by state health departments from January 1, 1993, through December 31, 1995, as well as follow-up investigations of cases and associated workplaces conducted through June 30, 1998.

Description of the Systems: State-based surveillance and intervention programs for WRA are conducted in California, Massachusetts, Michigan, and New Jersey as part of the Sentinel Event Notification Systems for Occupational Risks (SENSOR) cooperative agreement program, initiated by CDC's National Institute for Occupational Safety and Health (NIOSH).

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Results: From 1993 through 1995, a total of 1,101 cases of WRA were identified by SENSOR surveillance staff members in California, Massachusetts, Michigan, and New Jersey. Of these 1,101 cases, 19.1% were classified as work-aggravated asthma, and 80.9% were classified as new-onset asthma. Objective evidence substantiating asthma work-relatedness was documented in the medical records of 3.4% of WRA cases identified in the two states (Michigan and New Jersey) where medical records are routinely reviewed for this information. Indoor air pollutants, dusts, cleaning materials, lubricants (e.g., metalworking fluids), and diisocyanates were among the most frequently reported causes of WRA. In addition, a well-recognized cause of occupational asthma — natural rubber latex — was identified in a new setting, the health-care industry. The most common industries associated with WRA cases included transportation equipment manufacturing (19.3%), health services (14.2%), and educational services (8.7%). Air sampling for agents known to induce occupational asthma was performed in Michigan for comparison with established federal time-weighted average exposure limits. Sixteen (13.4%) of 119 workplaces tested had airborne concentrations exceeding NIOSH recommended exposure limits (RELs); 11 (9.1%) of 121 workplaces had concentrations exceeding permissible exposure limits (PELs) of the Michigan Occupational Safety and Health Act (MIOSHA) program.*

Interpretation: The surveillance data findings confirm well-recognized causes of asthma and have identified new putative causes (e.g., cleaning materials and metalworking fluids). Because the surveillance program depends on physicians' recognizing asthma work-relatedness and reporting diagnosed cases, the data are considered an underestimate of the magnitude of the WRA problem. The data also indicate that physicians are not commonly performing objective physiologic tests to substantiate a WRA diagnosis. Workplace findings suggest a need to evaluate existing exposure standards for specific agents known to induce occupational asthma (e.g., diisocyanates). Case-based surveillance can help improve the recognition, control, and prevention of WRA. The SENSOR model also provides a mechanism for workers and physicians to request workplace investigations aimed at primary prevention for other workers.

Public Health Action: NIOSH and state health department representatives are working to establish a long-term agenda for state-based surveillance of work-related conditions and hazards. The results from the SENSOR WRA programs described in this report support inclusion of WRA as a priority condition warranting surveillance at the state level.

INTRODUCTION

Asthma is a chronic inflammatory disease of the airways characterized by recurrent respiratory symptoms (e.g., wheezing, breathlessness, chest tightness, coughing) and variable airflow obstruction that is reversible either spontaneously or with treatment. The inflammatory process causes the airways to become hyperresponsive to various chemical, biologic, or physical stimuli. A diagnosis of work-related asthma (WRA) is

* Occupational Safety and Health Administration (OSHA) PELs and NIOSH RELs do not exist for all agents for which air sampling was performed. Thus, the number of workplaces where an OSHA PEL for a sampled substance existed was different than the number of workplaces where a NIOSH REL existed.

warranted when there is evidence of an association between the pattern of airways obstruction and workplace exposure to a precipitating factor.

With funding from CDC's National Institute for Occupational Safety and Health (NIOSH), WRA surveillance and prevention/intervention programs have been implemented in four states — California, Massachusetts, Michigan, and New Jersey. These programs use the Sentinel Event Notification Systems for Occupational Risks (SENSOR) model (*1*). The primary data source for all four states is physician reports. Surveillance staff members collect additional information related to each case-patient (e.g., detailed work and medical histories, including work-relatedness information), and they direct prevention and intervention activities toward individual workers, physicians, unions, and potentially hazardous workplaces. In 1987, SENSOR WRA programs were initiated in Massachusetts, Michigan, and New Jersey (the same year of the SENSOR program's inception), whereas California's program began in 1992. This report summarizes the WRA surveillance data collected in California from March 1, 1993, through December 31, 1995, and in Massachusetts, Michigan, and New Jersey from January 1, 1993, through December 31, 1995. Follow-up investigations of cases and associated workplaces were carried out through June 30, 1998. A report has been published previously on Michigan and New Jersey's 1988–1992 surveillance data (*2*); another published report summarizes Michigan's surveillance data from 1988 through 1994 (*3*).

METHODS

Case Identification

Details on how SENSOR cases were identified in Michigan and New Jersey have been published previously (*1,2,4*). The primary data source for all four states is physician reports. Physician case reports are solicited in Massachusetts, Michigan, and New Jersey. California has a passive surveillance system based on Doctor's First Reports (DFRs) of Occupational Injury or Illness — a longstanding, statewide physician-reporting system directly linked to physician reimbursement for medical services. All four states have legislation mandating physician reporting of occupational disease,* which includes WRA. Hospital reporting is also mandated in Michigan and New Jersey. Hospital reports and discharge records† are actively solicited to identify potential WRA cases.

Occupational disease reports have been actively solicited in the following ways:

- Potential cases are identified through a review of hospital discharge data files, and follow-up is conducted to assess work-relatedness.
- State SENSOR staff members periodically conduct educational outreach to physicians likely to encounter patients with WRA (e.g., pulmonologists, occupational medicine physicians, allergists, and members of the state thoracic society)

*Legislation mandating clinical reporting of WRA became effective in 1973 in California, 1978 in Michigan, 1990 in New Jersey, and 1992 in Massachusetts.

†Cases are identified for potential follow-up based on hospital discharge summaries that report a primary or secondary diagnosis of a) asthma (*International Classification of Diseases, Ninth Revision* [*ICD-9*], code 493) with workers' compensation as the expected payer or b) respiratory conditions due to chemical fumes and vapors (*ICD-9* 506.0–506.9) regardless of the expected payer.

to alert them to occupational disease reporting laws in their states, encourage them to report cases, and educate them about objectives and activities of the SENSOR program.

- State SENSOR staff members develop and distribute occupational disease newsletters to physicians to provide them with up-to-date educational materials on selected occupational conditions and summary information about SENSOR surveillance and intervention activities.
- Newly licensed physicians receive a letter informing them of their reporting requirements and telling them how to report cases.

Case Follow-Up

Surveillance staff members in state health departments administer follow-up questionnaires to patients with suspected WRA to collect information about their reported conditions (e.g., the association with workplace exposures and the industry and occupation of the affected person). This information helps identify specific workplaces to target for prevention and intervention activities. In Michigan and New Jersey, medical records also are routinely reviewed for objective physiologic findings to substantiate a WRA diagnosis. Industry and occupation data are coded using the 1987 Standard Industrial Classification and the 1990 U.S. Bureau of the Census codes, respectively.

Case Definition and Classification

This report updates previously published guidelines for conducting surveillance for occupational asthma (*1,2,4*). The current guidelines address cases of preexisting asthma exacerbated by workplace exposures as well as cases of new-onset asthma induced by occupational exposure to irritants or sensitizers (Box 1). The new surveillance guidelines have three components — the reporting guidance (Box 2), the surveillance case definition (Box 3), and the decision logic scheme for case classification (Figure 1). The reporting guidance is designed to help physicians and other health-care professionals determine what types of clinical cases should be reported to the surveillance system. The surveillance case definition, decision logic scheme for case classification, and case classification criteria list (Box 4) are designed to assist

BOX 1. Overview of work-related asthma (WRA) surveillance categories

WRA Surveillance Categories

1. Work-Aggravated Asthma
2. New-Onset Asthma
   - a) Reactive Airways Dysfunction Syndrome (RADS)
   - b) Occupational Asthma
     - Known asthma inducer* with objective evidence†
     - Known asthma inducer without objective evidence
     - Unknown asthma inducer with objective evidence
     - Unknown asthma inducer without objective evidence

*Agents previously documented in the medical literature to cause occupational asthma.
†Objective physiologic tests to substantiate asthma work-relatedness.

surveillance staff members in classifying cases consistently over time and across states. These guidelines are not intended as the sole criteria for establishing clinical diagnoses; additional clinical, exposure, and laboratory data might be needed to establish a diagnosis of WRA.

The WRA surveillance case definition (Box 3) requires a health-care professional's diagnosis of asthma (or a related diagnosis consistent with asthma) and an association between symptoms of asthma and work. Cases meeting these criteria are considered WRA for surveillance purposes.

WRA cases are classified (Figure 1) to distinguish between work-related exacerbations of a preexisting asthma condition (work-aggravated asthma) and asthma induced by workplace exposures (new-onset asthma). Workers with a history of symptomatic or treated asthma within 2 years of entering a new occupational exposure setting and who experience an increase in symptoms or an increase in the use of asthma medication upon entering the new work setting are classified as having work-aggravated asthma. Workers with no history of asthma or who had preexisting asthma (e.g., childhood asthma) that had been asymptomatic for at least 2 years before entering the workplace where asthma was diagnosed are considered to have new-onset asthma. The WRA classification system distinguishes between two types of new-onset asthma — reactive airways dysfunction syndrome (RADS) (i.e., persistent asthma symptoms induced by a one-time, high-level irritant exposure at work) (*5*) and occupational asthma (e.g., classic sensitizer-induced asthma and irritant-induced asthma not meeting the RADS criterion). Occupational asthma is further subclassified according to whether the suspected agent is a known asthma inducer (i.e., an agent previously documented in the medical literature to cause occupational asthma) (*6,7,8*) and whether any objective physiologic testing has been done to substantiate asthma work-relatedness. To facilitate consistency in agent coding across the participating states, putative causes of WRA are coded by using the Association of Occupational and Environmental Clinics' (AOEC) hierarchical exposure coding scheme (*9*). To promote consistency in subclassifying cases of occupational asthma, agents known to induce occupational asthma have been flagged in the AOEC scheme with the letter "A."

Workplace Follow-up

Surveillance staff members in each state program have developed their own criteria for determining which workplaces to target for follow-up investigations. Workplaces are selected, in part, on the basis of an individual program's needs, interests,

BOX 2. Work-related asthma (WRA) reporting guidance for state health departments

WRA Reporting Guidance for State Health Departments

State health departments should encourage health-care professionals to report all diagnosed or suspected cases of asthma that are caused by or exacerbated by workplace exposures or conditions. Reported cases should include asthma caused by sensitizers or irritants and should include cases of reactive airways dysfunction syndrome (RADS).*

*Brooks SM, Weiss MA, Bernstein IL. Reactive airways dysfunction syndrome (RADS): persistent asthma syndrome after high level irritant exposures. Chest 1985;88:376–84.

and experience, which can vary over time. Workplaces associated with occupational asthma commonly take priority over those associated with RADS or work-aggravated asthma. Workplaces with multiple cases usually take priority over those with one case. In California, follow-up priority is also given to industries with a high WRA incidence rate, based on California SENSOR WRA data, even if that rate is based on a small number of reported cases. Other criteria include whether a) the affected person indicates that a new chemical or process introduced into the workplace contributed to the symptoms, b) the affected person describes poor work conditions or lack of concern by the employer, c) a request for workplace assessment has been made by the affected person or by the referring physician, d) a previously unrecognized cause of asthma could be identified, and e) an industrywide intervention could result from the investigation of a particular workplace (e.g., asthma identified in a work setting not previously associated with the disease). All workplace follow-up investigations in Michigan are conducted under the Michigan Occupational Safety and Health Act (MIOSHA) program. In New Jersey, Massachusetts, and California, workplace follow-up investigations are conducted by state health department industrial hygienists. In Massachusetts, industrial hygienists at the Department of Labor and Workforce Development also conduct workplace evaluations. WRA education and prevention

BOX 3. Work-related asthma (WRA) surveillance case definition for state health departments

WRA Surveillance Case Definition for State Health Departments

A. Health-care professional's diagnosis consistent with asthma.*

AND

B. An association between symptoms of asthma and work.†

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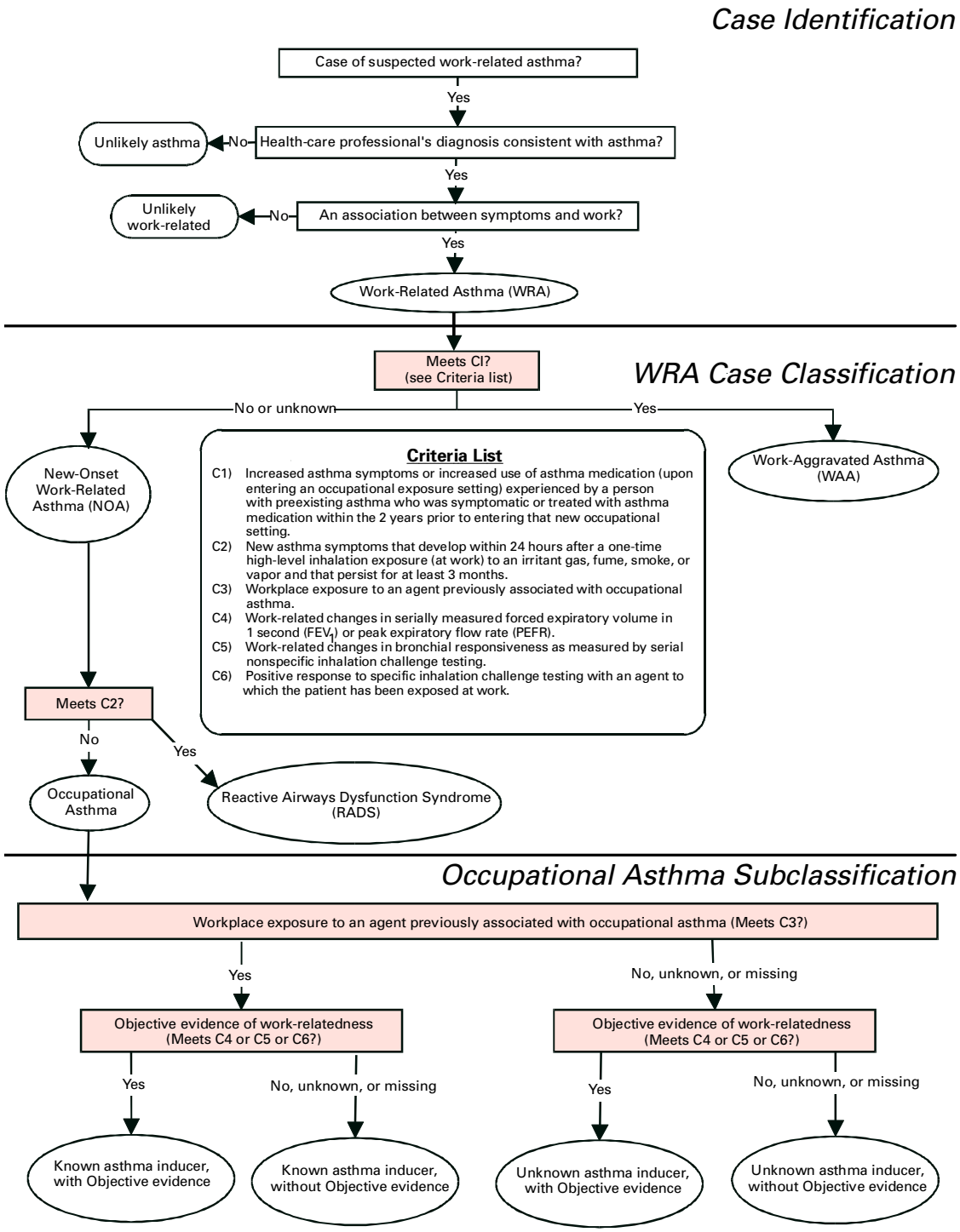
* Asthma is a chronic condition characterized by inflammation of the tracheobronchial tree associated with increased airway responsiveness to a variety of stimuli (*a*). Symptoms of asthma include episodic wheezing, chest tightness, cough, and dyspnea or recurrent attacks of bronchitis with cough and sputum production (*b*). The primary physiologic manifestation of airways hyperresponsiveness is variable or reversible airflow obstruction. It is commonly demonstrated by significant changes in the forced expiratory volume in 1 second (FEV_1) or peak expiratory flow rate (PEFR). Airflow changes can occur spontaneously, with treatment, with a precipitating exposure, or with diagnostic maneuvers such as nonspecific inhalation challenge.

† Patterns of association can vary and include a) symptoms of asthma that develop or worsen after a worker starts a new job or after new materials are introduced on a job (a substantial period can elapse between initial exposure and development of symptoms), b) symptoms that develop within minutes of specific activities or exposures at work, c) delayed symptoms that occur several hours after exposure (e.g., during the evenings of workdays), d) symptoms that occur less frequently or not at all on days away from work and on vacations, e) symptoms that occur more frequently when a worker returns to work, and f) symptoms that are temporally associated with workplace exposure to an agent with irritant properties. Work-related changes in medication requirements can accompany these symptom patterns.

Sources:

a. Anonymous. Standards for the diagnosis and care of patients with chronic obstructive pulmonary disease (COPD) and asthma. This official statement of the American Thoracic Society was adopted by the ATS Board of Directors, November 1986. Am Rev Respir Dis 1987;136:225–44.
b. Chan-Yeung M, Lam S. Occupational asthma. Am Rev Respir Dis 1986;133:686–703.

FIGURE 1. Decision logic and case classification scheme for work-related asthma



BOX 4. Work-related asthma (WRA) surveillance case classification criteria for state health departments

WRA Surveillance Case Classification Criteria for State Health Departments

Code	Criteria
C1)	Increased asthma symptoms or increased use of asthma medication (upon entering an occupational exposure setting) experienced by a person with preexisting asthma who was symptomatic or treated with asthma medication within the 2 years prior to entering that new occupational setting.
C2)	New asthma symptoms that develop within 24 hours after a one-time high-level inhalation exposure (at work) to an irritant gas, fume, smoke, or vapor and that persist for at least 3 months.
C3)	Workplace exposure to an agent previously associated with occupational asthma.*
C4)	Work-related changes in serially measured forced expiratory volume in 1 second (FEV_1) or peak expiratory flow rate (PEFR).†
C5)	Work-related changes in bronchial responsiveness as measured by serial nonspecific inhalation challenge testing.§
C6)	Positive response to specific inhalation challenge testing¶ with an agent to which the patient has been exposed at work.

* Many agents can induce occupational asthma via a specific hypersensitivity mechanism. A comprehensive list of these asthma inducers (*a,b,c*) is used for this criterion. Known asthma inducers have been integrated into the Association of Occupational and Environmental Clinics' (AOEC) coding scheme and have been flagged with the letter "A" (*d*).

† Spirometric measurements (e.g., FEV_1) can be obtained before and after a person's work shift (i.e., cross-shift spirometry). However, many cases of occupational asthma can fail to demonstrate a significant cross-shift reduction in FEV_1, either because of a delayed bronchoconstrictor response or because of intermittent exposure patterns. Cross-shift spirometry testing on multiple days might help confirm the association with work. Alternatively, PEFRs can be measured serially throughout the day using a portable peak flow meter.

§ Changes in bronchial responsiveness can be measured by serial inhalation challenge testing with nonspecific agents (e.g., using methacholine or histamine). Evidence of work-relatedness is manifested by increased bronchial responsiveness (i.e., bronchoconstriction at lower inhaled doses of methacholine or histamine) following work exposures and decreased or normal bronchial responsiveness after a period away from work.

¶ Specific inhalation challenge testing has distinct objectives, including the following: a) identifying previously unrecognized causes of occupational asthma, b) confirming a diagnosis of occupational asthma, and c) identifying the causative agent when more than one allergen is present in the occupational environment and identification of the causative agent is essential for management. Specific inhalation challenge testing is potentially dangerous and should be performed by experienced personnel in a hospital setting where resuscitation facilities are available and frequent observations can be made over sufficient time to monitor for delayed reactions. Specific inhalation challenge testing is usually not necessary for clinical diagnosis of occupational asthma.

Sources:

a. Chan-Yeung M, Malo J-L. Compendium 1: table of the major inducers of occupational asthma. In: Bernstein IL, Chan-Yeung M, Malo J-L, Bernstein DI, eds. Asthma in the workplace. New York, NY: Marcel Dekker, Inc., 1993:595–623.
b. Chan-Yeung M, Malo J-L. Aetiological agents in occupational asthma. Eur Respir J 1994; 7:346–71.
c. Malo J-L, Chan-Yeung M, Occupational agents. In: Barnes PJ, Grunstein MM, Leff AR, Woolcock AJ, eds. Asthma. Pennsylvania, PA: Lippincott-Raven Publishers, 1997:1217–44.
d. Hunting KL, McDonald SM. Development of a hierarchical exposure coding system for clinic-based surveillance of occupational disease and injury. Appl Occup Environ Hyg 1995;10:317–22. The exposure coding scheme is available on the Internet at <http://occ-env-med.mc.duke.edu/oem/aoec.htm>. Accessed February 26, 1999.

materials are given to selected workplaces, including those investigated and some that are not investigated. These materials include brochures on occupational asthma, a recommended medical screening protocol for workers exposed to occupational allergens, and a list of occupational allergens.

RESULTS

Epidemiology

From January 1, 1993, through December 31, 1995, a total of 1,101 WRA cases were identified by surveillance staff members in California, Massachusetts, Michigan, and New Jersey (Table 1).* Of these 1,101 cases, 891 (80.9%) were classified as new-onset asthma and 210 (19.1%) were classified as work-aggravated asthma. Overall, 123 (11.2%) of cases were classified as RADS and 768 (69.8%) as occupational asthma. By state, new-onset WRA cases varied from 65.8% of all cases in California to 90.1% in Michigan.

Michigan and New Jersey surveillance staff members routinely review medical records of WRA case-patients for objective physiologic evidence substantiating a WRA diagnosis. Only 29 case-patients in Michigan and New Jersey (5.2% of the 562 case-patients in these two states) had medical record documentation of pulmonary function testing. Of these, only 19 case-patients (3.4% overall) had medical record documentation of pulmonary function testing to substantiate asthma work-relatedness. Objective evidence of work-relatedness was documented through cross-shift spirometry in 13 cases and through serial peak expiratory flow rates (PEFRs) in six cases.

Of the 768 occupational asthma cases identified across all four states, 301 (39.2%) were associated with exposures to known asthma inducers, and 467 (60.8%) were associated with exposures not recognized as known asthma inducers.

Physician reports of occupational illness represented the sole case identification source in California and Massachusetts and the primary case source in Michigan and New Jersey. Hospital discharge data were used to identify 17.9% of WRA cases in Michigan and 9.5% of those in New Jersey. In Michigan, 4.7% of cases were identified from other sources (e.g., workers' compensation, federal regulatory agencies, and coworkers of the index case-patient whose WRA was subsequently diagnosed).

The mean and median ages of the WRA case-patients overall were both 41 years (age range: 18–71 years). Overall, 56.4% of WRA case-patients were female, and 43.6% were male.

The 10 most frequently reported putative agents associated with the 1,101 WRA cases (Table 2) were indoor air pollutants (86 cases); mineral and inorganic dust, not otherwise specified (NOS) (79 cases); chemicals, NOS (73 cases); lubricants, NOS (57 cases, including metalworking fluids); cleaning materials, NOS (51 cases); smoke, NOS† (50 cases); solvents, NOS (43 cases); toluene diisocyanate (41 cases); stainless steel welding fumes (37 cases); and diisocyanates, NOS (36 cases). Many of the agents

*The case identification period for California was March 1, 1993, through December 31, 1995. The case identification period for Massachusetts, Michigan, and New Jersey was January 1, 1993, through December 31, 1995.

†Includes pyrolysis products other than incinerator fume or cigarette, plastic, marijuana, or lead-containing smoke.

TABLE 1. Number of cases of work-related asthma by case classification category and state — California, Massachusetts, Michigan, and New Jersey SENSOR programs, 1993–1995*

Classification	California		Massachusetts		Michigan		New Jersey		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%
Work-aggravated asthma	131	34.2	20	12.8	44	9.9	15	12.9	**210**	**19.1**
New-onset asthma†	252	65.8	136	87.2	402	90.1	101	87.1	**891**	**80.9**
Reactive airways dysfunction syndrome	24	6.3	16	10.3	47	10.5	36	31.0	**123**	**11.2**
Occupational asthma	228	59.5	120	76.9	355	79.6	65	56.0	**768**	**69.8**
Known asthma inducer§	28	7.3	49	31.4	196	43.9	28	24.1	**301**	**27.3**
Unknown asthma inducer	200	52.2	71	45.5	159	35.7	37	31.9	**467**	**42.4**
Total	**383**	**100.0**	**156**	**100.0**	**446**	**100.0**	**116**	**100.0**	**1,101**	**100.0**

*Provisional surveillance data as of November 1997. The case identification period for California was March 1, 1993, through December 31, 1995. The case identification period for Massachusetts, Michigan, and New Jersey was January 1, 1993, through December 31, 1995.
†Includes cases of reactive airways dysfunction syndrome and occupational asthma.
§Known asthma inducers are agents previously documented in the published medical literature as being associated with occupational asthma. These agents are designated with the letter "A" in the Association of Occupational and Environmental Clinics' (AOEC) exposure coding system.

were associated with both work-aggravated and new-onset asthma. However, no cases of work-aggravated asthma were reported in association with toluene diisocyanate; glutaraldehyde; acrylates, NOS; wood dust, NOS; and paper dust, NOS.

Manufacturing industries and service industries were associated with 41.5% and 31.2% of cases, respectively (Table 3). Manufacturing was the most frequently reported industrial sector in Michigan and New Jersey. Transportation equipment manufacturing, the predominant manufacturing industry reported in Michigan, was associated with 43.5% of WRA cases in that state. In California and Massachusetts, service industries were associated with 40.5% and 51.3% of cases, respectively. Health services topped the list of service industries in Massachusetts, and health and educational services were associated with 14.6% and 14.4%, respectively, of cases in California.

The occupational category of operators, fabricators, and laborers was associated with the highest percentage of WRA cases overall (356 cases, 32.3%). The largest number of cases came from Michigan, with 55.4% of state cases coded to this category. The most frequently reported categories associated with WRA in the other three states included technical, sales, and administrative occupations in California (32.1% of cases); managerial and professional specialty occupations in Massachusetts (30.1% of cases); and both the managerial and professional specialty occupations and the operators, fabricators, and laborers category in New Jersey (23.3% of cases in both categories).

Workplace Follow-up

In Michigan, 185 (44.5%) of the 416 workplaces associated with WRA cases were inspected (Table 4). At 123 (66.5%) of these 185 workplaces, air sampling for agents known to induce occupational asthma was performed for comparison with established federal time-weighted average exposure limits. Sixteen (13.4%) of 119 workplaces had airborne concentrations exceeding the NIOSH recommended exposure limits (RELs);* 11 (9.1%) of 121 workplaces had concentrations exceeding the legally enforceable permissible exposure limit (PELs) established by the MIOSHA program.† Recommendations and citations were issued to several workplaces because of deficiencies noted during the inspections, with the most commonly reported recommendation being either to implement a hazard communication program or enhance an existing one (Table 4).

In California, seven workplaces were inspected, but air sampling for known hazards was not performed. Recommendations were made to all seven workplaces regarding specific ways to correct deficiencies in hazard communication and respiratory protection. In addition, each of the seven workplaces received recommendations to implement an employee medical screening program or modify an existing one and to implement engineering controls or enhance existing ones.

*Time-weighted average NIOSH RELs are intended to provide guidance on concentrations of specific substances to which nearly all workers can be exposed during a 10-hour workday and a 40-hour workweek without adverse health effect. NIOSH RELs are not legally enforceable and are usually lower than their corresponding Occupational Safety and Health Administration (OSHA) permissible exposure limits (PELs).

†OSHA PELs and NIOSH RELs do not exist for all agents for which air sampling was performed. Thus, the number of workplaces where an OSHA PEL for a sampled substance existed was different than the number of workplaces where a NIOSH REL existed.

TABLE 2. Most frequently reported putative agents associated with cases of work-related asthma, both new-onset and work-aggravated — California, Massachusetts, Michigan, and New Jersey SENSOR programs, 1993–1995*

AOEC code† and agent	New-Onset Asthma (WRA)		Work-Aggravated Asthma (WRA)		Total	
	No.	%	No.	%	No.	%
320.01 Air pollutants, indoor	67	7.5	19	9.0	**86**	**7.8**
010.00 Mineral and inorganic dust, NOS§	45	5.1	34	16.2	**79**	**7.2**
320.06 Chemicals, NOS	56	6.3	17	8.1	**73**	**6.6**
320.14 Lubricants, NOS¶	55	6.2	2	1.0	**57**	**5.2**
322.00 Cleaning materials, NOS	42	4.7	9	4.3	**51**	**4.6**
330.03 Smoke, NOS**	40	4.5	10	4.8	**50**	**4.5**
171.00 Solvents, NOS††	36	4.0	7	3.3	**43**	**3.9**
221.01 Toluene diisocyanate	41	4.6	—	0.0	**41**	**3.7**
023.01 Welding fumes, stainless steel	31	3.5	6	2.9	**37**	**3.4**
221.00 Diisocyanates, NOS	34	3.8	2	1.0	**36**	**3.3**
120.03 Formaldehyde	32	3.6	3	1.4	**35**	**3.2**
171.01 Paint	22	2.5	13	6.2	**35**	**3.2**
320.16 Pesticides, NOS	21	2.4	8	3.8	**29**	**2.6**
390.01 Mold	21	2.4	6	2.9	**27**	**2.5**
221.02 Methylene diisocyanate	24	2.7	2	1.0	**26**	**2.4**
270.02 Latex, natural rubber	24	2.7	2	1.0	**26**	**2.4**
320.11 Glues, NOS	14	1.6	9	4.3	**23**	**2.1**
030.02 Chlorine	16	1.8	6	2.9	**22**	**2.0**
010.09 Manmade mineral fibers	18	2.0	3	1.4	**21**	**1.9**
050.02 Bleach	16	1.8	5	2.4	**21**	**1.9**
023.00 Welding, NOS	16	1.8	3	1.4	**19**	**1.7**
120.05 Glutaraldehyde	19	2.1	—	0.0	**19**	**1.7**
331.01 Diesel exhaust	14	1.6	5	2.4	**19**	**1.7**
050.00 Acids, bases, oxidizers, NOS	17	1.9	1	0.5	**18**	**1.6**
110.02 Epoxy resins	17	1.9	1	0.5	**18**	**1.6**
330.02 Plastic smoke	8	0.9	6	2.9	**14**	**1.3**
142.00 Acrylates, NOS	12	1.3	—	0.0	**12**	**1.1**
373.00 Wood dust, NOS	12	1.3	—	0.0	**12**	**1.1**
052.02 Ammonia solution	9	1.0	2	1.0	**11**	**1.0**
060.11 4-phenylcyclohexene	5	0.6	6	2.9	**11**	**1.0**
231.00 Ethanolamines, NOS	10	1.1	1	0.5	**11**	**1.0**
331.00 Exhaust, NOS	9	1.0	2	1.0	**11**	**1.0**

370.00	Plant material, NOS	6	0.7	5	2.4	**11**	**1.0**
370.01	Paper dust	11	1.2	—	0.0	**11**	**1.0**
380.00	Animal material, NOS	7	0.8	4	1.9	**11**	**1.0**
330.01	Cigarette smoke	5	0.6	5	2.4	**10**	**0.9**
	All others	379	42.5	83	39.5	**462**	**42.0**

* Provisional surveillance data as of November 1997. The case identification period for California was March 1, 1993, through December 31, 1995. The case identification period for Massachusetts, Michigan, and New Jersey was January 1, 1993, through December 31, 1995. The sum of the number columns exceeds the total number of cases identified because as many as three putative causes of asthma were reported in association with each case of work-related asthma. Percentages are based on the actual number of cases.
† Association of Occupational and Environmental Clinics' (AOEC) exposure codes.
§ Not otherwise specified.
¶ Includes metalworking fluids.
** Includes pyrolysis products other than incinerator fume or cigarette, plastic, marijuana, and lead-containing smoke.
†† Includes graffiti removers.
— No cases were reported.

TABLE 3. Primary industries where exposure to agents causing work-related asthma occurred — California, Massachusetts, Michigan, and New Jersey SENSOR programs, 1993–1995*

SIC Divisions† and Major Groups	California		Massachusetts		Michigan		New Jersey		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%
Agriculture, Forestry, Fishing	**22**	**5.7**	**2**	**1.3**	**1**	**0.2**	**1**	**0.9**	**26**	**2.4**
Agricultural production crops (01§)	14	3.7	—	0.0	—	0.0	—	0.0	**14**	**1.3**
All other (02,07,08)	8	2.1	2	1.3	1	0.2	1	0.9	**12**	**1.1**
Mining (10,14)	**1**	**0.3**	**—**	**0.0**	**1**	**0.2**	**—**	**0.0**	**2**	**0.2**
Construction	**5**	**1.3**	**9**	**5.8**	**14**	**3.1**	**9**	**7.8**	**37**	**3.4**
Construction, special trade (17)	2	0.5	7	4.5	10	2.2	8	6.9	**27**	**2.5**
All other (15,16)	3	0.8	2	1.3	4	0.9	1	0.9	**10**	**0.9**
Manufacturing	**63**	**16.4**	**37**	**23.7**	**311**	**69.7**	**46**	**39.7**	**457**	**41.5**
Transportation equipment (37)	15	3.9	2	1.3	194	43.5	1	0.9	**212**	**19.3**
Chemicals and allied products (28)	5	1.3	4	2.6	17	3.8	12	10.3	**38**	**3.5**
Industrial and commercial machinery and computer equipment (35)	5	1.3	6	3.8	22	4.9	—	0.0	**33**	**3.0**
Fabricated metal products except machinery and transportation equipment (34)	5	1.3	5	3.2	15	3.4	1	0.9	**26**	**2.4**
Rubber and miscellaneous plastics products (30)	1	0.3	2	1.3	20	4.5	1	0.9	**24**	**2.2**
Primary metal industries (33)	2	0.5	—	0.0	16	3.6	5	4.3	**23**	**2.1**
Electronic and other electrical equipment and components except computer equipment (36)	7	1.8	2	1.3	3	0.7	6	5.2	**18**	**1.6**
Food and kindred products (20)	9	2.3	1	0.6	3	0.7	2	1.7	**15**	**1.4**
Paper and allied products (26)	—	0.0	2	1.3	5	1.1	7	6.0	**14**	**1.3**
Measuring, analyzing, and controlling instruments (38)	—	0.0	5	3.2	4	0.9	2	1.7	**11**	**1.0**
Printing, publishing, and allied industries (27)	2	0.5	1	0.6	6	1.3	1	0.9	**10**	**0.9**
All other (22–25,29,31,32,39)	12	3.1	7	4.5	6	1.3	8	6.9	**33**	**3.0**
Transportation	**28**	**7.3**	**2**	**1.3**	**12**	**2.7**	**6**	**5.2**	**48**	**4.4**
Electric, gas, and sanitary services (49)	11	2.9	2	1.3	4	0.9	1	0.9	**18**	**1.6**
All other (40–42,44,45,48)	17	4.4	—	0.0	8	1.8	5	4.3	**30**	**2.7**
Wholesale Trade (51,50)	**4**	**1.0**	**2**	**1.3**	**3**	**0.7**	**2**	**1.7**	**11**	**1.0**

Retail Trade	**20**	**5.2**	**5**	**3.2**	**11**	**2.5**	**3**	**2.6**	**39**	**3.5**
Food stores (54)	6	1.6	3	1.9	4	0.9	1	0.9	**14**	**1.3**
All other (52,53,55,58,59)	14	3.7	2	1.3	7	1.6	2	1.7	**25**	**2.3**
Finance, Insurance, and Real Estate (60,61,63,65)	**10**	**2.6**	**1**	**0.6**	**1**	**0.2**	**1**	**0.9**	**13**	**1.2**
Services	**155**	**40.5**	**80**	**51.3**	**72**	**16.1**	**37**	**31.9**	**344**	**31.2**
Health services (80)	56	14.6	48	30.8	35	7.8	17	14.7	**156**	**14.2**
Educational services (82)	55	14.4	16	10.3	15	3.4	10	8.6	**96**	**8.7**
Social services (83)	14	3.7	—	0.0	2	0.4	—	0.0	**16**	**1.5**
Engineering, accounting, research, management, and related services (87)	5	1.3	5	3.2	3	0.7	3	2.6	**16**	**1.5**
Business services (73)	9	2.3	—	0.0	3	0.7	1	0.9	**13**	**1.2**
Hotels, rooming houses, and camps (70)	4	1.0	2	1.3	3	0.7	2	1.7	**11**	**1.0**
All other (72,75,76,78,79,81,84,86,89)	12	3.1	9	5.8	11	2.5	4	3.4	**36**	**3.3**
Public Administration	**73**	**19.1**	**18**	**11.5**	**20**	**4.5**	**11**	**9.5**	**122**	**11.1**
Justice, public order, and safety (92)	34	8.9	6	3.8	6	1.3	1	0.9	**47**	**4.3**
Executive, legislative, and general government except finance (91)	17	4.4	1	0.6	1	0.2	3	2.6	**22**	**2.0**
Administration of human resource programs (94)	11	2.9	—	0.0	5	1.1	3	2.6	**19**	**1.7**
Administration of economic programs (96)	2	0.5	11	7.1	3	0.7	1	0.9	**17**	**1.5**
All other (93,95,97)	9	2.3	—	0.0	5	1.1	3	2.6	**17**	**1.5**
Nonclassifiable	**2**	**0.5**	**—**	**0.0**	**—**	**0.0**	**—**	**0.0**	**2**	**0.2**
TOTAL	**383**	**100.0**	**156**	**100.0**	**446**	**100.0**	**116**	**100.0**	**1,101**	**100.0**

* Provisional surveillance data as of November 1997. The case identification period for California was March 1, 1993, through December 31, 1995. The case identification period for Massachusetts, Michigan, and New Jersey was January 1, 1993, through December 31, 1995.
† 1987 Standard Industrial Classification (SIC).
§ Two-digit numbers correspond to SIC major groups.
— No cases were reported.

TABLE 4. Results of workplace follow-up inspections associated with work-related asthma cases — California, Massachusetts, Michigan, and New Jersey SENSOR programs, 1993–1995*

	California		Massachusetts†		Michigan		New Jersey		Total	
Workplaces	**No.**	**%**	**No.**	**%**	**No.**	**%**	**No.**	**%**	**No.**	**%**
Identified	349	100.0	128	100.0	416	100.0	116	100.0	**1,009**	**100.0**
Not inspected	342	98.0	107	83.6	231	55.5	89	76.7	**769**	**76.2**
Inspected	7	2.0	21	16.4	185	44.5	27	23.3	**240**	**23.8**
Inspected workplaces where air sampling for agents known to induce occupational asthma was conducted at the time of inspection	—		§		123		§			
Number of inspected workplaces where										
OSHA PELs¶ existed	—		NA**		121		NA			
Concentrations were >PELs	—		NA		11††		NA			
NIOSH RELs§§ existed	—		NA		119		NA			
Concentrations were >RELs	—		NA		16¶¶		NA			
Inspected workplaces where recommendations or citations were issued for the following:										
Medical monitoring	7		—		60		8			
Engineering controls	7		2		80		11			
Air monitoring	—		—		63		12			
Hazard communication program	7		2		126		6			
Respiratory protection program	7		1		71		7			

* Provisional workplace findings as of June 30, 1998.
† Data on recommendations made to workplaces inspected in Massachusetts are for 1993 only.
§ Sampling was not conducted to obtain results for comparison with established 8-hour time-weighted average exposure limits. In some instances, short-term direct-reading air sampling instrumentation was used to guide recommendations made.
¶ Occupational Safety and Health Administration (OSHA) permissible exposure limits (PELs).
** Data are not available.
†† Substance levels above Michigan Occupational Safety and Health Act (MIOSHA) program legally enforceable PELs included chromic acid, zinc oxide, glutaraldehyde (two companies), flour dust, welding fumes (three companies), oil mist, and wood dust (two companies).
§§ National Institute for Occupational Safety and Health (NIOSH) recommended exposure limits (RELs).
¶¶ Substance levels above NIOSH RELs included chromic acid, zinc oxide, ethylene oxide, glutaraldehyde (two companies), total dust (flour) (two companies), welding fumes (three companies), oil mist, wood dust (two companies), formaldehyde (two companies), and ethoxyethanol.
— No workplaces reported.

In Massachusetts and New Jersey, 21 and 27 workplaces, respectively, were inspected. However, air sampling for agents known to induce asthma for comparison with established 8-hour time-weighted average exposure limits was not performed. In some cases, direct-reading instruments were used to assess short-term airborne levels of hazardous substances and compliance with ceiling values. This information was used to guide the type of recommendations made. No single recommendation for prevention predominated among the workplaces investigated in these states (Table 4).

DISCUSSION

Surveillance systems have led to the current recognition that WRA is an important public health problem. In Quebec, Canada, and the United Kingdom, WRA is the most commonly reported occupational respiratory condition (*10,11*). Estimates of the proportion of asthma in the adult U.S. population that is work-related range from 2% to 26% (*3,12*). A recent study involving a review of medical records from a health maintenance organization in Massachusetts in 1998 reported that 21% of clinically significant adult asthma was work-related (*13*). Public health surveillance systems for WRA are needed to effectively plan and implement public health prevention programs through the identification and targeting of specific industries and workplaces.

More than 250 agents are known to cause occupational asthma (*6,7,8*). For this report, as many as three putative causes of WRA were reported for each case. The putative agents reported are ones in which all the evidence reviewed points to these agents as causing asthma or exacerbating a preexisting asthma condition. Several agents discussed in this report have been documented in the medical literature to cause occupational asthma (e.g., diisocyanates, natural rubber latex, glutaraldehyde, molds, and epoxy resins). The SENSOR WRA programs conducted in California, Massachusetts, Michigan, and New Jersey provide evidence that other less-recognized causes (e.g., cleaning agents and metalworking fluids) are also associated with WRA. In addition, SENSOR data played an important role, particularly in Massachusetts, in identifying a well-known cause of occupational asthma — natural rubber latex — in a new work setting, the health-care industry.

Cleaning agents, which can contain strong respiratory irritants (e.g., chlorine, ammonia) or sensitizers (e.g., benzalkonium chloride, chloramine, chlorhexidine, formaldehyde, glutaraldehyde), were frequently reported as putative agents associated with WRA. A total of 62 WRA cases were associated with agents coded as cleaning materials, including household cleaners (five cases), soap/detergent (four cases), metal polish (one case), copier cleaning fluids (one case), and cleaning materials, NOS (51 cases) (Table 2). Of these 62 cases, 51 were classified as new-onset asthma and 11 as work-aggravated asthma. Additional WRA cases were reported to be associated with cleaning-related processes, including some with putative agents coded as solvents, NOS (e.g., used in graffiti removal), ammonia solution, and bleach. Some of the reported cleaning agent cases involved improper mixing of products or chemicals. These findings suggest the need for enhanced health communications concerning the risks associated with and the proper use of various cleaning materials, as well as the need to target industries and workers at high risk. For example, based on seven WRA cases in California reported to be associated with the use of graffiti- removal products, staff members in that state's SENSOR program have conducted a series of workplace

inspections and are working to develop a graffiti-removal hazard fact sheet. This fact sheet will be disseminated through a national graffiti-removal organization, local governments, school districts, and other organizations and employers. Graffiti removers contain many chemicals, including acetone, amyl acetate, glycol ethers, methanol, methylene chloride, monoethanolamine, N-methyl-2- pyrrolidone, toluene, and d-limonene. Only monoethanolamine is a known inducer of occupational asthma, according to the most recent list of occupational asthma inducers the surveillance programs used (*8*).

One overall limitation of the SENSOR WRA program is that the data represent an underestimate of the number of WRA cases because of the underrecognition of asthma work-relatedness and the underreporting of recognized cases. The extent of underreporting varies by state, in part, because of differences in sources used to identify cases. In Massachusetts, physicians were the sole identification source, and a limited number of clinics and physicians reported WRA cases. Although industries and occupations that contribute to WRA were identified, the data are not considered representative or an indicator of the magnitude of WRA in Massachusetts. In California, cases were identified through an administrative data system that requires physicians to submit DFRs when seeking reimbursement from workers' compensation insurers. Thus, these data are considered more representative because all types of physicians throughout the state report using this mechanism. The California data also have been used to generate WRA incidence rates (*14*). Although the case identification methods used in Michigan are likely not as comprehensive a source of WRA cases as the DFRs system in California, the Michigan data also have been used to calculate incidence rates (*3,15*).

Beginning in 1997, the original case identification approach used in California (i.e., DFRs) was supplemented with statewide hospital discharge data and workers' compensation data from northern and southern regions of the state that are served by a large health maintenance organization. With this enhancement, the California SENSOR program should be able to assess how effective DFRs are for case identification and to estimate WRA incidence more accurately. In Massachusetts in 1997, case identification methods were enhanced by the addition of workers' compensation and hospital discharge data.

The workplace findings indicate that 9.1% (11 of 121) of investigated workplaces in Michigan had exposures above the legally enforceable PELs. Despite this small percentage, reports from Michigan demonstrate that coworkers of the index case-patient at approximately 70% of investigated companies had either received a diagnosis of asthma since beginning work at the company or had work-related asthma symptoms, regardless of the measured level of exposure to asthma-causing substances. This finding suggests that adhering to PELs might not prevent asthma or that intermittent high-level exposures (e.g., a spill or leak), which are unlikely to occur during industrial hygiene assessments, play an important role in asthma causation. In Michigan, surveillance staff members have indicated a need to reevaluate PELs for specific asthma-causing agents (e.g., diisocyanates) in terms of their effectiveness in preventing asthma (*3*), as well as a need to establish ceiling standards or standards for work practices in the event of intermittent high-level exposures (*3*).

Indoor air pollutants were reported as a cause of new-onset and work-aggravated WRA in all four states and represented the most frequent putative cause for WRA

cases overall. The types of exposures reported in association with indoor air pollutants included poor ventilation, pesticides, dusts and dirt, molds, environmental tobacco smoke, paint odors, and other nonspecific building odors. Affected workers included teachers, nurses, secretaries, librarians, computer operators and programmers, technicians, clerks, and office workers. Massachusetts surveillance staff members have asked environmental health assessment staff members in the Massachusetts Department of Public Health to investigate indoor air quality in public buildings, especially schools. In other SENSOR states, the links between indoor air problems and WRA have not commonly been investigated. In Michigan, workplaces where indoor air quality cases have been reported receive educational materials, including a list of occupational asthma inducers, OSHA technical manual instructions for conducting indoor air investigations, and selected NIOSH information about indoor air quality. Barriers cited to conducting indoor air quality investigations include a lack of resources to assemble and train a multidisciplinary team to conduct these investigations and a lack of an OSHA standard for indoor air quality.

SENSOR data indicate that WRA cases commonly lack confirmatory pulmonary function data, an apparent reflection of usual medical practice. Pulmonary function testing plays two major roles in the diagnosis of WRA — confirming the presence of asthma and documenting work-relatedness. Only 29 case-patients in Michigan and New Jersey (5.2% of the 562 case-patients in these two states) had medical record documentation of pulmonary function testing. Of these, only 19 case-patients (3.4% overall) had medical record documentation of pulmonary function testing to substantiate work-relatedness. By comparison, a health maintenance organization study in Massachusetts reported that a complete chart review of 67 case-patients with clinically significant asthma found only a minority had evidence of pulmonary function testing to substantiate asthma (seven had spirometry testing and seven had peak flow measurements) (*13*). In a study of 101 case-patients evaluated for occupational asthma in specialty occupational medicine clinics, objective physiologic tests to confirm asthma were performed on 75 case-patients (74.2%), and physiologic tests to evaluate work-relatedness were performed on 17 case-patients (16.8%). Eleven case-patients (10.9%) had positive physiologic work-related changes (*16*).

The data collection methods pioneered by the state-based SENSOR WRA programs have many strengths. Data standardization has allowed for aggregation of meaningful data across the participating states. This allows conclusions to be made regarding the nature and extent of WRA in the United States, which allows public health prevention programs to be developed and guided nationwide. In addition, surveillance systems based on physician reporting provide a vehicle for educational outreach to physicians on asthma work-relatedness. This is important because physicians are critical to WRA prevention. The SENSOR WRA programs also provide a mechanism for workers and physicians to request workplace investigations aimed at primary prevention for other workers.

NIOSH and state health department representatives are working to establish a long-term agenda for state-based surveillance of work-related conditions and hazards, including identification of priority conditions for surveillance at the state level. The results from the SENSOR WRA programs described in this report support inclusion of WRA in such a priority condition list and suggest that programs directed at adult asthma should address WRA.

Acknowledgements

The authors thank Helen S. Montagliani, NIOSH, for word processing services and James E. Nelson, HGO Technology, for computer application development services.

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