Work-Related Asthma in the *Educational Services* Industry: California, Massachusetts, Michigan, and New Jersey, 1993–2000

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Objectives *To characterize work-related asthma (WRA) cases working in the educational services industry identified by state-based occupational disease surveillance systems.*
Methods *We examined 2,995 WRA cases reported from 1993 to 2000 to four states: California, Massachusetts, Michigan, and New Jersey.*
Results *A total of 265 (9%) WRA cases were employed in the educational services industry; 69% of cases were classified as new-onset asthma and 31% as work-aggravated asthma. New-onset asthma cases were further classified as occupational asthma (61%) or as reactive airways dysfunction syndrome (8%). The most frequently reported occupation was teachers and teachers' aides (54%). The most frequently reported agents were indoor air pollutants (28%), unspecified mold (16%), dusts (14%), and cleaning products (7%).*
Conclusions *Asthma within the educational services industry is an occupational health problem. The health of school employees should also be considered when initiatives addressing asthma among schoolchildren are instituted. The identification, elimination, and/or control of respiratory hazards are important factors for the protection of staff and students alike.* Am. J. Ind. Med. 51:47–59, 2008. © *2007 Wiley-Liss, Inc.*

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INTRODUCTION

Asthma, a chronic disease of the airways, remains a major clinical and public health problem. It is one of the most prevalent chronic conditions in the United States. In the past 20 years the number of persons aged ≥18 years reporting asthma has more than doubled from 6.7 million in 1980 to approximately 16 million (7.5% of U.S. adults) in 2002 [Centers for Disease Control and Prevention, 2004]. During 1994–1996, asthma resulted in 2.5 work days lost per adult with asthma per year (14.5 million total days) [Mannino et al., 2002].

Work-related asthma (WRA) is defined as asthma resulting from exposure to irritants or sensitizers in the workplace or pre-existing asthma exacerbated by workplace exposure [Wagner and Wegman, 1998; Jajosky et al., 1999]. More than 400 agents and other factors in the work

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environment are potentially responsible for WRA [Malo and Chan-Yeung, 2006; AsmaPro, 2007]. A 2003 statement of the American Thoracic Society concluded that approximately 15% of all adult asthma cases are attributable to occupational factors [Balmes et al., 2003]. Subsequent U.S. studies found that 29% [Sama et al., 2006] to 33% [Vollmer et al., 2005] of new-onset asthma was attributable to workplace exposures; 23% of adults with existing asthma had evidence of workplace exacerbation of symptoms during a 1-year period [Henneberger et al., 2006]. The 1994 total estimated cost of asthma and the 1996 estimated cost of WRA were $10.7 and $1.6 billion, respectively [Weiss and Sullivan, 2001; Leigh et al., 2002].

In 1997, the mid-point of our data collection, there were approximately 10.5 million *educational services* industry employees in the United States, of whom 5.8 million were teachers and instructional faculty in approximately 128,000 public and private institutions [Bureau of Labor Statistics and U.S. Census Bureau, 2007]. In the same year, there were approximately 2.1 million *educational services* industry workers in the four states included in this surveillance report. *Educational services* is a diverse industry with many known hazards that may put workers at risk for work-related injury or illness [Alexander, 2001]. Several studies found that teachers and other teaching and related occupations report high prevalences of work-related upper respiratory symptoms, wheezing, and chest illness and are at risk for developing WRA [Ahman et al., 1995; Kraut et al., 1997; Arif et al., 2002, 2003; Whelan et al., 2003].

WRA surveillance data compiled by the National Institute for Occupational Safety and Health (NIOSH), Centers for Disease Control and Prevention (CDC), as part of the Sentinel Event Notification System for Occupational Risks (SENSOR) Program from four states—California, Massachusetts, Michigan, and New Jersey—for the period of 1993–1999 indicated that, overall, the *educational services* industry was the third most frequently reported industry associated with WRA after *transportation equipment manufacturing* and *health services* [Centers for Disease Control and Prevention, 2003]. We analyzed WRA SENSOR surveillance data from these same four states—for the period January 1, 1993, through December 31, 2000, to characterize the WRA cases among *educational services* industry workers and to formulate recommendations for prevention.

MATERIALS AND METHODS

Case Definitions

A person was considered to have WRA if he/she had a physician's diagnosis of asthma and respiratory symptoms associated with work. Cases were classified as being either work-aggravated asthma (WAA) or new-onset asthma (NOA) using standardized classification criteria [Jajosky et al., 1999]. NOA cases were further classified as reactive airways dysfunction syndrome (RADS) or occupational asthma (OA; with known or unknown inducer). RADS occurs within 24 hr of a one-time high-level exposure to airborne concentrations of an irritating gas, fume, smoke or vapor with symptoms that persist for at least 3 months. OA is asthma that develops after occupational exposure to known sensitizers or to substances for which the mechanism of the effect has not been characterized [Jajosky et al., 1999].

Case Ascertainment

Details of how SENSOR WRA cases are identified and the criteria for case confirmation and classification have been described previously [Rosenman et al., 1997; Jajosky et al., 1999]. Physicians provided the majority of WRA reports during the study period, 1993–2000 (100% in California, approximately 98% in Massachusetts, 75% in Michigan, and 78% in New Jersey). Such reports were actively solicited in Massachusetts, Michigan, and New Jersey. The California system is based on administrative data linked to physician reimbursement for medical services. Massachusetts, Michigan, and New Jersey identified additional cases by reviewing all hospital discharge records with the 9th International Classification of Diseases (ICD-9) code 506.0–506.9 (respiratory conditions due to chemical fumes and vapors) or with the ICD-9 code 493 (asthma) where workers' compensation was the primary payer. Workers' compensation claim data were not used to identify WRA cases because there was no specific code for asthma in the workers' compensation system data and because of the difficulty in accessing data. Surveillance staff administered standardized follow-up questionnaires by telephone to confirm and obtain more information on reported cases, including workplace exposures associated with asthma symptoms. In California, Massachusetts, and New Jersey up to three exposure agents, and in Michigan up to two exposure agents were recorded as the possible cause or trigger of the asthma for each case. Michigan and New Jersey also regularly reviewed medical records for pulmonary function tests to assess whether testing was performed in relation to work and, if so, the results of that testing.

Based on the information from the interviews or the medical records, cases were confirmed as being work-related and then classified as WAA or NOA (RADS or OA) [Jajosky et al., 1999]. Each state used the Association of Occupational and Environmental Clinics (AOEC) exposure system to code agents to which individuals were reportedly exposed. Agents documented in the medical literature [Malo and Chan-Yeung, 2006] to induce asthma have been identified in the coding system with the letter "A." The exposure codes are available on the internet at http://www.aoec.org/aoeccode.htm. Data on confirmed cases of WRA were forwarded to NIOSH for inclusion in a multistate database.

Based on job information for cases, industry and occupation were coded according to the 1987 Standard Industrial Classification Code (SIC) and the 1990 Census Occupation Code (COC), respectively. The SIC 82 was used to identify cases working in establishments providing academic or technical instruction (*educational services*). Substances or conditions at work that were associated with WRA were grouped into categories on the basis of information from the worker interview and the AOEC coding structure.

Statistical Analysis

We used SAS® version 8.02 (SAS Institute, Cary, NC) for analysis. Comparisons between groups were performed using chi-square statistics.

RESULTS

During 1993–2000, the four states confirmed 2,995 cases of WRA, including 2,312 (77.2%) classified as NOA, 640 (21.4%) classified as WAA, and 43 (1.4%) cases that had insufficient evidence to classify the WRA. The 265 cases (9% of all 2,995 cases) in the *educational services* industry included 182 (68.7%) classified as NOA, 82 (30.9%) classified as WAA, and one (0.4%) case with insufficient evidence to classify the WRA.

Of the 182 NOA cases, 20 (11.0%) were classified as RADS and 162 (89.0%) were classified as OA. Overall, the proportion of WAA cases in *educational services* was significantly higher than in all other industries (31.0% [82/264] vs. 20.8% [558/2,688]; $P < 0.001$).

Table I provides the state-specific distribution of WRA cases in educational services. For comparison purposes, the last column of Table I shows the number employed in the educational services industry in each of the four states in January 1997, the mid-point of the 8-year data analysis [Bureau of Labor Statistics and U.S. Census Bureau, 2007]. The proportion of WRA cases in educational services exceeded the proportion of the workforce employed in this industry for California and Massachusetts, but not for the other two states. Based on the totals for all four states, the 9% of WRA cases in *educational services* was only slightly greater than the 8% of the workforce in the same industry. However, the proportion of WAA cases in *educational services* was elevated (13%; 82/640), while the proportion of NOA cases was not (8%; 182/2,312), compared with the 8% of the workforce employed in *educational services*.

The demographic characteristics of *educational services* WRA cases are shown in Table II. Two thirds of the cases were aged 40–59 (median age 46 years, range 19–76 years) compared to 42 years (range 16–80 years) for all other WRA cases in non-*educational services*; cases were more likely to be female (81.5% vs. 57.5%, $P < 0.001$); and less likely to be black (8.3% vs.14.1%, $P < 0.001$) compared with other non-*educational services* WRA cases. Women were more likely to report WAA (35.2% vs. 12.2%, $P = 0.002$) compared with men. Less than half applied for workers' compensation (n = 113; 42.6%) similar to other WRA cases (n = 1,148; 42.1%) (data not shown). The occupational group with the most reports of asthma was *teachers* and *teachers' aides* (n = 144; 54.3%), followed by *administrative support staff* (n = 42; 15.8%), and *janitors*, *cleaners*, and *housekeepers* (n = 31; 11.7%) (Table II).

Among cases in the *educational services*, 83.9% (26 of 31) of *janitors*, *cleaners*, and *housekeepers*, 70.6% (101 of 144) of *teachers* and *teachers' aides*, 63.6% (14 of 22) of health care workers and other professionals, 57.1% (24 of 42) of *administrative support staff*, and 65.4% (17 of 26) of other occupations were classified as NOA. The remaining cases in each occupation were classified as WAA, except one among *teachers* and *teachers' aides* for which the information was insufficient for classification purposes.

Overall, WRA cases from elementary and secondary schools (SIC 8211) accounted for nearly three-quarters (n = 189; 71.3%) of all *educational services* WRA cases. Of these, *teachers* and *teachers' aides* comprised 61.9% (n = 117), followed by *janitors*, *cleaners*, and *housekeepers*

TABLE I. Number and Percent of Work-Related Asthma Cases by State—California, Massachusetts, Michigan, and New Jersey, 1993–2000

	Total number of WRA cases	Number of *educational services* industry workers with WRA	*Educational services* industry workers as a percent of cases (%)	*Educational services* industry workers as a percent of workforce (%) (and number)[a]
California	1,146	153	13	8 (1,101,923)
Massachusetts	429	53	12	8 (259,018)
Michigan	1,224	43	4	9 (405,083)
New Jersey	196	16	8	9 (367,626)
Totals	2,995	265	9	8 (2,133,650)

[a]Data for 1997; Bureau of Labor Statistics. 2005. Current Population Survey (CPS). http://www.census.gov/cps/.

TABLE II. Number and Percent of Work-Related Asthma Cases Among *Educational Services* Industry Workers by Selected Demographic Characteristics, Place of Work, and State—California, Massachusetts, Michigan, and New Jersey, 1993–2000

	California		Massachusetts		Michigan		New Jersey		Total	
Characteristics	**n**	**%**	**n**	**%**	**n**	**%**	**n**	**%**	**n**	**%**
Total	153		53		43		16		265	
Age group (years)										
10–19	1	0.7	0	0	0	0	0	0	1	0.4
20–29	14	9.2	1	1.9	1	2.3	2	12.5	18	6.8
30–39	35	22.9	8	15.1	5	11.6	3	18.8	51	19.3
40–49	53	34.6	13	24.5	20	46.5	7	43.8	93	35.1
50–59	40	26.1	28	52.8	14	32.6	4	25.0	86	32.5
60–69	9	5.9	3	5.7	3	7.0	0	0	15	5.7
70–79	1	0.7	0	0	0	0	0	0	1	0.4
Gender										
Women	129	84.3	41	77.4	36	83.7	10	62.5	216	81.5
Race/ethnicity										
White, non-hispanic	81	52.9	52	98.1	38	88.4	10	62.5	181	68.3
Black	15	9.8	0	0	4	9.3	3	18.8	22	8.3
Hispanic	31	20.3	0	0	1	2.3	2	12.5	34	12.8
Other/unknown	26	17.0	1	1.9	0	0	1	6.3	28	10.6
Applied for workers' compensation[a]	64	41.8	32	60.4	8	18.6	9	56.3	113	42.6
Occupational group[b]										
Teachers and teachers' aides	74	48.4	37	69.8	24	55.8	9	56.3	144	54.3
Administrative support	36	23.5	4	7.5	2	4.7	0	0	42	15.8
Janitors, cleaners, housekeepers	18	11.8	2	3.8	9	20.9	2	12.5	31	11.7
Food preparation	7	4.6	3	5.7	0	0	0	0	10	3.8
Health services	3	2.0	3	5.7	2	4.7	1	6.3	9	3.4
Other professionals	4	2.6	1	1.9	1	2.3	2	12.5	8	3.0
Construction trades, machinists	3	2.0	2	3.8	1	2.3	0	0	6	2.3
Librarians and library clerks	3	2.0	0	0	1	2.3	1	6.3	5	1.9
Bus drivers	4	2.6	0	0	1	2.3	0	0	5	1.9
Police, guards	0	0	1	1.9	1	2.3	1	6.3	3	1.1
Other	1	0.7	0	0	1	2.3	0	0	2	0.8
Facility type (SIC code)										
Elementary and secondary schools (8211)	109	71.2	40	67.8	27	73.0	13	81.3	189	71.3
Colleges, universities, and professional schools (8221)	27	17.6	10	16.9	6	16.2	1	6.3	44	16.6
Junior colleges and technical institutes (8222)	14	9.2	0	0	6	16.2	0	0	20	7.5
Vocational schools, NEC (8249)	1	0.7	3	5.1	1	2.7	0	0	5	1.9
Libraries (8231)	2	1.3	0	0	1	2.7	1	6.3	4	1.5
Schools and educational services, NEC (8299)	0	0.7	0	0	2	5.4	1	6.3	3	1.1

NEC, not elsewhere classified.

[a]Missing information on workers' compensation on 57 individuals (California—51, Massachusetts—one, Michigan—three, New Jersey—two).

[b]Occupations were identified using the 1990 Census Occupation Codes (COC): Teachers and teachers' aides (codes 078, 097, 114, 126, 127, 134, 137, 138, 143, 144, 153, 154, 156–159, 188, 224, 225, 235, 387, 467, 468, 737); Administrative and support staff (codes 014, 022, 023, 025, 027, 037, 064, 065, 276, 304, 313, 315, 323, 337, 345, 379, 385, 389); Janitors, cleaners, and housekeeping workers (codes 448, 453, 748); Food preparation workers (codes 017, 433, 436, 439, 444); Health services workers (codes 095, 204, 446, 447); Other professionals, including speech therapists, counselors, psychologists, welfare service aides (codes 104, 163, 167, 465); Construction trades, machinists (codes 486, 567, 599, 637, 696, 889); Librarians and library clerks (codes 164, 329); Bus drivers (code 808); Police, guards (codes 418, 426, 427); and other workers (codes 029, 774).

(n = 22; 11.6%), *administrative support staff* (n = 19; 10.0%), and *food workers* (n = 9; 4.8%). Forty-four (16.6%) cases worked in colleges, universities, and professional schools (SIC 8221) with *administrative support staff* comprising 40.9% (n = 18) followed by *teachers* and *teachers' aides* (n = 10; 22.7%).

Agent categories and specific agents to which *educational services* WRA cases reported being exposed are shown

TABLE III. Number and Percent of Work-Related Asthma Cases in *Educational Services* Associated With Different Agents or Conditions, by Type of Asthma—California, Massachusetts, Michigan, and New Jersey, 1993–2000

	New-onset asthma[b] (N = 182)		Work-aggravated asthma (N = 82)		Total (N = 265)	
Agent or condition (AOEC code)[a]	**n**	**%**	**n**	**%**	**n**	**%**
Indoor air pollutants (IAP) (n = 76)[c]						
Air pollutants, indoor (320.01)	63	34.6	10	12.2	73	27.5
Air pollutants, indoor—building renovation (320.33)	1	0.5	2	2.4	3	1.1
Cleaning products (n = 52)[c]						
Cleaning products, NOS (322.00)	16	8.8	2	2.4	18	6.8
Formaldehyde (120.03)[d]	5	2.7	2	2.4	7	2.6
Graffiti remover (322.22)	5	2.7	0	0	5	1.9
Bleach (322.10)	5	2.7	0	0	5	1.9
Carpet cleaners (322.16)	2	1.1	2	2.4	4	1.5
Ammonia solution, NOS (322.07)	4	2.2	0	0	4	1.5
Cleaners, disinfectant, NOS (322.19)	1	0.5	2	2.4	3	1.1
Chlorine (30.02)[d]	2	1.1	1	1.2	3	1.1
Monoethanolamine (231.01)[d]	2	1.1	0	0	2	0.8
Cleaners, household, general purpose (322.04)	1	0.5	1	1.2	2	0.8
Other cleaning products[e]	10	5.5	1	1.2	11	4.2
Solvents and Hydrocarbons (n = 49)[c]						
Paint (171.01)[f]	3	1.6	7	8.5	11	4.2
Solvents, NOS (171.00)	7	3.8	1	1.2	8	3.0
Polycyclic aromatic hydrocarbons, NOS (161.00)	1	0.4	4	4.9	5	1.9
Toluene (160.02)	4	2.2	0	0	4	1.5
Hydrocarbons, NOS (170.00)	3	1.6	1	1.2	4	1.5
Paint, oil-based (171.06)	1	0.5	2	2.4	3	1.1
Asphalt (061.07)	1	0.5	2	2.4	3	1.1
Lacquer (171.07)	1	0.1	1	1.2	2	0.8
Other solvents/hydrocarbons[g]	10	5.5	3	3.7	13	4.9
Dusts (n = 48)[c]						
Dust, NOS (010.00)[f]	23	12.6	14	17.1	38	14.3
Asbestos (010.02)	1	0.5	3	3.7	4	1.5
Calcium carbonate [chalk] (050.35)	1	0.5	3	3.7	4	1.5
Man-made mineral fibers (010.09)	2	1.1	2	2.4	4	1.5
Other dusts[h]	2	1.1	1	0.4	3	1.1
Mold (n = 47)[c]						
Mold, NOS (390.01 or 391.01)	30	16.5	13	15.6	43	16.2
Aspergillus (391.02)	2	1.1	1	1.2	3	1.1
Other mold[i]	0	0	1	1.2	1	0.4
Miscellaneous chemicals (n = 29)[c]						
Chemicals, NOS (320.06)	7	3.8	7	8.5	14	5.3
Photo developing chemicals, NOS (320.17)	2	1.1	0	0	2	0.8
Fire extinguisher discharge (320.10)	0	0	2	2.4	2	0.8
Other chemicals[j]	8	4.4	4	4.9	12	4.5
New carpet, odors, carpet dust, smoke, perfume (n = 27)[c]						
Smoke, NOS (330.03)	4	2.2	3	3.7	7	2.6
Perfume, NOS (320.23)	1	0.5	5	6.1	6	2.3
New carpet odor (060.11)	3	1.6	1	1.2	4	1.5
Exhaust (331.01)	2	1.1	2	2.4	4	1.5
Cigarette smoke (330.01)	2	1.1	0	0	2	0.8

(*Continued*)

TABLE III. (*Continued*)

	New-onset asthma[b] (N = 182)		Work-aggravated asthma (N = 82)		Total (N = 265)	
Agent or condition (AOEC code)[a]	**n**	**%**	**n**	**%**	**n**	**%**
Plastic smoke (330.02)	0	0	2	2.4	2	0.8
Odors (320.15)	1	0.5	1	1.2	2	0.8
Pesticides (n = 13)[c]						
Pesticides, NOS (320.16)	5	2.7	4	4.9	9	3.4
Herbicides, NOS (320.13)	0	0	2	2.4	2	0.8
Other pesticides[k]	1	0.5	1	1.2	2	0.8
Plant material (n = 11)[c]						
Wood dust, NOS (373.00)	2	1.1	2	2.4	4	1.5
Capsicum (370.35)	2	1.1	1	1.2	3	1.1
Pollen (370.10)	2	1.1	0	0	2	0.8
Other plant material[l]	1	0.5	2	2.4	3	1.1
Animal material (n = 12)[c]						
Dander, animal (380.04)	3	1.6	2	2.4	5	1.9
Animal material, NOS (380.00)	1	0.5	1	1.2	2	0.8
Mice (380.14)[d]	2	1.1	0	0	2	0.8
Other animal material[m]	3	1.6	0	0	3	1.1
Glues, NOS (320.11)	5	2.7	2	2.4	7	2.6
Isocyanates (n = 8)[c]						
Diisocyanates, NOS (221.00)[d]	4	2.2	0	0	4	1.5
Toluene diisocyanate (221.01)[d]	2	1.1	0	0	2	0.8
Methylene diisocyanate (221.02)[d]	1	0.5	0	0	1	0.4
Other isocyanates[n]	1	0.5	0	0	1	0.4
Welding, NOS (023.00)	2	1.1	0	0	2	0.8
Heat (350.05)	2	1.1	0	0	2	0.8
Stress (360.03)	1	0.5	0	0	1	0.4

[a]One hundred and sixty individuals had exposure to one, 59 to two, and 43 to three agents.
[b]For two new-onset asthma cases agents were not identified.
[c]Number of cases reporting exposure to any agent in the grouping.
[d]Denotes agents listed as asthmagens in the AOEC database; NOS, not otherwise specified.
The subgroups *Other* include agents with only 1 reported exposure (AOEC code):
[e]*Other cleaning materials*—photocopier cleaning fluid (322.03), iodophors (322.05), floor strippers (322.21), laundry detergent (322.23), citric acid (050.07), phenol (180.00), EGBE (091.03), cleaning mixtures (322.31), ethanolamines, nos (231.00), sodium hydroxide (050.18), methanol (070.07).
[f]One case had insufficient data to classify asthma.
[g]*Other solvents/hydrocarbons*—acetone (130.01), benzene (160.01), butyl acetate (141.02), cyclohexanone (130.07), aliphatic hydrocarbons (060.00), petroleum spirits (061.01), naphtha (061.02), paint thinner (171.02), strippers (171.03), methyl chloroform (190.08), xylene (160.03), cutting oils (170.01)[d], ethyl ether (100.05).
[h]*Other dusts*—cement dust (010.03), calcium oxide [lime](050.05), textile dust (320.22).
[i]*Other mold*—Stachybotrys (391.07).
[j]*Other miscellaneous chemicals*—hydroquinone (180.03), ethylene glycol (080.01), carbon monoxide (040.04), mace (320.27), cosmetics NOS (320.28), carbon dioxide (040.03), chromium hexavalent (022.00)[d], cobalt (020.15)[d], natural gas (060.08), nitric acid (050.13), metals NOS (020.47), radiographic fixative (320.32)[d].
[k]*Other pesticides*—dichlorobenzene (201.01), pyrethrins (320.18).
[l]*Other plant material*—plant material, NOS (370.00), grass cuttings (370.07), paper dust (370.01).
[m]*Other animal material*—bat guano (380.12)[d], rat antigens (380.18)[d], mites (382.13)[d].
[n]*Other isocyanates*—polyurethane (270.07).

in Table III. Overall, 98 different agents were reported of which 14 were identified in the AOEC database as documented asthmagens (November 2006). The three most commonly reported agents were the same for cases classified as NOA and WAA, although the ranking differed. Specifically, the three most commonly reported agents for the 182 NOA cases were *indoor air pollutants* followed by *mold*, *not otherwise specified* (*NOS*), and *dust*, *NOS*. The three most common agents for the 82 WAA cases were *mold*, *NOS*; *dust*, *NOS*; and *indoor air pollutants*.

Table IV shows the number of exposures in specific agent categories associated with WRA by facility type and

TABLE IV. Number of Exposures to Specific Agent Categories* Associated With Work-Related Asthma by Facility Type and Occupational Group—California, Massachusetts, Michigan, and New Jersey, 1993–2000 (N = 265)

	Facility type (standard industrial code, SIC)					
Occupation[a]	**Elementary and secondary schools (SIC 8211) (n = 189; 71.3%)**	**Colleges, universities, and professional schools (SIC 8221) (n = 44; 16.6%)**	**Junior colleges and technical institutes (SIC 8222) (n = 20; 7.5%)**	**Libraries (SIC 8231) (n = 4; 1.5%)**	**Vocational schools, NEC (SIC 8249) (n = 5; 1.9%)**	**Schools and educational services, NEC (SIC 8299) (n = 3; 1.1%)**
Teachers and teachers' aides (n = 144; 54.3%)	IAP (45) Mold (30) Dusts (24) Solvents and hydrocarbons (19) Misc. chemicals (11) Cleaning products (11) Odors, smoke (11) Pesticides (10) Animal material (6) Plant material (4) Glue (4) Isocyanates (1)	IAP (2) Mold (1) Solvents and hydrocarbons (2) Misc. chemicals (2) Cleaning products (3) Animal material (3) Plant material (1)	IAP (4) Mold (2) Dust (2) Solvents and hydrocarbons (1) Misc. chemicals (3) Glue (1) Isocyanates (1)	Solvents and hydrocarbons (1)	IAP (1) Mold (1) Solvents and hydrocarbons (3) Misc. chemicals (1) Isocyanates (1) Plant material (1) Welding (2)	Pesticides (1)
Administrative and support staff (n = 42; 15.8%)	IAP (4) Mold (3) Dusts (4) Solvents and hydrocarbons (7)[b] Misc. chemicals (1) Odors, smoke (4) Cleaning products (3) Plant material (3) Stress (1) Glue (1)	IAP (5) Mold (4) Dust (4) Solvents and hydrocarbons (3) Misc. chemicals (1) Odors, smoke (2) Cleaning products (2) Isocyanates (2) Heat (1) Glue (1)	Mold (1) Dust (1) Solvents and hydrocarbons (2) Misc. chemicals (1) Cleaning products (2)			
Janitors, cleaners, and housekeeping workers (n = 31; 11.7%)	IAP (1) Dusts (2) Solvents and hydrocarbons (1) Misc. chemicals (2) Odors, smoke (2) Cleaning products (18) Animal product (2)	IAP (1) Dusts (3) Solvents and hydrocarbons (1) Misc. chemicals (1) Cleaning products (3)	Dusts (2) Cleaning products (1) Odors, smoke (1)			Solvents and hydrocarbons (1) Cleaning products (1)

(*Continued*)

TABLE IV. (*Continued*)

Occupation[a]	Facility type (standard industrial code, SIC)					
	Elementary and secondary schools (SIC 8211) (n = 189; 71.3%)	**Colleges, universities, and professional schools (SIC 8221) (n = 44; 16.6%)**	**Junior colleges and technical institutes (SIC 8222) (n = 20; 7.5%)**	**Libraries (SIC 8231) (n = 4; 1.5%)**	**Vocational schools, NEC (SIC 8249) (n = 5; 1.9%)**	**Schools and educational services, NEC (SIC 8299) (n = 3; 1.1%)**
Health services and other professionals (n = 22; 8.3%)	IAP (6) Mold (3) Odors, smoke (2) Cleaning products (2) Dusts (1) Solvents and hydrocarbons (1) Pesticides (1)	IAP (2) Mold (1) Cleaning products (3) Dusts (2) Solvents and hydrocarbons (1)	Odors, smoke (1)	IAP (2) Cleaning products (1)		Solvents and hydrocarbons (1) Isocyanates (1)
Other workers (n = 26; 9.8%)	IAP (4) Dusts (3) Odors, smoke (3) Cleaning products (5) Misc. chemicals (3) Solvents and hydrocarbons (3) Plant material (2) Pesticides (1) Heat (1)	Solvents and hydrocarbons (2) Cleaning products (2) Misc. chemicals (2) Animal material (1) Isocyanates (2) Mold (1) Solvent (1)	Misc. chemicals (1)			

IAP = indoor air pollutants; Odors, smoke = New carpet, odors, carpet dust, smoke, perfume; NEC = not elsewhere classified.

*For list of agents and conditions in specific agent categories associated with work-related asthma see Table III.

[a]Occupations were identified using the 1990 Census Occupation Codes: Teachers and teachers' aides (codes 078, 097, 114, 126, 127, 134, 137, 138, 143, 144, 153, 154, 156–159, 188, 224, 225, 235, 387, 467, 468, 737); Administrative and support staff (codes 014, 022, 023, 025, 027, 037, 064, 065, 276, 304, 313, 315, 323, 337, 345, 379, 385, 389); Janitors, cleaners, and housekeeping workers (codes 448, 453, 748); Health services and other professionals include: Health services workers (codes 095, 204, 446, 447); other professionals, that is, speech therapists, counselors, psychologists, and welfare service aides (codes 104, 163, 167, 465); and Librarians and library clerks (codes 164, 329); Other workers include: food preparation workers (codes 017, 433, 436, 439, 444); Construction trades, machinists (codes 486, 567, 599, 637, 696, 889); Bus drivers (code 808); Police, guards (codes 418, 426, 427); and others (codes 029, 774).

[b]Six (23.1%) of 26 teachers and teachers' aides and 7 (58.3%) of 12 administrative support staff who reported exposure to solvents and hydrocarbons, specifically reported exposure to paint.

occupational group. *Teachers* and *teachers' aides* were most likely to report indoor air pollutants (36.1% [52 of 144]; including poor indoor air quality, lack of ventilation, or air quality problems related to building renovation), as were *health services* and *other professionals* (45.5%; 10 of 22), and *administrative* and *support staff* (21.4%; 9 of 42). *Janitors*, *cleaners*, and *housekeepers* most frequently reported cleaning products (74.2%; 23 of 31). In addition, 18.1% (26 of 144) *teachers* and *teachers' aides*, 21.5% (9 of 42) *administrative* and *support staff*; and 22.6% (7 of 31) *janitors*, *cleaners*, and *housekeepers* reported *dusts* (coded if the case reported exposure to any of the AOEC codes for *mineral* and *inorganic dusts* [e.g., *dust*, *NOS*], *calcium carbonate* [*chalk*], *calcium oxide* [*lime*], or *textile dusts*).

DISCUSSION

Sentinel surveillance is based on the assumption that index cases identify worksites where workers are at risk of disease and that prevention or abatement is possible. Findings from four states presented here add to the evidence that *educational services* industry workers may be at risk for WRA. During 1993–2000, 265 WRA cases were reported from this industry sector and accounted for 9% of all WRA cases, the third most frequent industry sector with reported cases. Sixty-nine percent of *educational services* industry WRA cases were classified as NOA. The majority of the WRA cases occurred among *teachers* and *teachers' aides* working in elementary and secondary schools, and most were women. A total of 98 different agents were reported by all cases. While some individuals reported exposures to specific known asthma-causing agents such as formaldehyde or diisocyanate, the majority of cases reported non-specific environmental conditions and exposures, such as indoor air pollutants, mold, dust, and cleaning products, as associated with their WRA. These broad categories may include specific asthmagens and may have been reported because cases were unaware of any specific agents in their work area. Similar findings that WRA among teachers was most commonly attributed to indoor air, mold, and dust were reported from a clinical case series in New York State [Fletcher et al., 2006].

Several studies have found an elevated prevalence of asthma among school employees. Using results from the Third National Health and Nutrition Examination Survey (NHANES III), Arif et al. [2002, 2003] found approximately 6.1% of the educational services workers reported the diagnosis of asthma compared with a general working population prevalence of 3.7%. In particular, teachers were twice as likely to report asthma compared with the referent group [Arif et al., 2003]. Whelan et al. found elevated prevalence of symptoms consistent with asthma (chest wheezing or whistling) among female teachers (28.4%) when compared with working women in the general population (16.4%) [Whelan et al., 2003]. Although the authors found physician-diagnosed asthma among teachers to be similar to that of all working women (8.8% and 8.6%, respectively), the study cohort was limited to young teachers (aged 18–45 years) whereas nearly half of the SENSOR cases reported here were older, with a median age of 46 years. From the 2001 National Health Interview Survey, Bang et al. estimated the prevalence of asthma among working adults in the *elementary/secondary schools* and *colleges* industrial category to be 8.6% compared with a general working population prevalence of 6.5% [Bang et al., 2005]. A Canadian study showed that the prevalence of physician-diagnosed asthma ranged from 2.5% among *teachers* to 4.5% among *other teaching* and *related occupations* compared with a prevalence of 1.9% among a studied working population [Kraut et al., 1997]. In these studies, however, the association of patients' symptoms with workplace exposure was not documented.

The higher prevalence of asthma in educational services might be due, in part, to the fact that more women than men work in this industry (1997 BLS data: 69% vs. 31%) and the prevalence of asthma among employed women is higher than among employed men [Kraut et al., 1997; Arif et al., 2002; Bang et al., 2005; Bureau of Labor Statistics and U.S. Census Bureau, 2007]. Indeed, the current study found that WRA cases working in the educational services industry were more likely to be female than WRA cases in all other industries (81.5% vs. 57.5%, respectively). There is also the possibility that people with asthma might preferentially self select into educational jobs because they believe these workplaces are relatively clean and will not exacerbate their symptoms. The larger risk pool for WAA (i.e., those who already have asthma) in educational services might explain, in part, the higher proportion of WAA compared with other industries and compared to the proportion of the workforce employed in this industry. In addition, literature indicates that women with asthma seek medical attention more often than men [Tinkelman et al., 2002; Schatz and Camargo, 2003]. An industry, like educational services, in which a greater proportion of its workers with asthma are female, coupled with a work situation that can cause aggravation of asthma is likely to experience more WAA cases seeking care and being identified by surveillance systems. In support of this explanation, a population-based Finnish study found that the prevalence of aggravation of asthma symptoms at work increased with age, self-reported occupational exposure to dusts, abnormal temperatures or poor indoor air quality. This was true for self-reported or expert-evaluated exposures to dusts, chemicals and physically strenuous work [Saarinen et al., 2003].

The proportion of WRA cases reported from the *educational industry* over the 8-year study period was similar to that previously reported from the SENSOR program (8.7%) for 1993–1995 [Jajosky et al., 1999]. This proportion varied by state and in California and Massachusetts exceeded the proportion of the total workforce who were employed in

this sector, while in Michigan and New Jersey, the proportion of cases did not (Table I). The differences may be due in part to the relative predominance of manufacturing industries with the potential for exposures that could cause or aggravate asthma in Michigan and New Jersey, or may reflect differences across states in diagnosis, reporting, and case confirmation practices or poorer school infrastructure in California and Massachusetts. In California, cases were identified through an administrative data system that requires physicians to submit Doctor's First Reports of Occupational Injury or Illness whenever a patient's illness or injury is suspected to be work-related. Thus, these data are considered more representative because they are linked to reimbursement, whereas the other three states rely on voluntary compliance with reporting requirements. Despite these differences, the identification of WRA cases in the educational services industry in all four states draws attention to respiratory hazards in schools as an occupational health problem.

Janitors, *cleaners*, and *housekeepers* had the largest proportion of cases classified as NOA (26 of 31, 83.9%), with exposure to *cleaning products* as the reported group of agents for 74%. Of the specific *cleaning products* identified, *formaldehyde*, *bleach*, and *graffiti remover* were the most frequently reported. These findings are consistent with a previous report from the SENSOR program [Rosenman et al., 2003]. This occupation's primary tasks usually require the use of cleaning products which are known to contain irritants and allergens, and such products have been associated with WRA [Jaakkola and Jaakkola, 2006; Rosenman, 2006]. Teachers and other school staff also reported asthma associated with *cleaning products*; these workers may have been exposed either as users or as bystanders when *cleaning products* were used in their work areas.

Among occupations in schools, *janitors*, *cleaners*, and *housekeepers* were more likely to be cases than expected based on the distribution of persons employed in occupations in the *educational services* industry. According to BLS (1997 BLS data) of all *educational services* industry workers, 60.2% were *teachers* and *teachers' aides* versus 54.3% in our data, 19.7% were *administrative support staff* versus 15.8% in our data, and 4.6% were *janitors*, *cleaners*, and *housekeepers* versus 11.7% in our data [Bureau of Labor Statistics and U.S. Census Bureau, 2007]. In this analysis, over 71% of cases worked in elementary and secondary schools. This percentage reflects the proportion of *educational services* industry workers who work in elementary and secondary schools (1997 BLS data: 79%) [Bureau of Labor Statistics and U.S. Census Bureau, 2007].

While it is not possible with SENSOR data to determine if the risk of WRA is greater in *educational services* than in other industries, there is evidence from other studies that the indoor environments at educational institutions pose a risk for the initiation and aggravation of asthma [Kreiss, 1989; Duffy et al., 1990; U.S. General Accounting Office, 1999; Daisey et al., 2003; Cox-Ganser et al., 2005]. During 1993–2000, NIOSH received 475 requests for health hazard evaluations (HHE) from schools, universities, and colleges (including technical and vocational schools). Of these, 82 (17%) were related to asthma, and 331 (70%) to indoor air quality problems (CDC, NIOSH. HHE Tracking Search; unpublished data). According to the 1995 GAO report many U.S. schools have one or more unsatisfactory environmental conditions, such as poor ventilation, heating or lighting problems [U.S. General Accounting Office, 1995]. In particular, approximately 31% of the schools in Massachusetts, 22% in California, 16% in Michigan, and 8% in New Jersey reported unsatisfactory indoor air quality [U.S. General Accounting Office, 1995]. A report by the Department of Education estimated approximately 11 million students attended 18,700 schools (24% of all elementary and secondary public schools) with at least one entire building (original, addition, or temporary) in need of extensive repairs or replacement [Lewis et al., 2000]. Inadequate ventilation can result in levels of a specific allergen sufficient to affect sensitive students, teachers, and staff [Dautel et al., 1999]. The presence of mold and other fungi in the damp school or office environments has been associated with development of respiratory symptoms and affects both students and teachers [Tortolero et al., 2002; Hardin et al., 2003; Santilli and Rockwell, 2003; Dangman et al., 2005]. A recent report by Dangman et al. [2005] showed that staff from schools with ongoing water intrusion or visible mold growth on indoor surfaces may be at risk for the development of WRA.

Pesticide exposure was linked to 13 (4.9%) of the *educational services* WRA cases in the state surveillance data. This may be an underestimate, given that many school staff attributed their symptoms to unidentified air pollutants, and staff may be unaware of pesticide application. Alarcon et al. [2005] reported the presence of respiratory symptoms among school employees and students associated with exposure to pesticides applied on school grounds or pesticide drift from farmland. The authors listed several factors that might be responsible, for example, lack of federal and state rules regulating pesticide usage in schools; regulatory noncompliance by schools, and pesticide applicators in states in which regulations and recommendations have been passed; and insufficient involvement of stakeholders including parents, teachers, students, school administrators, and pest managers.

Strengths and Limitations of Data

The strength and limitations of the SENSOR data have been previously discussed [Jajosky et al., 1999]. SENSOR data cannot provide estimates of the true incidence or prevalence of WRA. Although WRA is a reportable condition in

all four states, cases of WRA are both under-diagnosed and under-reported [Milton et al., 1998; Enright et al., 1999; Deprez et al., 2002]. Some patients with symptoms of asthma are not adequately diagnosed or the association of symptoms with workplace exposure is not recognized. A study using the Behavioral Risk Factor Surveillance System (BRFSS) in California, Massachusetts and Michigan would suggest that the vast majority of cases of WRA are not reported to the state surveillance system [Flattery et al., 2006]. Reporting presumably differs by industrial sector since some workers are more likely to have health benefits and access to health care provider. Moreover, information on exposure was reported by cases who might not possess full knowledge of what triggers their asthma. In addition to the SENSOR data limitation, the definition of ''*educational services* industry workers'' used in this report included only cases coded to SIC 82 and did not include workers with asthma among other industries who might have actually worked in school settings (e.g., bus drivers or food preparation contractors). As a result, other occupations at risk for developing asthma might remain unidentified.

Challenges to Public Health Intervention and Prevention

Schools are diverse environments involving multiple exposures that potentially place two populations at risk for asthma: staff and students. Moglia et al. [2006] identified high cost, lack of resources or knowledge, and competing priorities as frequently reported barriers to implementation of an indoor air quality (IAQ) program in schools. In addition, there are few federal standards that address known asthma hazards. There are no federal Occupational Safety and Health Administration (OSHA) standards for IAQ, and few standards for specific substances are based on protecting against sensitization. OSHA regulations and standards that protect workers in the private sector do not apply to those who work in public educational institutions unless they are in states with OSHA-approved state-run safety and health programs. In 2005, there were only 25 states and territories in which OSHA protections extended to public sector workers [U.S. Department of Labor, 2000].

Recommendations

The identification, elimination, and/or control of respiratory hazards is important for the protection of staff and students alike. Careful attention to prevention of moisture incursion, to facilities and ventilation systems maintenance, to control of air contaminants from construction or renovation, and to planned timing of renovation and cleaning can prevent exposure to mold and ameliorate other IAQ hazards [Environmental Protection Agency, 2000]. Employee training and education for safe handling of *cleaning products* can minimize WRA resulting from exposure to these products. Methods to protect the environment by reducing the amount of dirt entering the workplace and by selecting safer products should be underscored. For example, a new law in New York state, effective September 1, 2006, requires all public and non-public elementary and secondary schools to use environmentally sensitive cleaning products that minimize adverse impacts on children's health (Environmentally Sensitive Cleaning and Maintenance Products State Education Law 409-i and State Finance Law 163-b). In Massachusetts, the Commonwealth's Operational Services Division encourages school facility managers and staff to use environmentally preferable cleaning products by certifying selected products. Efforts are needed in purchasing programs to ensure that approved products do not contain known sensitizing agents with asthma-inducing potential, in addition to being environmentally preferable. Implementation of integrated pest management programs in schools, practices to reduce pesticide drift from farmland, and adoption of pesticide spray buffer zones around schools are also important prevention strategies.

Multiple guidance documents and tools for improvement of school environments exist at the state, regional, and national level, and more are becoming available. For example, at the national level, CDC, and the Environmental Protection Agency (EPA) developed guidance for schools to support asthma management activities, improve air quality, and raise awareness about factors associated with poor air quality, such as high carbon dioxide levels, mold, chemicals, pollen, dust, pesticides, and dirt [Environmental Protection Agency, 2000; Centers for Disease Control and Prevention, 2006a,b]. At the state level, California's Cal/OSHA program added language to the Sanitation standard requiring employers in general industry (including school districts) to correct ''exterior water intrusion, leakage from interior water sources, or other uncontrolled accumulation of water [. . .] because of the potential for these conditions to cause the growth of mold.'' While few school employees may be aware of the standard, it can be used to compel an employer stop a leak or condensation, whether or not it has already caused mold (*Sanitation* available at www.dir.ca.gov/title8/3362.html see Section [g]). There is some evidence that when the school administrations supported IAQ programs they had a positive impact on health status of students and improved workplace satisfaction [Moglia et al., 2006]. In 2002, approximately 42% of schools reported development of IAQ programs of which half used EPA's *IAQ Tools for Schools* program. However, practice does not always follow policy: having a program was not equivalent to implementation of effective policies and procedures.

Extension of OSHA protections to public sector workers in states currently without coverage is needed. All OSHA-approved state-run programs must be at least as effective as federal OSHA but can go beyond and implement additional

or more stringent standards. New Jersey is one of only three states, including Connecticut and New York, that is authorized by OSHA to oversee a safety and health program for public employees only, while federal OSHA maintains responsibility for the private sector. Approximately 489,700 public employees in New Jersey are covered by OSHA regulations that have been adopted by the New Jersey Public Employees Occupational Safety and Health (PEOSH) Program [New Jersey Department of Health and Senior Services, 2006]. In 1997, New Jersey PEOSH promulgated an IAQ standard that it enforces in the public sector. PEOSH conducts industrial hygiene investigations, offers on-site industrial hygiene consultations, and provides free educational materials and training sessions. New Jersey's PEOSH Program and state IAQ standard can serve as models for other states.

This report documents cases of WRA occurring among teachers and other school staff. The results may help decision-makers with choices related to school construction, renovation, implementation of indoor air quality programs and strategies to reduce, control, or eliminate exposures to protect both staff and students. As Moglia et al. [2006] suggested, a study of the relationship between implementation of IAQ management practices and actual IAQ in schools, could identify additional benefits or barriers to implementation of such programs, and address a need for in-depth evaluation of the efficacy of the different asthma program strategies in schools [American Lung Association of Maine, 2007].

The NIOSH-funded state-based sentinel surveillance programs for WRA remain the only sources of surveillance data in the United States for detecting emerging issues in WRA. Data collected through the state systems are essential for identifying industries and occupations in which WRA can be a problem, potential exposures and other risk factors, and the impact of WRA on workers' lives. Thus, a case of WRA among teachers and other staff, as a sentinel event, may serve as a signal that public health action is warranted, not only to protect other workers but also to protect the larger, more vulnerable, student population.

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REFERENCES

Ahman M, Soderman E, Cynkier I, Kolmodin-Hedman B. 1995. Work-related respiratory problems in industrial arts teachers. Int Arch Occup Environ Health 67:111–118.

Alarcon WA, Calvert GM, Blondell JM, Mehler LN, Sievert J, Propeck M, Tibbetts DS, Becker A, Lackovic M, Soileau SB, Das R, Beckman J, Male DP, Thomsen CL, Stanbury M. 2005. Acute illnesses associated with pesticide exposure at schools. JAMA 294:455–465.

Alexander DL. 2001. School employees: The forgotten municipal workers. Occup Med 16:65–78.

American Lung Association of Maine. 2007. Manage Your Asthma. Asthma Action Plans. Available at: http://www.mainelung.org/Topics/asthma.asp. Accessed March 5.

Arif AA, Whitehead LW, Delclos GL, Tortolero SR, Lee ES. 2002. Prevalence and risk factors of work related asthma by industry among United States workers: Data from the third national health and nutrition examination survey (1988–94). Occup Environ Med 59:505–511.

Arif AA, Delclos GL, Whitehead LW, Tortolero SR, Lee ES. 2003. Occupational exposures associated with work-related asthma and work-related wheezing among U.S. workers. Am J Ind Med 44:368–376.

AsmaPro. 2007. Table of agents and substances which can cause asthma. http://www.remcomp.com/asmanet/asmapro/agents.htm. Accessed March 5.

Balmes J, Becklake M, Blanc P, Henneberger P, Kreiss K, Mapp C, Milton D, Schwartz D, Toren K, Viegi G. 2003. American Thoracic Society Statement: Occupational contribution to the burden of airway disease. Am J Respir Crit Care Med 167:787–797.

Bang KM, Hnizdo E, Doney B. 2005. Prevalence of asthma by industry in the US population: A study of 2001 NHIS data. Am J Ind Med 47: 500–508.

Bureau of Labor Statistics and U.S., Census Bureau. 2007. Current Population Survey (CPS). http://www.census.gov/cps/. Accessed March 5.

Centers for Disease Control and Prevention. 2003. Work-related lung disease surveillance report2002.DHHS (NIOSH)2003-111. Cincinnati, OH: Department of Health and Human Services, Centers for Disease Control and. Prevention, National Institute for Occupational Safety and Health.

Centers for Disease Control and Prevention. 2004. Asthma prevalence and control characteristics by race/ethnicity—United States, 2002. MMWR Morb Mortal Wkly Rep 53:145–148.

Centers for Disease Control and Prevention. 2006a. NIOSH Safety Checklist Program for Schools. NIOSH Publication No. 2004-101. http://www.cdc.gov/niosh/docs/2004-101/default.html.AccessedMarch 5, 2007.

Centers for Disease Control and Prevention. 2006b. Strategies for addressing asthma within a coordinated school health program. http://www.cdc.gov/healthyyouth/asthma/strategies.htm. Accessed March 5, 2007.

Cox-Ganser JM, White SK, Jones R, Hilsbos K, Storey E, Enright PL, Rao CY, Kreiss K. 2005. Respiratory morbidity in office workers in a water-damaged building. Environ Health Perspect 113:485–490.

Daisey JM, Angell WJ, Apte MG. 2003. Indoor air quality, ventilation and health symptoms in schools: An analysis of existing information. Indoor Air 13:53–64.

Dangman KH, Bracker AL, Storey E. 2005. Work-related asthma in teachers in Connecticut: Association with chronic water damage and fungal growth in schools. Conn Med 69:9–17.

Dautel PJ, Whitehead L, Tortolero S, Abramson S, Sockrider MM. 1999. Asthma triggers in the elementary school environment: A pilot study. J Asthma 36:691–702.

Deprez RD, Asdigian NL, Oliver LC, Anderson N, Caldwell E, Baggott LA. 2002. Development of a prototype system for statewide asthma surveillance. Am J Public Health 92:1946–1951.

Duffy DL, Martin NG, Battistutta D, Hopper JL, Mathews JD. 1990. Genetics of asthma and hay fever in Australian twins. Am Rev Respir Dis 142:1351–1358.

Enright PL, McClelland RL, Newman AB, Gottlieb DJ, Lebowitz MD. 1999. Underdiagnosis and undertreatment of asthma in the elderly. Cardiovascular Health Study Research Group. Chest 116:603–613.

Environmental Protection Agency. 2000. IAQ Tools for Schools (TfS) Program. Managing Asthma in the School Environment. EPA # 402-K-00-003. http://www.epa.gov/iaq/schools/asthma/index.html. Accessed March 5, 2007.

Flattery J, Davis L, Rosenman KD, Harrison R, Lyon-Callo S, Filios M. 2006. The proportion of self-reported asthma associated with work in three States: California, Massachusetts, and Michigan, 2001. J Asthma 43:213–218.

Fletcher AM, London MA, Gelberg KH, Grey AJ. 2006. Characteristics of patients with work-related asthma seen in the New York State Occupational Health Clinics. J Occup Environ Med 48:1203–1211.

Hardin BD, Kelman BJ, Saxon A. 2003. Adverse human health effects associated with molds in the indoor environment. J Occup Environ Med 45:470–478.

Henneberger PK, Derk SJ, Sama SR, Boylstein RJ, Hoffman CD, Preusse PA, Rosiello RA, Milton DK. 2006. The frequency of workplace exacerbation among health maintenance organisation members with asthma. Occup Environ Med 63:551–557.

Jaakkola JJ, Jaakkola MS. 2006. Professional cleaning and asthma. Curr Opin Allergy Clin Immunol 6:85–90.

Jajosky RA, Harrison R, Reinisch F, Flattery J, Chan J, Tumpowsky C, Davis L, Reilly MJ, Rosenman KD, Kalinowski D, Stanbury M, Schill DP, Wood J. 1999. 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. MMWR CDC Surveill Summ 48:1–20.

Kraut A, Walld R, Mustard C. 1997. Prevalence of physician-diagnosed asthma by occupational groupings in Manitoba, Canada. Am J Ind Med 32:275–282.

Kreiss K. 1989. The epidemiology of building-related complaints and illness. Occup Med 4:575–592.

Leigh JP, Romano PS, Schenker MB, Kreiss K. 2002. Costs of occupational COPD and asthma. Chest 121:264–272.

Lewis L, Snow K, Farris E, Smerdon B, Cronen S, Kaplan J, Greene B. 2000. Condition of America's public school facilities, 1999. Washington, DC: U.S. Dept. of Education, Office of Educational Research and Improvement. National Center for Education Statistics.

Malo JL, Chan-Yeung M. 2006. Appendix. Agent causing occupational asthma with key references. In: Bernstein IL, Chan-Yeung M, Malo JL, Bernstein DI, editors. 3rd edition. Asthma in the workplace, and related conditions. New York: Taylor & Francis. pp. 825–866.

Mannino DM, Homa DM, Akinbami LJ, Moorman JE, Gwynn C, Redd SC. 2002. Surveillance for asthma–United States, 1980–1999. MMWR Surveill Summ 51:1–13.

Milton DK, Solomon GM, Rosiello RA, Herrick RF. 1998. Risk and incidence of asthma attributable to occupational exposure among HMO members. Am J Ind Med 33:1–10.

Moglia D, Smith A, MacIntosh DL, Somers JL. 2006. Prevalence and implementation of IAQ programs in U.S. schools. Environ Health Perspect 114:141–146.

New Jersey Department of Health and Senior Services. 2006. Right to Know Program. http://www.state.nj.us/health/eoh/rtkweb/. Accessed March 5, 2007.

Rosenman KD. 2006. Cleaning products-related asthma. Clin Pulm Med 13:221–228.

Rosenman KD, Reilly MJ, Kalinowski DJ. 1997. A state-based surveillance system for work-related asthma. J Occup Environ Med 39:415–425.

Rosenman KD, Reilly MJ, Schill DP, Valiante D, Flattery J, Harrison R, Reinisch F, Pechter E, Davis L, Tumpowsky CM, Filios M. 2003. Cleaning products and work-related asthma. J Occup Environ Med 45:556–563.

Saarinen K, Karjalainen A, Martikainen R, Uitti J, Tammilehto L, Klaukka T, Kurppa K. 2003. Prevalence of work-aggravated symptoms in clinically established asthma. Eur Respir J 22:305–309.

Sama SR, Milton DK, Hunt PR, Houseman EA, Henneberger PK, Rosiello RA. 2006. Case-by-case assessment of adult-onset asthma attributable to occupational exposures among members of a health maintenance organization. J Occup Environ Med 48:400–407.

Santilli J, Rockwell W. 2003. Fungal contamination of elementary schools: A new environmental hazard. Ann Allergy Asthma Immunol 90:203–208.

Schatz M, Camargo CA Jr. 2003. The relationship of sex to asthma prevalence, health care utilization, and medications in a large managed care organization. Ann Allergy Asthma Immunol 91:553–558.

Tinkelman DG, McClure DL, Lehr TL, Schwartz AL. 2002. Relationships between self-reported asthma utilization and patient characteristics. J Asthma 39:729–736.

Tortolero SR, Bartholomew LK, Tyrrell S, Abramson SL, Sockrider MM, Markham CM, Whitehead LW, Parcel GS. 2002. Environmental allergens and irritants in schools: A focus on asthma. J Sch Health 72:33–38.

U.S., Department of Labor, Office of Inspector General Office of Audit. 2000. Evaluating the Status of Occupational Safety and Health Coverage of State and Local Government Workers in Federal OSHA States. Report No. 05-00-001-10-001.

U.S. General Accounting Office. 1995. School facilities, condition of America's schools. http://www.gao.gov/archive/1995/he95061.pdf. Report No. GAO/HEHS-95-61.

U.S. General Accounting Office. 1999. Indoor pollution: Status of federal research activities. http://www.gao.gov/archive/1999/rc99254.pdf. Report No. GAO/RCED-99-254.

Vollmer WM, Heumann MA, Breen VR, Henneberger PK, O'connor EA, Villnave JM, Frazier EA, Buist AS. 2005. Incidence of work-related asthma in members of a health maintenance organization. J Occup Environ Med 47:1292–1297.

Wagner GR, Wegman DH. 1998. Occupational asthma: Prevention by definition. Am J Ind Med 33:427–429.

Weiss KB, Sullivan SD. 2001. The health economics of asthma and rhinitis. I. Assessing the economic impact. J Allergy Clin Immunol 107:3–8.

Whelan EA, Lawson CC, Grajewski B, Petersen MR, Pinkerton LE, Ward EM, Schnorr TM. 2003. Prevalence of respiratory symptoms among female flight attendants and teachers. Occup Environ Med 60: 929–934.