Occurrence of Occupational Asthma*

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To estimate the percentage of adult asthmatics with occupational asthma in Michigan, a sample of 94 patients, aged 20 to 65 years, who were discharged from one of three Michigan hospitals in 1990 with the primary diagnosis of asthma were interviewed. The patients were classified using the National Institute for Occupational Safety and Health (NIOSH) criteria as having either probable occupational asthma, possible occupational asthma, or not having occupational asthma. Three percent of the adult asthmatics interviewed met the criteria for having probable occupational asthma. One patient from each hospital had probable occupational asthma. Fifteen of 60 patients (25 percent) from hospital A, 3 of 25 patients (12 percent) from hospital B, and 2 of the 9 patients (22 percent) from hospital C had probable or possible occupational asthma. After adjusting for the difference in response rate among patients from the three hospitals, the percentage of adult asthmatics in Michigan whose asthma is caused by work exposure is estimated to be between 3 percent and 20.2 percent. In contrast, 25.5 percent of the patients stated their asthma was caused by bad working conditions. If these percentages were generalizable to the whole state, then according to our survey 330 to 2,222 or by self-reports of the patients, 2,800 of the 11,000 hospital discharges per year in Michigan for asthma among adults could be attributed to a work exposure. *(Chest 1993; 104:816-20)*

NIOSH = National Institute for Occupational Safety and Health; RADS = reactive airways dysfunction syndrome

Occupational asthma is defined as a variable airway narrowing related to exposure in the working environment to airborne dusts, gases, vapors, or fumes.[1] Occupational asthma affects a diverse group of people ranging from bakers to chemical workers. Research has identified more than 200 causal agents such as organophosphates, formalin, diisocyanates, platinum salts, and wood dusts.[1]

Limited work has been performed on how much adult asthma can be attributed to work. A study from Japan found that in 15 percent of adult asthmatics, their asthma was caused by their occupation. However, the Japanese industries associated with occupational asthma are different from those found in the United States.[2] For example, in Japan, occupational asthma was reported in the sericulture (silk production) industry and the manufacture of Maiko, which is used in the production of some Japanese foods. A survey of patients receiving Social Security disability for asthma in the United States also attributed 15 percent of asthma to work exposures.[3] Patients in this study were considered to have occupational asthma if they felt that the cause of their asthma was related to the workplace. Data were not available to evaluate the patient's self-reported assessment of cause. Finally, a national committee of pulmonary experts estimated that 2 percent of asthma in adults was caused by work exposures. A study was not conducted to derive this estimate.[4]

There are approximately 11,000 adults discharged each year from Michigan hospitals with the diagnosis of asthma. Adult asthmatics discharged from three hospitals were interviewed to provide an estimate of how much asthma could be attributed to work exposures.

Material and Methods

The patients in this study were discharged from one of three Michigan hospitals in 1990 with a primary diagnosis of asthma. The three hospitals were contacted in the spring of 1991 and asked to identify patients with a primary discharge diagnosis of *ICD-493*. The hospitals complied by sending the following data: name of patient, age of patient, gender, address, and phone number. Three large urban hospitals geographically separated were selected. These hospitals are hospital A (294 beds) in Detroit, hospital B (540 beds) in Flint, and hospital C (285 beds) in Lansing. All of these hospitals provide care to a significant indigent population. All patients with the primary diagnosis of asthma *(ICD-493)* between the ages 20 to 65 years discharged from these three hospitals in 1990 were contacted in the summer of 1991. The patient's physician was first sent a letter asking if he had any objection to our contacting his patient. None of the physicians objected. Each patient was sent an introductory letter and a consent form. Each patient was interviewed over the phone by the same interviewer. The interviewer administered a standardized medical questionnaire that included questions on symptoms, medication, and a lifetime occupational history. The same question used in the study of Social Security disability recipients regarding whether the patient thought their asthma was work related was included in the questionnaire.[3] This question is: "Was your asthma caused by bad working conditions such as smoke or chemicals?"

By reviewing the completed questionnaires, each patient was classified by one of the authors, a board-certified internist and occupational medicine physician, according to criteria of the National Institute for Occupational Safety and Health (NIOSH) (see Table 1).[5]

All patients met criteria A because their primary hospital discharge diagnosis was asthma. If the patient only met criterion A, he was classified as not having occupational asthma. To meet criterion B, a patient must have reported having been bothered at work by shortness of breath, chest tightness, or wheezing. In addition, these symptoms must have begun after the patient started a new occupation and at least initially improved when they were away from work either on the weekends or on vacation. If the patient did not know if the symptoms improved at these times, then in order to meet criterion B, he must have stated that the symptoms

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Table 1—*NIOSH Criteria*

Criteria
A. A physician diagnosis of asthma and
B. An association between symptoms of asthma and work and
C. Any one of the following criteria:
1. Workplace exposure to an agent or process
2. Significant work-related changes in forced expiratory volume in one second (FEV_1) or peak expiratory flow rate (PEFR) or
3. Significant work-related changes in airway responsiveness as measured by nonspecific inhalation challenge or
4. Positive response to inhalation provocation testing with an agent to which the patient is exposed at work.

got worse during the day when he worked and that they got worse throughout the work week. For a patient with reactive airways dysfunction syndrome (RADS) to meet criterion B, he had to have evidence that his asthma developed after a short-term exposure at work. However, an evaluation regarding whether the patient had nonspecific airway reactivity was not performed.[6] Patients met criterion C if their work history indicated that their symptoms developed at a job previously associated with occupational asthma according to the medical literature. If a patient had a physician diagnosis of asthma (criterion A), an association between symptoms of asthma and work (criterion B), and workplace exposure to an agent or process previously associated with occupational asthma (criterion C1), he was considered to have probable occupational asthma. Charts were not reviewed, and thus we did not have access to pulmonary function tests that would be necessary to determine the presence of criteria C2-C4. If the patient met only criteria A and B, then he was classified as having possible occupational asthma.

Results were analyzed by χ^2 analysis. Fisher's exact test analysis was performed where the expected was less than 5. To account for differences in the percentage of patients interviewed in each hospital and differences in the percentage of patients with possible occupational asthma in each hospital, rates were adjusted in two ways. First, rates were calculated assuming none of the noninterviewed patients had probable or possible occupational asthma. Second, the rates were calculated assuming the noninterviewed patients had the same rates of probable and possible occupational asthma as the interviewed patients.

Results

All 202 adult patients with a primary hospital discharge diagnosis of asthma in 1990 were selected from three Michigan hospitals for a possible interview. Ninety-four of these patients were interviewed. Of the 108 nonresponders, 2 had died, 19 refused, and 87 could not be located after a mailing and an attempted phone call. There was no significant difference between the gender of the nonresponder and responder groups ($\chi^2 = 0.013$, $p = 0.971$) (Table 2). However, the responders were on the average 7 years older ($p = 0.0001$). A larger percentage of patients who responded were covered by private insurance (68.8 percent vs 34.3 percent) and a lower percentage were covered by Medicaid (20.8 percent vs 51.4 percent). A larger percentage of patients responded from hospitals A (50.8 percent) and C (69.2 percent) than hospital B (35.2 percent) ($\chi^2 = 7.23$, $p = 0.023$).

Three patients (3.2 percent) met the criteria for having probable occupational asthma, and 17 patients (18.1 percent) met the criteria for having possible occupational asthma. There was one patient with probable occupational asthma from each hospital. Short summaries of the patients who were classified as having probable occupational asthma are included below.

Case Reports

Case 1

A woman in her late 50s who began working as a transcriptionist in the pathology department of a large hospital and presently worked as a supervisor in the same area developed symptoms of shortness of breath, chest tightness, and wheezing after working at the job for 11 years. The patient's symptoms improved when she was not at work. She had a 25-year history of smoking one half a pack of cigarettes per day. She had a family history of asthma and a personal history of allergies that began at the age of 7 years. She had to walk through the laboratory where formaldehyde was used on a daily basis. In addition, one of her job duties required that she enter the laboratory to discuss specific procedures with the laboratory personnel. Formaldehyde, which is typically used in a pathology laboratory, has been reported to cause occupational asthma.[8-10]

Case 2

A man in his late 20s developed wheezing and a dry throat 2 years after beginning to work as an automation technician at company manufacturing automobile parts. His symptoms were associated with work and improved on weekends and vacations. He had smoked one half a pack of cigarettes a day for 14 years. He also had a history of childhood asthma but had been asymptomatic for 2 years prior to the occurrence of his symptoms at the new occupation. He had a daughter with asthma and a history of allergies that began in early childhood. He also reported having a history of chronic bronchitis at the age of 9 years that had not persisted.

He was exposed on a daily basis to oil mist. Case reports and one epidemiologic study have associated exposure to aerosolized coolants with bronchoconstriction.[11-13]

Table 2—*Characteristics of Responders and Nonresponders*

	Responders	Nonresponders	p Value
Average age,* yr	44	37	0.0001
Gender,* %			
Women	79	78	
Men	21	22	NS
Average length of stay,† d	4.00	4.40	NS
Insurance,‡ No. (%)			0.0114
Private	33 (68.8)	12 (34.3)	
Medicare	5 (10.4)	5 (14.3)	
Medicaid	10 (20.8)	18 (51.4)	
Worker compensation	1 (2.1)	0 (0)	
ICD codes,§ No. (%)			NS
493.0	12 (17.4)	14 (23.7)	
493.1	25 (36.2)	17 (28.8)	
493.9	24 (34.8)	20 (33.9)	
Have more than one of the above ICD codes	8 (11.6)	8 (13.6)	

*This information was available on all responders and nonresponders.

†This information was available on 69 responders and 58 nonresponders.

‡This information was available on 49 responders and 35 nonresponders.

§This information was available on 69 responders and 59 nonresponders.

Table 3—*Summary of the Industries, Occupations, Exposures, and Years Worked Before Onset of Symptoms for 17 Patients With Possible Occupational Asthma*

Industry	Occupation	Substances Patient Believed Caused Their Asthma	Years Worked Before Wheezing, Chest Tightness, or Shortness of Breath Developed
Hospital	Nurse's aide	Industrial cleaners	4
Nursing home	Nurse's aide	Industrial cleaners	5
Manufacture of automobile parts	Metal finisher	Paints, fiberglass	8
Automobile parts testing	Office manager	Dyes, penetrants, exhaust fumes	6
Manufacture of automobile parts	Grinder	Smoke, dust	7
Manufacture of automobile parts	Welder	Smoke, unknown chemical in which parts were dipped	0.5
Manufacture of automobile parts	Welder	Unknown	17
Vocational schools	Electronics teacher	Unknown	17
Cosmetology	Cosmetologist	Curl relaxants	3
Manufacture of automobile parts	Supervisor of sheet metal parts production	Oils, lubricants, welding smoke, exhaust fumes	15
Hotel	Clothes presser	Laundry detergent	2
Physician's office	Office manager	Exhaust fumes	3
Manufacture of automobile parts	Sewing machine operator	Dust, pollen, snow	5
Hospital	Office worker	Unknown	30
Manufacture of automobile parts	Press operator	Dust	2
Men's and boys' clothing and accessory stores	Seamstress	Unknown	7
Manufacture of automobile parts	Grinder	Unknown	6

CASE 3

A man in his early 50s who had been working as a firefighter for 28 years developed symptoms of wheezing and shortness of breath after fighting a fire in a kitchen of a residence hall at a large university. He continued to work for 6 more years as a firefighter, at which time his symptoms worsened after a fire at a dentist's office. He had not worked at any job since that time. He had been a smoker for 34 years and smoked about a pack per day. He did not have a personal or family history of asthma. The patient reported he was told he also had chronic bronchitis. He had a history of allergies. Asthma has been reported to develop after exposure to smoke.[6,14] This was the one patient whose hospitalization was covered by worker's compensation.

The percentage of probable and possible occupational asthmatics at hospital A was 25 percent, at hospital B it was 12 percent, and at hospital C it was 22 percent. The overall percentage for all three hospitals was 21.3 percent. After adjusting for a differential response from the three hospitals, the overall percentage of probable and possible occupational asthma was 9.9 percent if one assumed none of the noninterviewed patients had probable or possible occupational asthma. If one assumed the noninterviewed patients had the same prevalence of probable or possible occupational asthma as the interviewed patients, the adjusted prevalence of probable and possible occupational asthma was 20.2 percent.

Table 3 lists the industry, occupation, suspected substances that caused the asthma, and years worked before onset of symptoms for the possible occupational asthma patients. Table 4 compares the industries in which the patients, who were classified as not having occupational asthma, worked with those of the patients classified as having possible occupational asthma.

Of the 94 patients interviewed, 61 percent (57/94) were working at the time their asthma symptoms began. Of those patients not working at the time their symptoms began, 18 percent (17/94) had been diagnosed as having asthma during childhood. The predominant industries in which the patients were working at the time their symptoms began included health services, manufacturing of transportation equipment, and public administration. The industry manufacturing of transportation equipment employed the most patients who met the criteria for having probable and possible occupational asthma (45 percent). The distribution of industries was similar between the group of patients classified as having probable or possible occupational asthma and the group of patients who met the criteria for not having occupational asthma except there were more patients with probable or possible occupational asthma who worked in the manufacture of transportation equipment.

The majority (78 of 94, 83 percent) of patients who were interviewed reported being started on a regimen of medication for their asthma at the time of diagnosis (Table 5). Twenty-four of 94 of the patients (25.5 percent) believed that their asthma was caused by bad working conditions such as smoke or chemicals. Fifty-five percent (11/20) of the patients who were classified as having probable or possible occupational asthma and 17.6 percent (13/74) of those who were classified as not having occupational asthma believed their asthma was caused by bad working conditions. Three of 24 (12.5 percent) patients stated that they were still exposed to the substance they believed was causing their asthma. There was no significant difference in the history of tobacco use between the patients with

Table 4—*Industry In Which Patients With Occupational and Nonoccupational Asthma Were Working at the Time of Onset of Their Asthma*

SIC Codes	Industry	Patients With Nonoccupational Asthma, No. (%)*	Patients With Occupational Asthma, No. (%)
15	Construction	1 (2.7)	
23, 56	Manufacture and retail sale of apparel	2 (5.4)	1 (5.0)
27	Printing, publishing	1 (2.7)	
36, 37	Manufacture of automobile parts	4 (10.8)	9 (45.0)
39, 76	Miscellaneous manufacturing industries	2 (5.4)	
47	Transportation services	1 (2.7)	
48	Communications	2 (5.4)	
54	Food stores	1 (2.7)	
58, 70	Restaurants, hotels	2 (5.4)	1 (5.0)
72, 73	Personal and business services	2 (5.4)	1 (5.0)
75	Automobile repair	1 (2.7)	
80	Health services	10 (27.0)	4 (20.0)
82	Education	3 (8.1)	1 (5.0)
88	Private households	1 (2.7)	
92, 94, 95, 07	Public administration	4 (10.8)	
	Total	37†	20 (100)

*Because of rounding errors, percentage total does not exactly equal 100 percent.

†Of the 74 patients with nonoccupational asthma, 37 were not working at the time their asthma symptoms began. This includes 17 patients who were diagnosed as having asthma as children.

probable or possible occupational asthma and those classified as not having occupational asthma (75 percent, 15 of 20, vs 68.9 percent, 51 of 74, respectively; $p = .488$). The percentage of patients in each group that still smoked was not significantly different (33 percent vs 32 percent, respectively; $\chi^2 = 0.049$, $p = 0.825$). There was no difference in the history of bronchitis (50 percent vs 54.1 percent, respectively; $p = 0.474$) or emphysema (15 percent vs 5.4 percent, respectively; $p = 0.155$) between the two groups. There was no difference between the groups in the family history of asthma or skin allergies (65 percent, 13 of 20, vs 63.5 percent, respectively; $p = 0.554$). The groups showed no significant difference (50 percent vs 52.7 percent, respectively; $p = 0.924$) in the percentage of patients with a prior diagnosis of allergies. Although patients classified as having probable or possible occupational asthma were 6.8 years older at the time of diagnosis than those classified as not having occupational asthma (32.5 vs 25.7 years), this difference was not statistically significant.

Table 5—*Characteristics of Patients With Probable and Possible Occupational Asthma in Comparison to the Patients With Nonoccupational Asthma*

	Probable or Possible Occupational Asthma	Nonoccupational Asthma	p Value
Age, yr	44	44	NS
Gender, No. (%)			NS
Women	12 (60)	62 (83.8)	
Men	8 (40)	12 (16.2)	
Started on regimen of asthma medication at time of diagnosis, No. (%)	16 (80)	62 (83.8)	NS
Believed asthma caused by work, No. (%)	11 (55)	13 (17.6)	0.029
History of cigarette smoking, No. (%)	15 (75)	51 (68.9)	NS
Currently smoking cigarettes, No. (%)	5 (25)	17 (23)	NS
History of bronchitis, No. (%)	10 (50)	40 (54.1)	NS
History of emphysema, No. (%)	3 (15)	4 (5.4)	NS
Family history of asthma or skin allergies, No. (%)	13 (65)	47 (63.5)	NS
Personal history of allergies, No. (%)	10 (50)	39 (52.7)	NS
Age at diagnosis, yr	32.5	25.7	NS

Discussion

The percentage of adult patients whose asthma can be attributed to occupational exposure is not known. Previous estimates have ranged from 2 to 15 percent.[2-4] Our study applied NIOSH criteria to questionnaire data derived from interviews of adult patients with a primary hospital discharge diagnosis of asthma in 1990 from three Michigan hospitals in Detroit, Flint, and Lansing. We found 3 percent of the patients who were interviewed met our criteria for probable occupational asthma and 18.1 percent met our criteria for possible occupational asthma. We adjusted for a differential response rate to our questionnaire among patients from the three hospitals. The adjusted percentage of possible occupational asthmatics is 17.2 percent if we assume the nonrespondents had the same prevalence of possible occupational asthma as the respondents or

9.9 percent assuming none of the nonrespondents had possible occupational asthma. If the percentage of probable and possible occupational asthmatics (12.9 percent to 20.2 percent) were applied to all hospitals in the state, then annually 1,419 to 2,222 of the 11,000 hospital discharges due to asthma in Michigan could be attributable to work exposure. For just probable occupational asthmatics, the estimate would be 330.

The patients who met the criteria for probable or possible occupational asthma were similar to the patients not having occupational asthma. Both groups had a similar age of diagnosis, history of smoking, family history of asthma, and history of allergies. The two groups also had similar percentages of patients with a history of emphysema and bronchitis.

The three patients who met the criteria for having probable occupational asthma worked in different industries. The industry with the largest percentage of patients with probable or possible occupational asthma was the manufacturing of transportation equipment, which includes the automobile parts industry.

From this study, if patients were classified only on the basis of whether they attribute the cause of their asthma to work exposure, the percentage of patients with occupational asthma would be 25.5 percent. This compares with the result of 15 percent in a national study that asked the same question. Of the patients who self-reported an association with work, only 11 (45.8 percent) met the criteria outlined in this study for having probable or possible occupational asthma. Conversely, 55 percent of the patients we classified as having probable or possible occupational asthma did not attribute their asthma to work exposure. Given the absence of confirmatory testing for occupational asthma, one cannot actually determine if the self-reported percentage of 25.5 percent of patients who thought their asthma was caused by poor working conditions is a more accurate percentage than the percentage obtained by using the NIOSH criteria.

The study had a number of limitations. The first limitation was that the primary hospital discharge diagnosis of asthma was not standardized. No attempt was made to determine the criteria used by individual physicians to make the diagnosis of asthma. We accepted the hospital discharge diagnosis to be adequate to meet criterion A. The fact that 12.9 percent of the patients reported having emphysema highlights our concern about the criteria used by physicians to diagnose asthma. Other limitations included the small sample size, the response rate (46.5 percent), and the selection of patients from only three hospitals. Although the response rate was low, there was no difference in gender and age between the responders and nonresponders. We adjusted for the difference in response by hospital. If we assumed that none of the patients who were not interviewed had probable or possible occupational asthma, then our estimated prevalence rate would be 9.9 percent. This rate is still higher than some national estimates. Finally, definitive tests were not performed to confirm the diagnosis of occupational asthma. None of the three probable occupational asthma cases was confirmed and there could be alternative explanations for their symptoms. Formaldehyde sensitivity occurs in a minority of patients with symptoms from exposure to formaldehyde. There is limited evidence of oil mist sensitivity and the firefighter who by history had RADS was a smoker whose symptoms increased over time.

Further studies with a larger sample size and a wider selection of patients from other hospitals are necessary to determine an exact estimate of the prevalence of occupational asthma. Additional tests, such as the use of peak flow meters, are needed to confirm the questionnaire data on the relationship between symptoms and work exposure.[7] Actual characterization of the work exposure should also be included in these future studies.

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References

1 Chan-Yeung M, Lam S. State of art: occupational asthma. Am Rev Respir Dis 1986; 133:686-701
2 Kobayashi S. Different aspects of occupational asthma in Japan. In: Frazier CA, ed. 1980 occupational asthma. New York: Van Nostrand Reinhold, 1980; 229-244.
3 Blanc P. Occupational asthma in a national disability survey. Chest 1987; 92:613-17
4 Salvaggio J, ed. Occupational and environmental respiratory disease in NIAID task force report: asthma and other allergic disease. Washington DC: US Dept of Health Education and Welfare, May 1979 (NIH publication No. 79-387)
5 Matte TD, Hoffman RE, Rosenman KD, Stanbury M. Surveillance of occupational asthma under the SENSOR model. Chest 1990; 95:173s-178s
6 Brooks SM, Weiss MA, Bernstein IL. Reactive airways dysfunction syndrome (RADS): persistent asthma syndrome after high level irritant exposures. Chest 1985; 83:376-84
7 Rosenman KD. Asthma and work: how do you diagnose the association? Chest 1991; 100:1481-82
8 Burge PS, Harries MG, Lam WK, O'Brien IM, Patchett PA. Occupational asthma due to formaldehyde. Thorax 1985; 40:255-60
9 Nordman H, Keskinon H, Tuppurainen M. Formaldehyde asthma—rare or overlooked? J Allergy Clin Immunol 1985; 75: 91-9
10 Thrasher J, Broughton A, Micevich P. Antibodies and immune profiles of individuals occupationally exposed to formaldehyde: six case reports. Am J Ind Med 1988; 14:479-88
11 Robertson AS, Weit DC, Burge PS. Occupational asthma due to oil mists. Thorax 1988; 43:200-05
12 Hendy MS, Beattie BE, Burge PS. Occupational asthma due to an emulsified oil mist. Br J Ind Med 1985; 42:51-4
13 Kennedy SM, Greaves IA, Kriebel D, Eisen EA, Smith TJ, Woskie SR. Acute pulmonary responses among automobile workers exposed to aerosols of machining fluids. Am J Ind Med 1989; 15:627-41
14 Moisan TC. Prolonged asthma after smoke inhalation: a report of three cases and a review of previous reports. J Occup Med 1991; 33:458-61