1999

Annual Report on Work-Related Asthma in Michigan

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A Joint Report
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Summary:

This is the ninth annual report on work-related asthma in Michigan. An average of 148 new people each year are reported to the Michigan Department of Consumer and Industry Services (MDCIS) with asthma caused by work. The reports received by the Michigan Department of Consumer and Industry Services represent 18.5%-64.9% of the number of estimated people in Michigan who develop work-related asthma each year. Inspections at the workplaces of these individuals reveal a large number of fellow workers with asthma or respiratory symptoms compatible with asthma. The work exposures may cause new onset asthma from exposure to an allergen or an irritant that precipitates inflammatory changes, or work exposures may exacerbate pre-existing asthma from exposure to an irritant. Almost ninety percent of the reports received involve the new onset of asthma.

Known allergens such as isocyanates and metal working fluids are the most common cause of work-related asthma in Michigan. Despite the association of a patient's asthma with work, many times a known allergen is not identified. Practitioners need to maintain a high level of clinical suspicion for new causes of work-related asthma. There are approximately 350 known causes of work-related asthma. The most comprehensive listing of known causes of work-related asthma is at an Internet website: www.remcomp.com/asmanet/asmapro/asmawork.htm#start.

Work-related asthma is affecting men and women, generally in their 30s - 50s. The rate among African Americans was 2.2 times greater than among whites. Exposures are occurring in a wide range of workplaces. When an inspection is conducted at the workplace, significant numbers of symptomatic individuals have been identified. However, air monitoring at these same facilities typically reveals that the exposures to the suspected allergen or irritant are within existing workplace standards. Often a specific workplace standard for the suspected allergen or irritant does not exist.

The Occupational Health Standards Commission under the authority of the Michigan Occupational Safety and Health Act (MIOSHA) has proposed expanding the isocyanate standard to require an education and training program for companies that work with isocyanates. The program would include information on: hazards; engineering controls; personal protective equipment; safe work practices; and emergency contingencies. The federal Occupational Safety and Health Administration (OSHA) is considering lowering the allowable exposure standard for metal working fluids. The National Institute for Occupational Safety and Health (NIOSH) has recommended reducing metal working fluid aerosols to 0.4 mg/m^3 (thoracic particulate mass) as a time-weighted average (TWA) for up to 10 hours/day for a 40 hour work week. In addition to lowering the recommended exposure limit (REL), NIOSH recommends the development of a comprehensive health and safety program at companies that use metal working fluids. NIOSH recommends that the program include: 1) safety and health training; 2) worksite analysis; 3) hazard prevention and control, and; 4) medical monitoring of exposed workers (1).

Background:

Based on extrapolation from national estimates there are approximately 230,000 adults with asthma in Michigan (2). It is estimated that work place exposures are responsible for asthma in 2 - 33% of adults (3-10). A Michigan study estimates that workplace exposures are possible contributing causes to the development of asthma in 3 -26% of adults hospitalized with asthma in Michigan (6).

In 1988, the Michigan Department of Consumer and Industry Services (formerly the Michigan Department of Public Health) instituted a surveillance program for work-related asthma with financial assistance from the National Institute for Occupational Safety and Health (NIOSH). The goal of the surveillance program is to prevent work-related asthma through the reporting of index patients. The reporting of the index patient is regarded as a sentinel health event that may lead to the identification of other employees from the same facility who are at risk of developing asthma or who have developed similar breathing problems. There are three sources used to identify persons with work-related asthma: reports from physicians; reports from hospitals (since 1989); and claims filed since 1988 with the Bureau of Workers' Compensation. Both physicians in private practice and those working for industry send reports to the Michigan Department of Consumer and Industry Services (MDCIS). Reports from hospitals are requested once each year. Hospital discharge summaries for individuals with a primary or secondary diagnosis of a respiratory condition due to chemical fumes and vapors (ICD-9 506.0-.9) as well as individuals with a primary or secondary diagnosis of asthma (ICD-9 493) where the principal payer is listed as workers' compensation are obtained from the Michigan Health and Hospital Association's (MHA) Michigan inpatient database to verify the completeness of reporting by the hospitals, and the work-relatedness of the condition is determined.

A person is considered to have occupational asthma from sensitization to a workplace exposure if: A) they have a physician diagnosis of asthma, and B) onset of respiratory symptoms associated with a particular job that then improve or are relieved when the patient is not working, and C) they work with a known occupational allergen, or have evidence of an association between work exposures and a decrease in pulmonary function testing.

Additional criteria are used to record three other categories of asthma associated with work. If only criteria (A) and (B) above are met the person is considered to have possible occupational asthma. An industrial hygiene investigation at the patient's work site is performed to determine the allergen

and documents its associated exposure levels. If a person had physician-diagnosed asthma before beginning work and their asthma became worse at a particular job the person is considered to have aggravated asthma. Occupational asthma from exposure to an allergen at work typically develops after a variable period of symptomless exposure to the sensitizing agent. However, if a person develops asthma for the first time immediately after an acute exposure to an irritating chemical at work the patient is considered to have Reactive Airways Dysfunction Syndrome (RADS) (11).

After the patient has been interviewed and the work-relatedness of their condition evaluated, an industrial hygiene investigation may be conducted at the patient's workplace. At this follow-up investigation, co-workers are interviewed to determine if other individuals are experiencing similar breathing problems from exposure to the suspected allergen. An industrial hygienist conducts air monitoring for any suspected allergens and reviews the company's health and safety program. After the investigation is completed, a report of air sampling results and any recommendations are sent to the company and union (or designated labor representative, if the company does not have a union).

In 1998, the surveillance program also began sending letters about potential problems with exposures to some of the companies where the index cases were exposed to an allergen, in cases where a formal MIOSHA inspection was not planned. These letters, in lieu of inspections, are sent to the company health and safety director, and ask the company to evaluate exposures to whatever suspected allergens were identified through the telephone interview with the index case.

Results:

Reports

Table 1 shows that 1,497 people were confirmed with work-related asthma between 1988 - 1999. Figure 1 presents the same data in a bar graph of the number of cases identified each year, and the types of work-related asthma that were confirmed. The reports are divided into four categories: occupational asthma, possible occupational asthma, aggravated asthma and RADS. One hundred sixty-one additional patients have been confirmed since last year's report. There were 31 confirmed reports in 1988, 63 in 1989, 144 in 1990, 115 in 1991, 150 in 1992, 177 in 1993, 152 in 1994, 127 in 1995, 155 in 1996, 161 in 1997, 133 in 1998, and 89 in 1999. Figure 2 shows the overlap of the 1,408 patients by reporting sources for 1988-1998.

The data is incomplete for 1988 since the surveillance system was initiated in that year. To date we have not yet received complete hospital reporting for 1998 and 1999. Patient interviews are still needed for 8 reports of patients from hospitals and 7 reports of patients from physicians in 1998; and, for 4 reports of patients from hospitals and 11 reports of patients from physicians in 1999.

Gender

Seven hundred fifty-nine (50.7%) of the persons with work-related asthma are women and 738 (49.3%) are men.

Race

One thousand one hundred forty-three (76.4%) of the persons with work-related asthma are white, 280 (18.7%) are African American, 42 (2.8%) are Hispanic, 15 (1.0%) are Alaskan or American Indian, 5 (0.3%) are Asian and, 12 (0.8%) were listed as "other."

The average number of African Americans with asthma each year for 1992-1996 was 30.4. In 1998 there were 539,621 African Americans in the Michigan labor force (12). The annual rate for work-related asthma in African Americans, therefore, was 5.6/100,000 workers. The respective data for whites was 114.8 per year and 4,368,720 whites in the Michigan labor force. The annual rate of work-related asthma in whites, therefore, was 2.6/100,000 workers. The African American rate of work-related asthma was 2.2 times greater than the rate for whites.

Age

The dates of birth range from 1905 - 1978. The average year of birth is 1952.

Location in State

Figure 3 shows the county in which the patient worked where they developed work-related asthma. The main locations are: Wayne (409 cases, 27.7%), Oakland (198 cases, 13.4%), and Macomb (146 cases, 9.9%). Table 2 and Figure 4 show the annual average incidence rates of work-related asthma among the general working population in each county. Based on the annual average incidence of reports of confirmed cases per 100,000 adult workers, Luce (21.7 per 100,000), Clare (10.9 per 100,000) and Cheboygan (13.2 per 100,000) have the highest rates. Table 3 shows the annual incidence rates for the larger metropolitan areas and the whole state for the years 1990 through 1997 separately.

Type of Industry

Table 4 shows the types of Michigan industries where the exposures to the occupational allergens occurred from 1988 to 1999. Figure 5 shows the distribution of major industry types for all cases identified from 1988-1999. The predominant industries for the total number of cases identified between 1988 and 1999 were in the manufacturing sector: automobile (43.2%), industrial and commercial machinery and computer equipment (3.9%), foundries (3.2%), fabricated metal products (4.6%), and rubber and miscellaneous plastic products (4.2%). Workers in the health field also accounted for a high percentage of the total number of patients (8.8%).

The incidence rate of work-related asthma by industry type ranges from 0.2 cases per 100,000 in finance, insurance & real estate to a high of 20.6 cases per 100,000 in the manufacture of transportation equipment. The industries with the highest annual average incidence rates besides the manufacture of transportation equipment included: foundries with 13.6 cases per 100,000 workers; the manufacture of rubber products with 11.1 cases per 100,000 workers; the manufacture of other nondurables with 11.6 cases per 100,000 workers; and education with 11.7 cases per 100,000

workers.

Table 5 shows the annual incidence rates for the 1990 through 1997 work-related cases within those industries which had 20 or more reports.

Overall, by broad industrial classification, there were: 13.2 cases per 100,000 workers in the manufacturing industry; 3.1 cases per 100,000 workers in the construction and mining industry; and 0.9 cases per 100,000 workers in the service producing industry.

Table 6 shows the predominant exposures causing work-related asthma in Michigan. The most frequent exposures were to isocyanates (18.5%), metal working fluids (12.2%), vehicle exhaust (5.3%), welding fumes (4.7%), and solvents (3.0%). The agent has not yet been identified for 208 patients (13.9%). The exposures to unknown agents occurred 117 times in the manufacturing sector and 91 times in an office setting.

Medical Results

Table 7 shows patients' cigarette smoking status. Almost 20% of patients were smoking when their work-related asthma developed. This is a lower percentage than the state average and markedly lower than that found in a blue collar working population.

Over forty percent of the work-related asthma patients had a family history of allergies (Table 8).

Forty-five percent of the asthma patients had a personal history of allergies or asthma (Table 9). Two hundred eighty-two (41.9%) of the 674 patients with a personal history of allergies or asthma previously had asthma.

One thousand two hundred fourteen of the patients identified with work-related asthma had persistence of their asthma symptoms (Table 10). This was true for 409 of 429 (95.3%) of those still exposed as well as 805 of 969 (83.1%) no longer exposed to the substance causing their asthma. Among those no longer exposed, 50.2% stated their symptoms were less severe compared to 34.5% among those still exposed who reported their symptoms were less severe. Similarly, 84.4% of those still exposed were continuing to take asthma medications while 76.1% of those no longer exposed were still taking asthma medications. Among those no longer exposed, 30.1% stated they were taking fewer medications while only 21.4% of those still exposed were taking fewer medications (Table 10).

Six hundred fifty of 1,373 (47.3%) patients with known workers' compensation status had applied for workers' compensation. Cases were pending for 318 (48.9%) of those who applied, while 234 (36.0%) had received awards and 98 (15.1%) had been denied.

Although 1,497 individuals were confirmed with work-related asthma, we could find objective testing for hyper-reactivity in only 65% and peak flow monitoring or pre/post work shift testing in

an even smaller percentage (6%).

Industrial Hygiene

The 1,497 people with work-related asthma worked at 1,009 different facilities. Inspections were performed at 475 (45.2%) of these facilities. Forty-five inspections were completed since last year's report. Inspections are scheduled at 6 (0.6%) facilities (Table 11). In addition, because of inadequate resources to conduct inspections at all the identified facilities, 56 facilities received letters notifying them that a disease report had been received and asked them to investigate potential exposures causing the respiratory problem, including indoor air problems.

Air sampling for allergens was conducted during 325 of the inspections. Forty-two of the 325 (12.9%) facilities were above the National Institute for Occupational Safety and Health recommended exposure limit (REL). Twenty-one of the 325 (6.5%) were above the enforceable Michigan Occupational Safety and Health Act (MIOSHA) permissible exposure limit (PEL) (Table 12).

Interviews of fellow workers were performed at 361 of the 475 inspections. Workers had daily or weekly breathing symptoms or onset of new asthma since beginning to work at that company in 257 of the 361 (71.2%) companies. The average percentage of workers with symptoms in these 257 companies was 21.3%, ranging from 2% to 100%. Interviews conducted in 104 companies found no co-workers with symptoms. One thousand two hundred and seven of the 6,920 (17.4%) fellow workers interviewed had symptoms consistent with occupational asthma (new onset asthma or bothered at work by daily or weekly shortness of breath, wheezing or chest tightness) (Table 13).

Four hundred seventeen workers from 78 companies were listed by employers on the Occupational Safety and Health Administration (OSHA) Injury and Illness log as having asthma or asthma-like symptoms. Eight workers had both daily or weekly breathing symptoms and were listed on the OSHA log. Therefore, a total of 1,616 symptomatic workers were identified during the 475 inspections.

Comparison of Work-Related Asthma in Michigan with Other Geographic Areas

The annual rate of 3.4 cases per 100,000 received in the Michigan surveillance system is similar to the rates reported in other surveillance systems. In England the rates reported vary from 2.0 to 4.3 cases per 100,000 with rates as high as 6.3 per 100,000 reported in some regions (13-15). Similarly in Michigan there is regional variation with rates in some counties as high as 21.7 cases per 100,000 (Table 2). Reported rates in specific occupations in England have ranged as high as 65.0 cases per 100,000 (15). The system in England is voluntary, and is based only on reports received from pulmonary and occupational physicians (16). This differs from Michigan's surveillance system which is mandatory and covers physicians of all specialties. In Michigan 54% of the reports are from occupational and pulmonary physicians, 7% are from allergists and the remaining 38% are from other specialties. Finland has a national mandatory reporting system that is connected with their workers' compensation system; their reported rate is 15.2 cases per 100,000 (17). Isocyanates are typically

the most common cause of work-related asthma reported in other surveillance systems (16,18). However, since farmers were included in the workers' compensation system in Finland, cow dander has become the most commonly reported allergen in that country (19).

A more recent report from a study performed at an HMO in Massachusetts estimated the annual rate of work-related asthma at 71.0 cases per 100,000 (20). Possible reasons for this much higher rate reported in the study from Massachusetts include 1) less restrictive case criteria in the HMO study; 2) more intense case-findings in the HMO study; 3) increasing incidence of work-related asthma between the time of the more recent HMO study and previous studies; and 4) the fact that the annual estimates from the HMO study were extrapolated from cases identified during the 3 month period of July, August, and September.

Isocyanates

Isocyanates remain the most common cause of work-related asthma in Michigan. During this past year as the state considered expanding the isocyanate standard we evaluated the 261 reports on isocyanate related asthma that had been received at that time. The type of isocyanates reported are in Table 14. Although MDI is less volatile and therefore considered less hazardous we find more symptomatic individuals among fellow workers of the index patient are from MDI using facilities than the TDI or HDI using facilities (Table 15). The industries where isocyanates were used are shown in Table 16. We compared inspections initiated because of a patient report to inspections where we had received patient reports of work-related asthma but the inspection had already been initiated because of an employee complaint to inspections initiated because of an employee complaint and no work-related asthma patient report had been received (See Table 17). Employee complaint-initiated inspections were more likely to uncover companies above the allowable isocyanate air standard although this occurred only 13% of the time in those companies.

Among companies inspected where there was an initial patient report of work-related asthma, companies where spills of isocyanates had occurred were more likely to have co-workers with breathing symptoms who worked in the same area of exposure as the patient initially reported (Table 18). Spills may account for some of the cases of work- related asthma even when the 8 hour time weighted average air levels are below the standard on the day of the inspection.

The Michigan Department of Consumer and Industry Services has a pilot project with a small number of isocyanate using companies evaluating whether an expanded education and training program of workers can reduce work-related asthma.

Discussion:

In our previous annual reports, we have emphasized the fact that the cases reported in Michigan's surveillance system are likely an underestimation of the true number of cases of work-related asthma in the state. This continues to be true. Studies suggest that work exposures are important etiologic agents in a significant percentage (20% or greater) of adults with asthma (3-10,20).

An average of 148 new people each year are reported to the Michigan Department of Consumer and Industry Services (MDCIS) with confirmed work-related asthma. National estimates would indicate that there are a total of 4,600 - 34,500 adults with work-related asthma in the state (3-10). A Michigan study predicts possibly 6,900 - 59,800 adults whose work contributed to the development of their asthma (5). Using capture-recapture analysis we estimate 228-801 adults in Michigan develop work-related asthma each year(21).

As we found in our previous annual reports on work-related asthma in Michigan, the workers reported are generally young to middle age white men and women, with the greatest number being reported from the Detroit metropolitan area. However, the rate of work-related asthma in African Americans is 2.2 times greater than among whites. The people typically develop their asthma from work in the manufacturing sector, particularly automobiles, machinery, metals, chemicals, and rubber and plastics. The predominant causes of work-related asthma remain isocyanates and metal-working fluids.

Asthma symptoms persist despite removal from the precipitating work exposures (Table 10). Studies have shown that the sooner an individual is removed from exposure causing their asthma after symptoms develop the more likely the individual's symptoms will resolve. On the average among the 969 individuals no longer exposed 2.5 years elapse from time of onset of respiratory symptoms at work to date last exposed. We do not have data on how much of this delay is secondary to the individual not seeking medical care and how much to the physician not recommending the individual cease exposure.

Neither personal habits such as cigarette smoking nor individual susceptibility as measured by personal or family history of allergies are predictive of who will develop work-related asthma. Approximately 50% of the asthma patients have no personal or family history of allergies and 80% are not smoking cigarettes at the time their asthma symptoms develop (Tables 7-9).

Although most facilities where the patient developed asthma were not in violation of exposure standards, there were high percentages of symptomatic fellow workers in facilities using occupational allergens. We identified 1,207 fellow workers with symptoms compatible with work-related asthma. Four hundred seventeen individuals were listed on the OSHA log as having work-related asthma. There was only an overlap of 8 individuals. Half of the symptomatic individuals indicate they have never seen a doctor for their respiratory symptoms. This indicates the need for more companies to implement medical surveillance programs. The high percentages of symptomatic individuals are consistent with estimates of the prevalence of work-related asthma in the state. The presence of symptomatic co-workers suggests that some of the occupational health standards are not sufficiently protective to ensure a safe workplace.

Reevaluations of allowable exposure standards are needed. These reevaluations should consider comprehensive workplace controls which address not only daily average exposures but exposures during spills and leaks and provision of medical surveillance for potentially exposed workers. Medical monitoring is particularly relevant to reducing the burden of work-related causes of asthma. The longer a person with symptoms remains exposed, the more likely their asthma will become a chronic problem (22). The percentages of individuals reported with work-related asthma who we could document as having had breathing tests performed in relation to work is less than 10%. This reflects the standard of medical care in the United States where the diagnosis of work-related asthma is made from patient history. More frequent use of objective pulmonary function testing performed in relation to work would allow health care providers to feel more confident about advising their patients to cease their exposure. Cessation of exposure is the most important aspect of treatment of work-related asthma. Patients who are removed from exposure the soonest have the best prognosis (22).

The Michigan Department of Community Health is preparing a planning document for a new effort to reduce Michigan's asthma burden, the Michigan Asthma Strategic Planning Initiative. The planning document is scheduled to be completed in the Fall of 2000. Work-related asthma needs to be integrated into new overall asthma initiatives planned on surveillance and education, both for health care providers and the public.

The report of a patient with known or suspected work-related asthma is a sentinel health event that is critical to effective occupational disease surveillance. Case reporting from physicians offers the opportunity for the most timely workplace interventions, compared to receiving reports from hospitals. With continued support and increasing awareness of work-related asthma by physicians and other health professionals, we can continue to provide timely intervention in the workplace, offer suggestions for reducing workplace exposures even if they are below current permissible levels, suggest the need for the development of new standards, identify new occupational allergens and prevent co-workers from developing disease.

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Figure 1. Number of Confirmed Cases of Work-Related Asthma by Year and Type

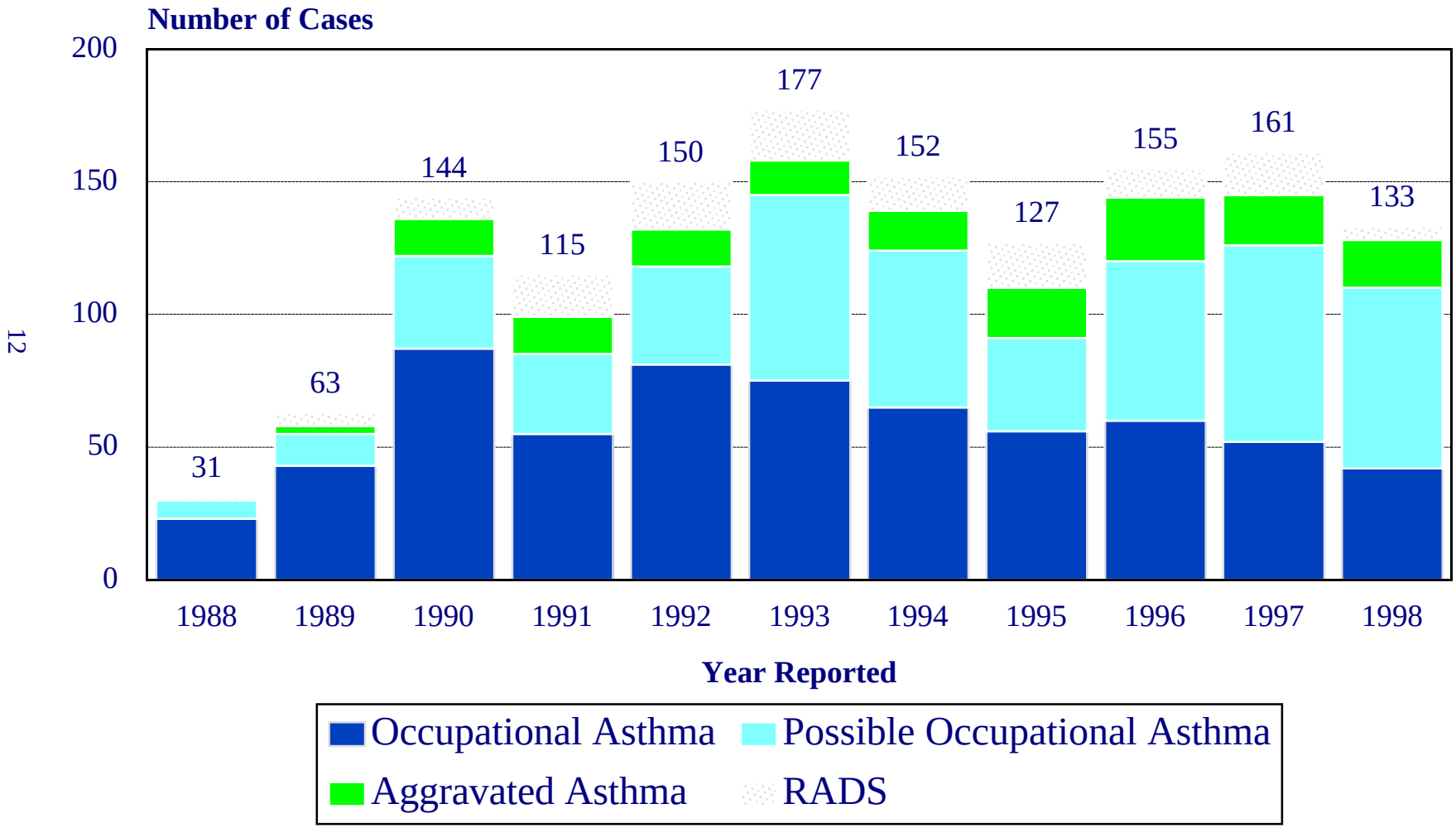
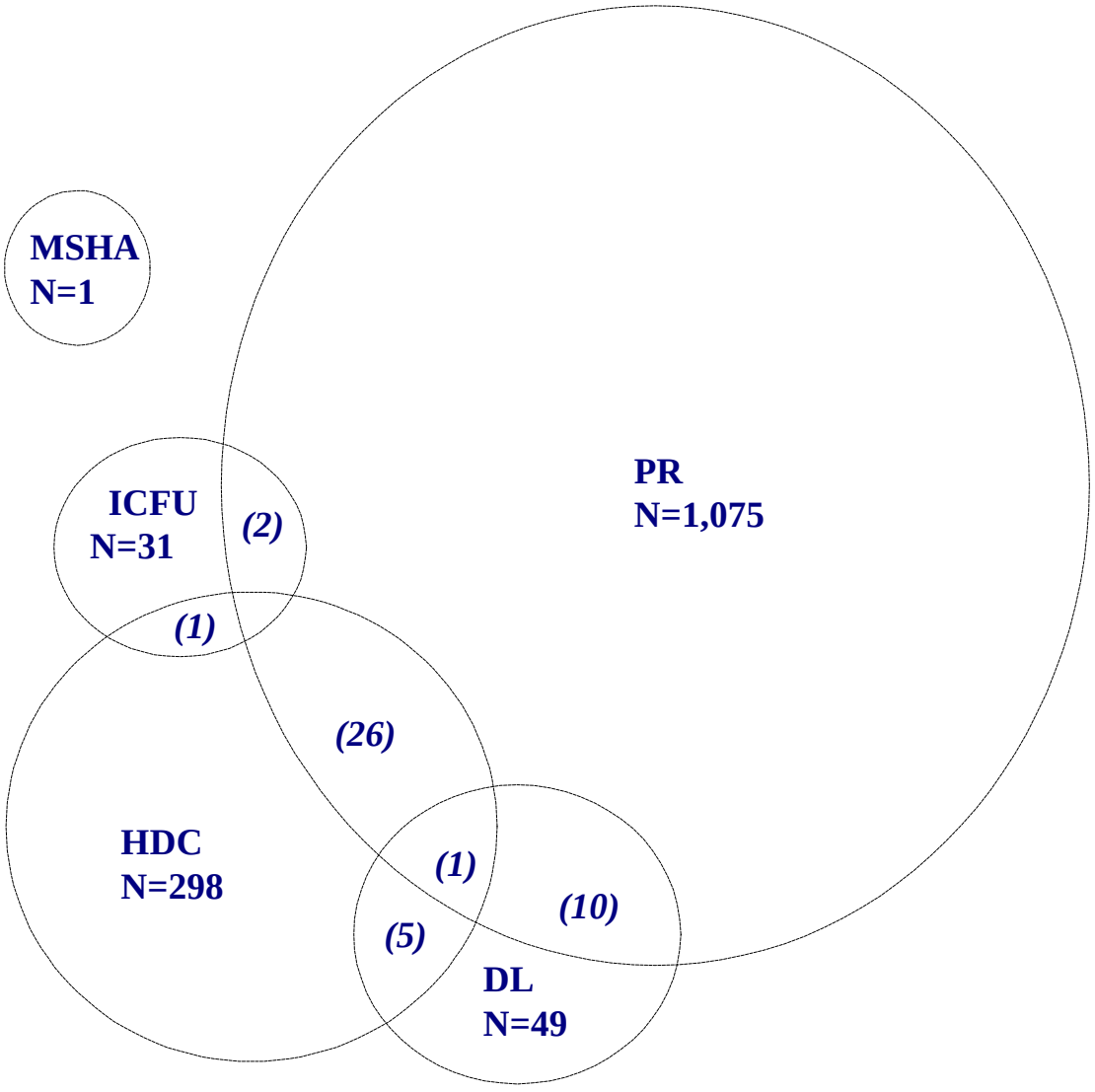
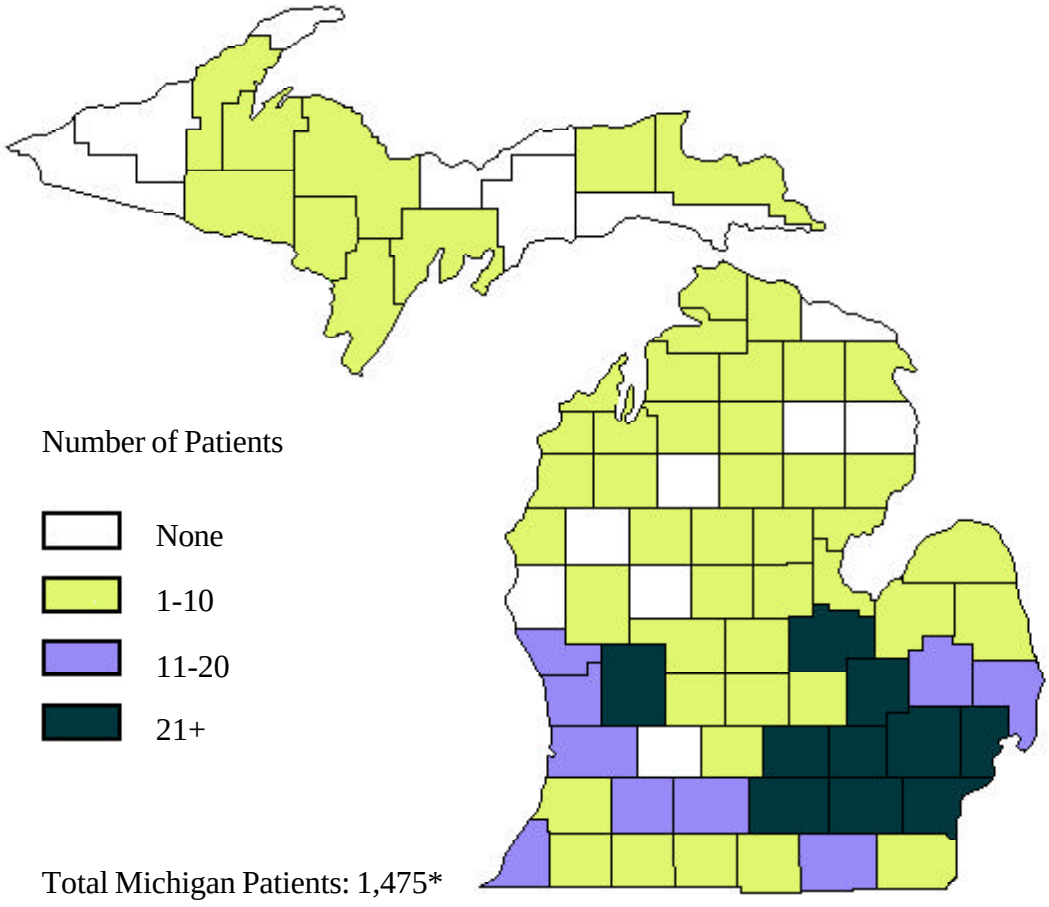


Figure 2. Overlap of Reporting Sources for Confirmed Work-Related Asthma Patients: 1988-1998*



*** Diagram represents 1,408 individuals initially reported from 1988-1998.**
N's represent the total number for that source. Numbers in parentheses represent the overlap of reporting sources.
Reporting Source Codes: HDC=Hospital Discharge Data; PR=Physician Referral; DL=Department of Labor; ICFU=Index Case Follow-Up; MSHA=Mine Safety and Health Administration.

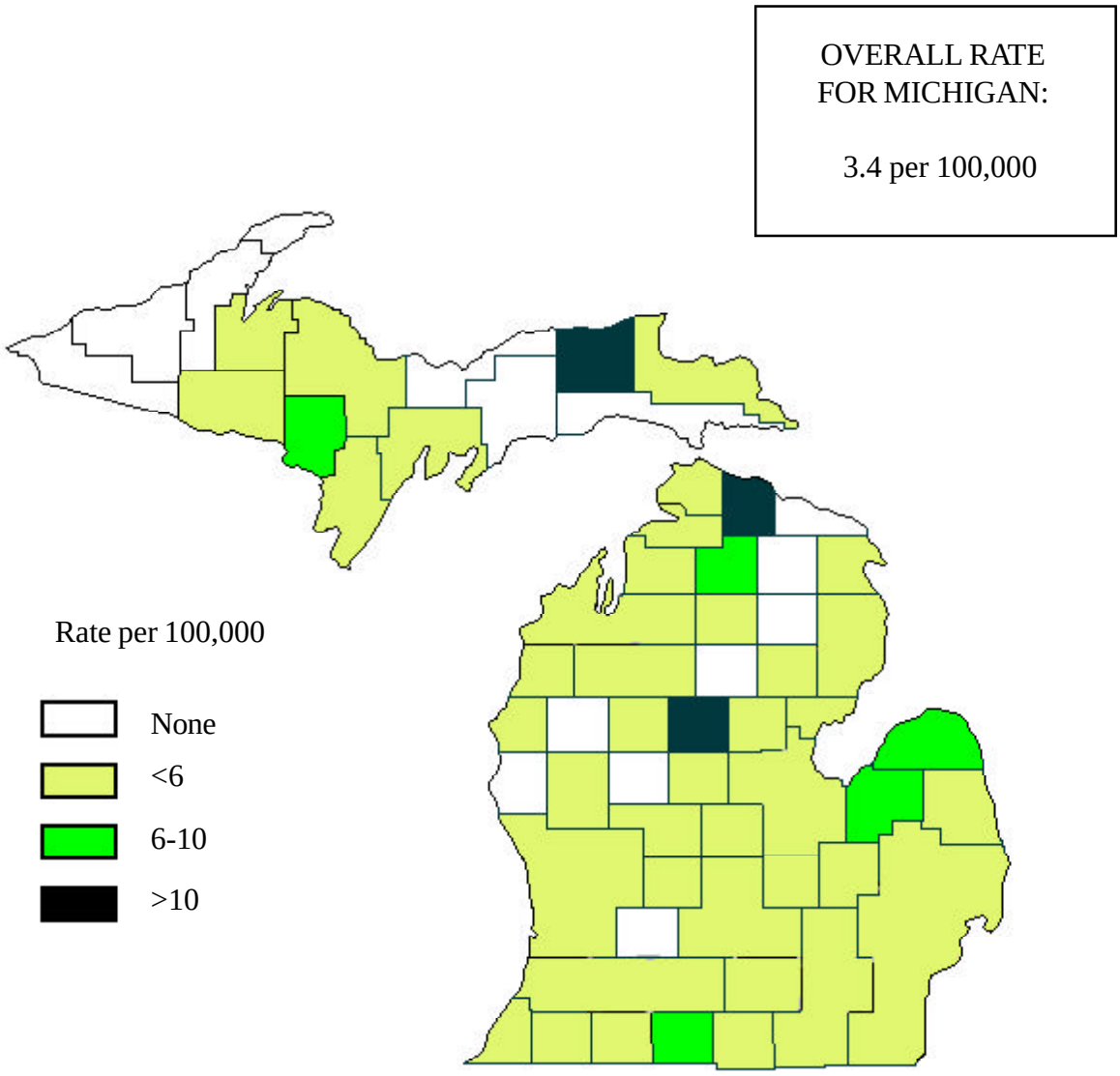
Figure 3. Distribution of Confirmed Work-Related Asthma Patients by County of Exposure: 1988-1999



Oakland and **Wayne** counties had the highest number of work-related asthma patients, with 198 and 409 individuals, respectively.

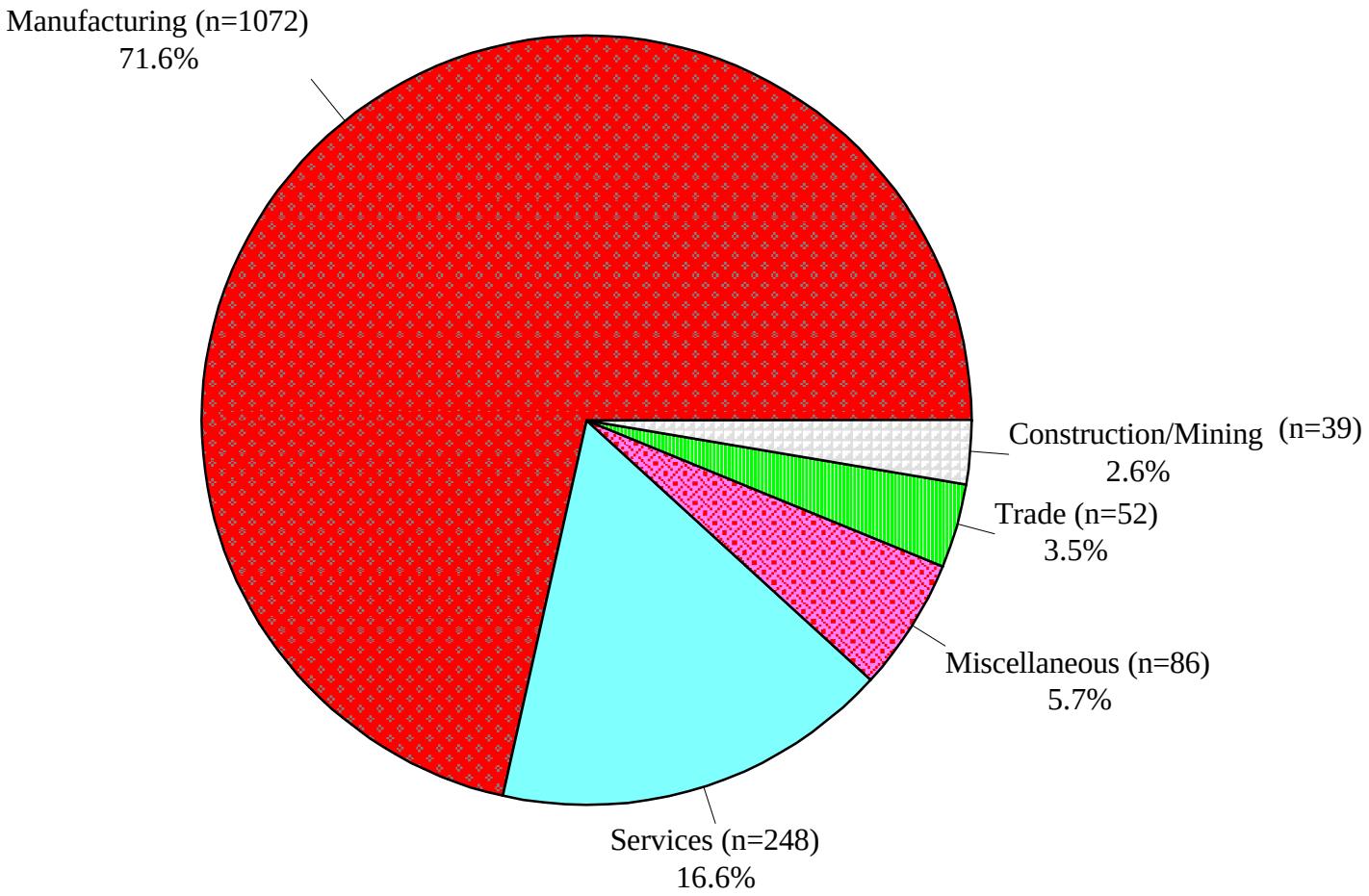
*County of exposure was unknown for 7 patients. Fifteen patients were exposed to an allergen out-of-state.

Figure 4. Average Annual Incidence Rates of Work-Related Asthma Among Michigan Workers by County of Exposure: 1989-1997*



*Rate per 100,000 among Michigan workers. Source: MESC 1993 Annual Average Labor Statistics for Employment by Place of Work. In 1993, there were a total of 3,982,000 Michigan workers.

Figure 5. Major Industry Type for Confirmed Work-Related Asthma Patients: 1988-1999*



*Number of patients in parentheses, percent below.

Table 1. Number of Confirmed Cases of Work-Related Asthma by Year and Type

	Disease Status*				
Year	**OA**	**POA**	**AA**	**RA**	**TOTAL**
1988	23	7	0	1	31
1989	43	12	3	5	63
1990	87	35	14	8	144
1991	55	30	14	16	115
1992	81	37	14	18	150
1993	75	70	13	19	177
1994	65	59	15	13	152
1995	56	35	19	17	127
1996	60	60	24	11	155
1997	52	74	19	16	161
1998	42	68	18	5	133
1999	38	41	7	3	89
Total	677	528	160	132	1497

*OA = occupational asthma; POA = possible occupational asthma; AA = aggravated asthma; RA = reactive airway dysfunction syndrome.

Table 2. Average Annual Incidence Rates of Work-Related Asthma Among Michigan Workers by County of Exposure: 1989-1997

County	Number Of Employees*	Avg. Ann. Inc. Rate**	Total # Cases 1989-1997
Alcona and Iosco (0, 2 cases respectively)	9,750	2.3	(2)
Alpena	11,925	2.8	(3)
Antrim	4,900	4.5	(2)
Arenac	4,175	5.3	(2)
Baraga	2,975	3.7	(1)
Berrien	67,100	2.6	(16)
Branch	11,900	6.5	(7)
Cass	10,000	3.3	(3)
Charlevoix	9,075	3.7	(3)
Cheboygan	6,725	13.2	(8)
Chippewa	13,825	2.4	(3)
Clare	7,150	10.9	(7)
Clinton-Eaton-Ingham (3, 9, 37 cases respectively)	213,700	2.5	(49)
Crawford	4,475	5.0	(2)
Delta	13,825	1.6	(2)
Dickinson	12,925	6.9	(8)
Emmet	13,550	0.8	(1)
Genessee	164,400	5.6	(83)
Gladwin	4,475	2.5	(1)
Grand Traverse-Benzie-Kalkaska-Leelanau (7, 2, 4, 2 cases respectively)	51,525	3.2	(15)
Gratiot	13,475	2.5	(3)
Hillsdale	13,925	5.6	(7)
Huron	11,325	6.9	(7)
Ionia	14,875	4.5	(6)
Iron	3,800	2.9	(1)
Isabella	21,675	1.0	(2)
Jackson	55,200	4.6	(23)
Kalamazoo-Calhoun -VanBuren (12,12,3 cases respectively)	195,400	1.5	(27)
Kent-Ottawa-Muskegon -Allegan (32, 11, 13, 10 cases respectively)	464,800	1.6	(66)
Luce	2,050	21.7	(4)
Manistee	6,850	1.6	(1)
Marquette	28,250	2.0	(5)
Mason	9,850	1.1	(1)
Menominee	8,825	1.3	(1)
Montcalm	17,375	5.1	(8)
Newaygo	9,300	2.4	(2)
Ogemaw	5,575	2.0	(1)
Osceola	7,050	3.2	(2)
Otsego	8,850	6.3	(5)
Sanilac	11,400	4.9	(5)
Shiawassee	18,875	2.4	(4)
St. Joseph	22,000	2.0	(4)
Tuscola	13,250	6.7	(8)
Washtenaw-Lenawee-Livingston (78, 12, 19 cases respectively)	244,700	4.9	(109)
Wexford-Missaukee (3, 0 cases respectively)	15,300	2.2	(3)
Saginaw-Bay-Midland (30, 10, 5 cases respectively)	164,600	3.0	(45)
Detroit MSA***	1,877,000	3.9	(659)
Out of State	--	--	(12)
Unknown	--	--	(5)
All Michigan Counties	**3,982,000**	**3.4**	**(1227)**

*Source: MESC 1993 Annual Average Labor Statistics for Employment by Place of Work. Some employee population data is only available at a multi-county level, as indicated (i.e. not available at a single county level). Therefore, some data is presented with grouped counties. **Rates are based on the average number of cases per year from 1989-1997, per 100,000 Michigan workers. ***MSA = Metropolitan Statistical Area and includes Lapeer (15 cases), Macomb (124 cases), Monroe (9 cases),

Table 3. Annual Incidence Rates of Work-Related Asthma Among Michigan Workers by Major Metropolitan Area: 1990-1997

	Clinton-Eaton-Ingham	Kent-Ottawa-Muskegon-Allegan	Saginaw-Bay-Midland	Detroit MSA**	Total (all Michigan)
1990	1.4 (3)	2.2 (8)	2.4 (4)	3.0 (58)	3.6 (144)
1991	3.8 (8)	1.4 (5)	4.3 (7)	2.7 (50)	2.9 (114)
1992	5.6 (12)	0.7 (3)	1.8 (3)	4.6 (86)	3.8 (150)
1993	3.7 (8)	1.3 (6)	1.8 (4)	6.4 (121)	4.4 (176)
1994	1.8 (4)	3.5 (7)	1.8 (3)	4.4 (85)	3.7 (152)
1995	2.2 (5)	1.2 (6)	1.7 (3)	3.4 (69)	2.9 (122)
1996	1.3 (3)	0.9 (5)	2.9 (5)	4.0 (91)	3.4 (149)
1997	2.2 (5)	1.1 (6)	4.5 (8)	3.7 (77)	3.5 (156)

*Rate per 100,000 Michigan workers. Rate, number of cases in parentheses.

Source: MESC Annual Average Labor Statistics for Employment by Place of Work, for each year 1990-1997 separately.

**MSA=Metropolitan Statistical Area. For the years 1990-1995,includes Lapeer, Livingston, Macomb, Monroe, Oakland, St. Clair, and Wayne counties. For 1996 and 1997, does not include Livingston county because of a change in the counties associated with certain MSA's (including Detroit), beginning in 1996.

Table 4. Primary Industrial Exposure for Confirmed Work-Related Asthma Patients: 1988-1999

Industry (SIC Code)*	Number of Cases (1988-1999)**		Number of Employees***	Ann. Average Inc. Rate**** 1989-1997	
MANUFACTURING (20-39)					
Automobile (37)	647	(43.2)	279,000	20.6	(518)
Ind. & Comm. Mach. & Computer Equipment (35)	58	(3.9)	117,000	4.9	(52)
Fabricated Metal Products (34)	69	(4.6)	116,000	5.8	(61)
Rubber and Misc. Plastic Products (30)	63	(4.2)	55,000	11.1	(55)
Foundries (33)	48	(3.2)	36,000	13.6	(44)
Food and Kindred Products (20)	28	(1.9)	44,000	6.6	(26)
Printing and Publishing (27)	13	(0.9)	45,000	3.2	(13)
Paper and Allied Products (26)	13	(0.9)	21,000	6.9	(13)
Lumber and Wood (24)	15	(1.0)	15,000	8.9	(12)
Electrical Equipment (36)	13	(0.9)	30,000	4.1	(11)
Furniture and Fixtures (25)	7	(0.5)	34,000	1.6	(5)
Apparel Made from Fabric (23)	2	(0.1)	18,000	1.2	(2)
Other Durables (32,38,39)	32	(2.1)	41,000	7.6	(28)
Other Nondurables (22,28,29,31)	64	(4.3)	50,000	11.6	(52)
WHOLESALE AND RETAIL TRADE (50-59)					
Wholesale-Nondurable Goods (51)	11	(0.7)	72,000	1.5	(10)
Food Stores (54)	11	(0.7)	101,000	1.1	(10)
Eating and Drinking Places (58)	7	(0.5)	262,000	0.3	(7)
Wholesale-Durable Goods (50)	11	(0.7)	125,000	1.0	(11)
Automotive Dealers and Gasoline Services (55)	5	(0.3)	76,000	0.4	(3)
General Merchandise Stores (53)	4	(0.3)	120,000	0.3	(3)
Miscellaneous Retail (52,57,59)	3	(0.2)	141,000	0.1	(1)
SERVICES					
Health (80)	132	(8.8)	331,000	3.3	(97)
Education (82)	46	(3.1)	38,000	11.7	(40)
Automotive Repair (75)	10	(0.7)	34,000	2.3	(7)
Business (73)	12	(0.8)	203,000	0.6	(11)
Social Services (83)	7	(0.5)	74,000	1.1	(7)
Engineering, Accounting, etc. (87)	6	(0.4)	83,000	0.7	(5)
Other Services (70,72,76,79,81,86,89)	35	(2.3)	254,000	1.4	(32)
CONSTRUCTION AND MINING (10-17)					
Special Trade Construction (17)	26	(1.7)	89,000	2.7	(22)
Other Construction (15-16)	9	(0.6)	43,000	2.3	(9)
Mining (10-14)	4	(0.3)	9,000	4.9	(4)
MISCELLANEOUS INDUSTRIES					
Government (91-97)	49	(3.3)	640,000	0.7	(42)
Transportation and Utilities (40-49)	25	(1.7)	156,000	1.6	(23)
Finance, Insurance and Real Estate (60-67)	7	(0.5)	192,000	0.2	(4)
Agricultural Production and Services (01,02,07)	3	(0.2)	90,000	0.4	(3)
Unknown	2	(0.1)	–	–	(1)
TOTAL	**1497**	**(100.1)*****	**3,982,000**	**3.5**	**(1243)**

*Standard Industrial Classification.
**Number of cases, percentages are in parentheses.
***Source:MESC 1993 civilian labor force and industrial employment estimates.
****Average annual incidence rate, total number of cases for 1989-1997 are in parentheses. Rates are based on average number of cases from 1989-1997 per 100,000 adult workers in each industrial category.

Table 5. Primary Industrial Exposure for Confirmed Work-Related Asthma Patients: 1990-1997

Industry (SIC code*)	1990**	1991	1992	1993	1994	1995	1996	1997
Manufacturing (20-39)								
Food & Kindred Products (20)	20.0 (9)	6.7 (3)	2.3 (1)	-- (0)	2.3 (1)	4.4 (2)	6.8 (3)	4.9 (2)
Chemicals & Allied Product & Petroleum Refining (28,29)	17.0 (8)	4.3 (2)	14.0 (7)	12.0 (6)	7.8 (4)	14.3 (7)	*** (3)	*** (7)
Rubber & Misc. Plastic Products (30)	9.3 (5)	19.6 (10)	-- (0)	7.3 (4)	11.3 (7)	15.1 (10)	10.4 (7)	13.2 (9)
Foundries (33)	9.5 (4)	23.7 (9)	8.1 (3)	19.4 (7)	18.9 (7)	5.4 (2)	18.9 (7)	8.1 (3)
Fabricated Metal Products (34)	6.6 (8)	4.4 (5)	2.6 (3)	3.4 (4)	5.7 (7)	3.1 (4)	12.5 (16)	8.6 (11)
Industrial & Commercial Machinery & Computer Equipment (35)	6.3 (8)	1.7 (2)	6.1 (7)	8.5 (10)	6.6 (8)	3.0 (4)	3.0 (4)	2.2 (3)
Automobile (37)	19.0 (56)	15.6 (44)	28.7 (82)	26.5 (74)	25.0 (71)	17.3 (51)	21.1 (59)	21.1(61)
Other Durables (38,39)	19.2 (5)	8.0 (2)	4.9 (2)	9.8 (4)	-- (0)	-- (0)	6.7 (3)	4.4 (2)
Miscellaneous Industries								
Special Trade Construction (17)	1.1 (1)	2.3 (2)	4.6 (4)	6.7 (6)	3.2 (3)	0.9 (1)	1.7 (2)	0.8 (1)
Transportation & Utilities (40-49)	0.6 (1)	1.3 (2)	1.9 (3)	4.5 (7)	2.5 (4)	1.2 (2)	– (0)	0.6 (1)
Health (80)	1.6 (5)	1.9 (6)	3.4 (11)	3.6 (12)	3.8 (13)	3.7 (13)	3.3 (12)	6.3 (23)
Education (82)	5.4 (2)	5.3 (2)	8.1 (3)	21.1 (8)	7.7 (3)	10.2 (4)	18.6 (8)	20.5 (9)
Government (91-97)	8.1 (5)	6.6 (4)	7.9 (5)	14.3 (9)	6.3 (4)	1.1 (7)	0.8 (5)	0.5 (3)
Total (all industries)	3.4 (144)	2.8 (114)	3.5 (150)	4.0 (176)	3.4 (152)	3.0 (127)	3.3 (152)	3.2 (161)

*Standard Industrial Classification.

**Annual Incidence rate; number of cases for that year are in parentheses.
Rates are based on the number of cases per 100,000 adult workers in Michigan for each year separately. Source: MESC Annual Average civilian labor force and industrial employment estimates.

***Denominator not available in 1996 and 1997.

Table 6. Occupational Allergens Identified for 1497 Confirmed Work-Related Asthma Patients: 1988-1999

Allergen	Number	Percent
Isocyanates	277	18.5
Metal-Working Fluids	182	12.2
Unknown (Mfg.)	117	7.8
Unknown (Office)	91	6.1
Exhaust, Smoke, Fumes	79	5.3
Cleaning Solutions	74	4.9
Welding Fumes	71	4.7
Solvent	45	3.0
Latex/Rubber	42	2.8
Formaldehyde	38	2.5
Epoxy	37	2.5
Paint Fumes	31	2.1
Acrylates	30	2.0
Acids	26	1.7
Chlorine	26	1.7
Styrene	20	1.3
Cobalt	20	1.3
Wood Dust	18	1.2
Plastic Fumes	14	0.9
Flour	12	0.8
Ammonia	12	0.8
Chromium	11	0.7
Herbicide, Pesticide	11	0.7
Printing Inks	11	0.7
Amines	9	0.6
Caustics	8	0.5
Grain Dust	7	0.5
Animals	7	0.5
Fiberglass	7	0.5
Pickling Ingredients	6	0.4
Meat Wrappers' Asthma	5	0.3
Cement Dust	5	0.3
Rose Hips	4	0.3
Sulfonate	4	0.3
Sulfur Dioxide	4	0.3
1,1,1 Trichloroethane	4	0.3
Cosmetology Chemicals	4	0.3
Colophony	3	0.2
Nitrogen	3	0.2
Photo Developing Fluids	3	0.2
Phthalic Anhydride	3	0.2
Glutaraldehyde	3	0.2
Cadmium Solder	2	0.1
Enzymes	2	0.1
Nickel	2	0.1
Other*	107	7.1
Total	**1497**	**99.7****

*Includes: x-ray developing fluids, chemicals used in the construction industry, freon, sulfite, gas and oil refinery exposures, maleic anhydride, solder fumes, vinyl acetate, ozone, zinc, textile lint, 1,3, dichloro-2-propanol, pepper gas, exercise, weeds, soda ash, asbestos, limone, coal dust, ethylene oxide, trichloroethylene, iodine, polyvinyl butyrate, lime dust, polyester, MEK, nylon-polyhexamethylene adipamide, potassium aluminum fluoride, ammonium hydroxide, methanol, naptha, drywall dust, paper dust, zinc oxide, methylene chloride, ethylene glycol monobutyl ether, sewage, tar fumes, monoammonium phosphate, potassium hydroxide, ethyl alcohol, heptane, stress, sodium hydroxide, platinum, phosgene, cyanide, heat, polyethylene, perchloroethylene, hydraulic oil, blood, 1,3 dichloro 5 5-dimethyl hydrantoin, ninhydrin,cigarette smoke, azodicarbamide, lactase, medications, sodium acetate, cellulose, glaze, sulfuric acid, aspirin, tetrahydrofuran, zinc borate, leather, rust inhibitor, citrus spray, mold release, sand, hydrogen sulfide, teflon and flux.

Table 7. Cigarette Smoking Status of Confirmed Work-Related Asthma Patients: 1988-1999

	Disease Status				
Smoking Status	**ALL***	**OA****	**POA**	**AA**	**RA**
Current Smoker	287 (19.7)	149 (22.4)	80 (15.5)	31 (20.8)	27 (20.9)
Ex-Smoker	607 (41.6)	266 (39.9)	230 (44.7)	50 (33.6)	61 (47.3)
Non-Smoker	565 (38.7)	251 (37.7)	205 (39.8)	68 (45.6)	41 (31.8)
Total	**1459**	**666**	**515**	**149**	**129**

*Total number of cases: 1459. Smoking status was missing on 38 individuals.
Number of patients, percentages are in parentheses.
**OA=occupational asthma; POA=possible occupational asthma; AA=aggravated asthma;
RA=reactive airway dysfunction syndrome.

Table 8. Family History of Allergies Among Confirmed Work-Related Asthma Patients: 1988-1999

	Disease Status				
Family History of Allergies	**ALL***	**OA****	**POA**	**AA**	**RA**
YES	559 (41.6)	238 (38.6)	200 (41.6)	74 (58.3)	47 (39.8)
NO	784 (58.4)	379 (61.4)	281 (58.4)	53 (41.7)	71 (60.2)
Total	**1343**	**617**	**481**	**127**	**118**

*Total number of cases: 1343. Missing data on 154 patients. Number of patients, percentages are in parentheses.
**OA=occupational asthma; POA=possible occupational asthma; AA=aggravated asthma; RA=reactive airway dysfunction syndrome.

Table 9. Personal History of Allergies or Asthma Among Confirmed Work-Related Asthma Patients: 1988-1999

	Disease Status				
Personal History	**ALL***	**OA****	**POA**	**AA**	**RA**
YES	674 (45.0)	267 (39.4)	217 (41.1)	146 (91.3)	44 (33.3)
NO	823 (55.0)	410 (60.6)	311 (58.9)	14 (8.8)	88 (66.7)
Total	**1497**	**677**	**528**	**160**	**132**

*Number of patients, percentages are in parentheses.
**OA=occupational asthma; POA=possible occupational asthma; AA=aggravated asthma; RA=reactive airway dysfunction syndrome.

Table 10. Persistence of Symptoms and Medication Use in Confirmed Work-Related Asthma Patients: 1988-1999

Exposure Status	Total*	Symptoms		Asthma Medications	
		Yes	Less	Yes	Less
Still Exposed	429	409 (95.3)	148 (34.5)	362 (84.4)	92 (21.4)
No Longer Exposed	969	805 (83.1)	486 (50.2)	737 (76.1)	292 (30.1)
Total	**1398**	**1214**	**634**	**1099**	**384**

*Total number of cases: 1398. Information missing on 99 individuals. Number of patients, percentages are in parentheses.

Table 11. Status of Facilities Where 1497 Patients with Confirmed Work-Related Asthma were Exposed to Allergens: 1988-1999

Inspection Status	Number of Patients Represented	Number	Percent
Inspections	816	475*	45.2
No Follow-up Planned	562	465	44.2
Scheduled for Inspection	6	6	0.6
Closed	31	29	2.8
No Longer Use Occupational Allergen	23	21**	2.0
Sent Company an Indoor Air Letter	15	13	1.2
Sent Company a Letter to Check Exposures	44	43	4.1
Total	**1497**	**1052*** **	**100.1**** **

*475 inspections were conducted in 432 different facilities.
**Five companies that no longer use the allergen were previously inspected.
***Represents 1,009 different facilities.
****Percent does not add to 100 due to rounding.

Table 12. Results of 475 Industrial Hygiene Inspections in 432 Facilities Where Patients with Confirmed Work-Related Asthma were Exposed to Allergens: 1988-1999

Inspection Results	Number	Percent
Air Sampling - NIOSH Standard		
Above NIOSH Standard	42	8.8
Below NIOSH Standard	276	58.1
No NIOSH Standard	7	1.5
Unknown (no report yet)	15	3.2
Did Not Sample for an Allergen	9	1.9
Did Not Sample	126	26.5
Total	**475**	**100.0**
Air Sampling - MIOSHA Standard		
Above MIOSHA Standard	21	4.4
Below MIOSHA Standard	303	63.8
No MIOSHA Standard	2	0.4
Unknown (no report yet)	15	3.2
Did Not Sample for an Allergen	8	1.7
Did Not Sample	126	26.5
Total	**475**	**100.0**

Table 13. Symptoms Consistent with Work-Related Asthma Among Fellow Workers of the 1497 Confirmed Work-Related Asthma Patients

	Disease Status of Index Patient				
Symptoms*	**ALL****	**OA**	**POA**	**AA**	**RA**
Daily or Weekly SOB, Wheezing or Chest Tightness	1207 (17.4)	910 (17.8)	262 (16.9)	4 (16.0)	31 (13.5)
OSHA Log***	417 (16.4)	314 (20.4)	92 (9.3)	2 (14.3)	9 (11.1)
Total	**1624********	**1224*****	**354**	**6**	**40**

*Denominator for calculating percentages was the number of workers interviewed. SOB=shortness of breath.

**Number of individuals with symptoms, percentages are in parentheses. OA=occupational asthma; POA=possible occupational asthma; AA=aggravated asthma; RA=reactive airways dysfunction syndrome.

***Numerator for calculating percentages was the number of companies with an employee other than the index patient on the OSHA log. Denominator for calculating percentages was the number of companies inspected.

****Eight individuals were identified both on the questionnaire and the OSHA log.

Table 14. 261 Isocyanate - Induced Occupational Asthma Cases: Type of Isocyanate Exposure

Type	Number	Percent
TDI	84	32
MDI	69	26
HDI	14	5
MDI & TDI	10	4
NDI	8	3
Unknown	76	29
Total	**261**	**99**

Table 15. Inspections Based on Isocyanate-Exposed Cases at 36 Companies with Co-Worker Breathing Symptom Interviews, by Isocyanate Type

Isocyanate	Companies with Co-Workers Breathing Symptoms	Average % Symptomatic Co-Workers
TDI	6/9 (67%)	15%, sd 13% range 0% - 38%
MDI	15/18 (83%)	23%, sd 16% range 0%-60%
HDI	5/9 (56%)	14%, sd 16% range 0% - 30%
	(Chi Sq = 2.49, p=0.29)	(Chi Sq = 9.92, p=0.007)

Table 16. Industry of Isocyanate-Induced Asthma Cases

Industry	Number	Percent
Automobile Mfg.	165	63
Miscellaneous Mfg.	24	9
Rubber & Plastic Mfg.	23	9
Chemical Mfg.	16	6
Foundry	15	6
Trade	7	3
Automotive Repair & Sales	6	2
Construction	2	1
Research Labs	2	1
Trucking	1	< 1
Total	**261**	**100**

Table 17. 157 Inspections Conducted 10-93 to 3-99: Sampling Results for Isocyanates

Companies	Always <.005 ppm		Ever >=.005 ppm	
	Number	Percent	Number	Percent
SENSOR	35	100	–	–
Patient Associated	6	86	1	14
Never SENSOR	100	87	15	13
Total	**141**	**90**	**16**	**10**

Table 18. Inspections Based on Isocyanate-Exposed Cases at 36 Companies with Co-Worker Breathing Symptom Interviews, by Isocyanate Spill Status

	1 + Spills in Last 5 Years	No Spills
Companies with Co-Worker Breathing Symptoms	11/13 (85%) OR = 2.93 (95% CL 0.43 -34)	15/23 (65%)
Average % Symptomatic Co-Workers	23%, sd 13% range 0% - 46%	16%, sd 17% range 0%-60%
	OR = 1.42 (95%CL 0.99-2.03)	

**Percentages do not add to 100 due to rounding.

*****Percent does not add to 100 due to rounding.