2003

Annual Report on Work-Related Asthma in Michigan

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Summary:

This is the 13th annual report on work-related asthma (WRA) in Michigan. For the years 1989-2001, where all reports have been processed, an average of 141 new people each year have been reported to the Michigan Department of Labor and Economic Growth (formerly the Michigan Department of Consumer and Industry Services) with asthma caused or aggravated by exposures in the workplace. From 1988 to 2003, a total of 2,074 people with WRA have been identified through the Michigan Surveillance System that tracks occupational illness. Additional reports for 2002 and 2003 are still being processed.

We know that the reports received are an under-representation of the true number of individuals with WRA in our state. There are a number of ways to estimate the extent of WRA in a given population, including: the use of self-reports from surveys; statistical estimates from studies; and an actual census count of disease. A consensus statement from the American Thoracic Society concluded: "The median value of 15% is a reasonable estimate of the occupational contribution to the population burden of asthma" (1). All of these methods to estimate the magnitude of work-related asthma in Michigan indicate that WRA is a significant problem in our state. We estimate there are 65,000 – 97,000 people in Michigan with work-related asthma.

Workplace 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 in Michigan involve the new onset of asthma. Michigan Occupational Safety and Health Administration (MIOSHA) enforcement inspections at the workplaces of these individuals reveal a large number of fellow workers with asthma or respiratory symptoms compatible with asthma.

There are over 400 documented agents or work processes associated with work-related asthma. The most comprehensive listing of known causes of work-related asthma can be found at the following web site: www.remcomp.fr/asmanet/asmapro/agents.htm. Known allergens such as isocyanates and metal working fluids are the most commonly reported cause of work-related asthma in Michigan, representing 15.6% and 12.0% of the Michigan WRA cases, respectively. We estimate that potentially 1% of the workforce in manufacturing in Michigan is exposed to isocyanates.

This past year, one worker died after repeated exposure to an isocyanate used in the spray-on truck-bed lining industry. Reasons for his death included poor ventilation, inadequate respiratory protection equipment and lack of awareness of risk by him, his employer and the medical care provider who evaluated him. Site visits by a safety and health specialist to the 100 or so small companies around the state that do similar work is underway. Educational material and the opportunity for a free site evaluation is being provided.

Work-related asthma is affecting men and women equally, generally in the 30-50 year old age range. The average annual incidence rate of work-related asthma among African Americans is 2.0 times greater than among Caucasians. 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 (94% of the time).

The Michigan WRA surveillance team has worked on many recent initiatives to understand more about certain high-risk exposures or industry and occupation groups. A manuscript on cleaning agent exposures from the four states that track work-related asthma (California, Massachusetts, Michigan and New Jersey) was published (2). Despite their wide spread use in both the workplace and the home, these substances are not tested for their ability to cause sensitization and asthma before being put on the market.

A second initiative we continue to work on is a Local Emphasis Program (LEP) for workers exposed to welding fumes. The Michigan surveillance team continues to collect information obtained during MIOSHA enforcement inspections to better understand the types of welding fume exposures and work practices associated with WRA. To date, we have conducted 71 inspections under this LEP. We expect to conduct analyses of the inspection findings in the Fall of 2004.

Another initiative in Michigan has been the development and presentation of a training workshop on work-related asthma to the State's industrial safety and health staff. Trainings were completed for: Construction Safety and Health staff; General Industry Safety and Health; and the Consultation, Education and Training group. The workshops were developed to increase awareness of asthma, including its causes and triggers in the workplace so that field staff can evaluate the potential for exposures at the facilities they inspect and offer work-related asthma prevention recommendations to those companies. Plans are underway to present similar workshops on work-related asthma to employers whose workers use occupational allergens.

Background:

In 1988, the State of Michigan instituted a surveillance program for work-related asthma with financial assistance from the National Institute for Occupational Safety and Health (NIOSH). The surveillance program is a joint project of the Michigan Occupational Safety and Health Administration (MIOSHA) in the Michigan Department of Labor and Economic Growth (MDLEG) and Michigan State University (MSU). 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 major 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 MDLEG. 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, so that the work-relatedness of the condition can be determined. Other sources used to identify cases

include: Michigan's two Poison Control Centers (since 2001); reports from co-workers or from the State's industrial hygienists; and one report from the Mine Safety and Health Administration.

A person is considered to have work-related asthma from sensitization to a workplace exposure if: A) they have a physician diagnosis of asthma, 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 work-related asthma. An enforcement industrial hygiene investigation at the patient's work site may be conducted by MIOSHA to determine the allergen and to document 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 work-aggravated asthma. Occupational asthma from exposure to an allergen at work typically develops after a variable period of symptom-less 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) (3).

After the patient is interviewed and the work-relatedness of the 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 2,074 people were confirmed with work-related asthma between 1988 - 2003. 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 forty-eight additional patients have been confirmed since last year's report. Figure 2 shows the overlap of the 1,993 patients by reporting sources for the years 1988-2002.

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 the years 2002 and 2003. Patient interviews are still needed for 14 reports of patients from hospitals, one report of a patient from a poison control center, and one report of a patient from a physician in 2002. Patient interviews are still needed for 46 reports of patients from hospitals, eight reports of patients from physicians, and five reports of patients from a poison control center in 2003.

Gender

One thousand seventy-four (51.8%) of the persons with work-related asthma are women and 1,000 (48.2%) are men.

Race

Race was known for 2,058 of the 2,074 individuals with work-related asthma. Of the 2,058, 1,580 (76.8%) of the persons with work-related asthma are Caucasian, 374 (18.2%) are African American, 52 (2.5%) are Hispanic, 19 (0.9%) are Alaskan or American Indian, seven (0.3%) are Asian, and 26 (1.3%) were listed as "other."

The average number of incident cases of African Americans with work-related asthma each year for 1992-2001 was 28. In 1998 there were 539,621 African Americans in the Michigan labor force (4). The annual incidence rate for work-related asthma in African Americans, therefore, was 5.2/100,000 workers. The respective data for Caucasians was 113 new cases per year and 4,368,720 Caucasians in the Michigan labor force. The annual incidence rate of work-related asthma in Caucasians, therefore, was 2.6/100,000 workers. The African American rate of work-related asthma was 2.0 times greater than the rate for Caucasians.

Age

The dates of birth range from 1905 - 1984. The average year of birth is 1954.

Location in State

Figure 3 shows the county in which the patient worked where they developed work-related asthma. The main locations are: Wayne (515 cases, 25.4%), Oakland (273 cases, 13.5%), and Macomb (190 cases, 9.4%). 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 (16.0 per 100,000), Clare (12.4 per 100,000), Osceola (8.9 per 100,000), and Cheboygan (8.3 per 100,000) have the highest rates. It should be noted that, even though Luce county had the highest incidence rate of work-related asthma, the rate is based on only five cases (see Table 2). Table 3 shows the annual incidence rates for the larger metropolitan areas and the whole state for the years 1990 through 2001 separately.

Type of Industry

Figure 5 shows the distribution of major industry types for all asthma cases identified from 1988-

2003. Sixty-eight percent of the WRA cases worked in manufacturing, followed by 18% in the services industry, 4% in the trade industry, 3% in construction and mining, and 6% in miscellaneous industries. Table 4 shows the specific types of Michigan industries where the exposures to the occupational allergens occurred from 1988 to 2003. The predominant industries for the total number of cases identified between 1988 and 2003 were in the manufacturing sector: automobile (41.5%), fabricated metal products (4.1%), rubber and miscellaneous plastic products (3.4%), industrial and commercial machinery and computer equipment (3.9%), and foundries (3.2%). Workers in the health field also accounted for a high percentage of the total number of patients (9.4%).

The incidence rate of work-related asthma by industry type ranges from 0.3 cases per 100,000 in restaurants to a high of 20.3 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 12.3 cases per 100,000 workers; the manufacture of other nondurables with 11.1 cases per 100,000 workers; the manufacture of other durables with 8.0 cases per 100,000 workers; and the manufacture of rubber products with 7.8 cases per 100,000 workers.

Table 5 shows the annual incidence rates for the 1990 through 2001 work-related cases within those industries that had 20 or more reports.

Overall, by broad industrial classification, the average annual incidence rates were: 10.1 cases per 100,000 workers in the manufacturing industry; 2.3 cases per 100,000 workers in the construction and mining industry; and 0.8 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 (15.6%), metal working fluids (12.0%), vehicle exhaust (5.6%), welding fumes (4.8%), and solvents (3.2%). The agent has not yet been identified for 306 patients (13.5%). The exposures to unknown agents occurred 162 times in the manufacturing sector and 144 times in an office setting.

Medical Results

Table 7 shows patients' cigarette smoking status. Twenty percent 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.

Forty-three percent of the WRA 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). Three hundred ninety-eight (43.1%) of the 924 patients with a personal history of allergies or asthma previously had asthma.

One thousand six hundred eighty-seven of the patients identified with work-related asthma had persistence of their asthma symptoms (Table 10). This was true for 531 of 553 (96.0%) of those still exposed as well as 1,156 of 1,348 (85.8%) no longer exposed to the substance causing their asthma. Among those no longer exposed, 49.5% stated their symptoms were less severe

compared to 31.1% among those still exposed who reported their symptoms were less severe. Similarly, 86.4% of those still exposed were continuing to take asthma medications while 77.9% of those no longer exposed were still taking asthma medications. Among those no longer exposed, 29.4% stated they were taking fewer medications while only 19.7% of those still exposed were taking fewer medications (Table 10).

Eight hundred eighty-eight of 1,866 (47.6%) patients with known workers' compensation status had applied for workers' compensation. Cases were pending for 453 (51.0%) of those who applied, while 303 (34.1%) had received awards and 132 (14.9%) had been denied.

Although 2,074 individuals were confirmed with work-related asthma, we could find objective testing for hyperreactivity by methacholine challenge or pre- and post-bronchoprovocation for 50% of cases. In addition, we found only 0.8% of cases had specific antigen bronchoprovocation, 3.5% of cases had peak flow monitoring and only 3.1% of cases had pre- and post-work shift testing.

Industrial Hygiene

The 2,074 people with work-related asthma worked at 1,363 different facilities. Five hundred twelve facilities were inspected 588 times. Seventy-six of the 1,363 facilities were inspected more than once. Twenty inspections were completed since last year's report. Inspections are scheduled at 16 (1.1%) facilities (Table 11). Seventy-nine companies 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. No follow-up was planned for 688 companies, 46 companies were no longer in business, and 22 companies no longer used the occupational allergen associated with the development of asthma in the index case.

Air sampling for allergens was conducted during 420 of the inspections. Sixty of the 420 (14.3%) facilities were above the National Institute for Occupational Safety and Health recommended exposure limit (REL). Twenty-seven (6.4%) were above the enforceable Michigan Occupational Safety and Health Administration (MIOSHA) permissible exposure limit (PEL) (Table 12).

Interviews of fellow workers were performed at 464 of the 588 inspections. Co-workers of the index cases reported daily or weekly breathing symptoms or onset of new asthma since beginning to work at that company in 329 of the 464 (70.9%) companies. The average percentage of co-workers with symptoms in these 329 companies was 20.3%, ranging from 2% to 100%. Interviews of 1,023 co-workers from 135 companies found no co-workers with symptoms. One thousand three hundred ninety-seven of the 8,443 (16.5%) co-workers interviewed had symptoms consistent with work-related asthma (new onset asthma or bothered at work by daily or weekly shortness of breath, wheezing or chest tightness) (Table 13).

The Michigan Occupational Safety and Health Administration (MIOSHA) Injury and Illness logs kept by employers listed 548 workers from 115 companies as having asthma or asthma-like symptoms. Only nine workers identified in the interviews with daily or weekly breathing symptoms were also listed on the Michigan OSHA log. Therefore, a total of 1,936 symptomatic workers were identified during the 588 inspections.

Proportion of Asthma Attributed to Work

The Behavioral Risk Factor Surveillance System (BRFSS) is a random-digit-dialed telephone survey of the civilian, non-institutionalized population ages ≥ 18 years that is administered by states throughout the country. In the 2002 BRFSS survey in Michigan, 12.8% (95% CI 11.7 – 13.9%) of the respondents answered "yes" to "Have you ever been told by a doctor, nurse or other health professional that you had asthma?" and 8.8% of the respondents (95% CI, 7.8 – 9.7%) answered "yes" to "Do you still have asthma?" (5).

Table 14 shows the results of two questions about work-related asthma that were administered in California, Massachusetts and Michigan in 2001: "Were you ever told by a doctor or other medical person that your asthma was related to any job you ever had?" and "Did you ever tell a doctor or other medical person that your asthma was related to any job you ever had?" Among individuals who currently have asthma and their asthma began as an adult, 20.1% of the men and 9.9% of the women answered yes to at least one of the two questions about the work-relatedness of asthma. For men the percentage who said they told a health care professional their asthma was related to a job was over twice as high as the men who reported that a health care provider said their asthma was work-related (18.0% vs. 7.7%). The percentages were greater for adult onset vs. child onset asthma. The results were comparable in the states, although Michigan adults were more likely to tell their health care providers their asthma was related to a job than in the other two states.

The 2000 year census counted 9,938,444 people in Michigan of whom 7,344,510 were 18 years or older. Applying the most recent BRFSS data, that 8.8% of Michigan adults currently have asthma would translate into 646,317 adults in Michigan who have asthma. The Michigan BRFSS survey suggests that there is an association with work in 9.7% (95 % CI 6.5-12.9) of the Michigan adults who currently have asthma (Table 14). This translates into 62,693 (95% CI 42,011-83,375) adults with asthma in Michigan where the health care provider or the patient reported an association with work. If a male develops asthma as an adult, the data from BRFSS suggests that either he or his health care provider will attribute the new onset asthma as work-related 20% of the time. Estimates from the published literature on the percentage of adult asthma that is work-related range from 2-45% with a median of 9%. Calculation of the estimate using the most methodologically sound articles would suggest that 15% of adult asthma is work-related (6). A recent consensus document from the American Thoracic Society also concluded that 15% was a reasonable estimate (1). Applying the 15% to the BRFSS estimate of 650,000 Michigan adults with asthma would translate into approximately 97,500 adults in Michigan with work-related asthma.

Using a technique called capture-recapture, another estimate of the extent of work-related asthma in Michigan suggests that the average of 141 reports received by the MDLEG each year represents 18.2% - 64.0% (228-801) of the true number of adults who develop new onset asthma caused by exposure at work (7).

Michigan Workforce Exposed to Isocyanates

Isocyanates are the most commonly reported cause of work-related asthma in Michigan. The United States Environmental Protection Agency (EPA) requires reporting by facilities that use any one of 650 different chemicals in amounts greater than 10,000 pounds per year and are a

manufacturer, mining or electrical generator and have at least 10 employees. Isocyanates are one of the 650 substances for which reporting is required. Queries of reportable chemicals can be generated to identify state-level statistics on facilities.

We identified Michigan's isocyanate-using companies in the Toxic Release Inventory to estimate the number of workers potentially exposed to isocyanates in the state. This estimate under-counts non-manufacturing exposed workers such as auto body paint shop employees since the EPA database does not include these types of non-manufacturing establishments. On the other hand it is an over-count of manufacturing employees since the total number of employees at a given manufacturing facility that reported isocyanates were counted even though only a smaller percentage of the workers would have directly worked with and therefore have been potentially exposed to isocyanates.

A list of counties with the companies that reported the use of isocyanates in calendar year 2002 (the most recent year for which this information is available) can be found in Table 15. The number of employees potentially exposed to isocyanates, the total number of workers in these counties, and the percentage of workers potentially exposed to isocyanates is listed.

Work-Related Asthma Fatality

Fortunately, only 0.01-0.02% of individuals with asthma die from asthma. In 2003, there was an acute fatality from repeated exposure to an isocyanate (methylene diphenyl diisocyanate (MDI)) used in the truck bed spray-on lining business.

Facilities that provide spray-on truck bed-liners are typically small shops that are using a potent allergen without adequate workplace controls and little knowledge of the hazard. There are about 100 such facilities in Michigan.

A description of the events on the day of the death of a man in his mid-40's who was applying a spray-on bed-liner follows:

The vehicle to be sprayed was a cargo van. This was the first time the company had applied the spray-on bed-liner material to a cargo van. The van was prepped the day before. The spray-on liner was to be applied on the floor and partially up the sides of the cargo van. The victim and another co-worker arrived at the business at approximately 6:30am to spray the van's interior. They set up the supplied air system for the respirator. According to the owner, he thought that the ambient air pump that supplied air to the respirator was usually placed outside of the overhead door in the parking lot. After the death, the ambient air pump was found at the pedestrian door. The overhead door was then lowered to a few feet above the ground. They opened the pedestrian door near the rustproofing area and placed a box fan in that door opening and prepared the spray machine. The victim donned the respiratory protection equipment, protective suit, knit cap and hood. The ambient air pump had an 80-foot airline that was connected to the ½ -mask respirator face-piece assembly.

The victim told the co-worker to leave the area and the co-worker went to the victim's basement apartment to wait for him to spray the van, which the victim thought would take about 20 minutes. The victim began the application of the spray-on truck bed-liner at approximately 7:00am. It is unknown how the victim sprayed the inside of the van, whether he crawled in the

rear and was in the confined area of the van for most of the spraying time or whether he sprayed most of the van interior while standing on the outside of the van on the shop floor. The confined area of the van interior would have a limited amount of ventilation and potentially increased the levels of isocyanate aerosols, thus increasing his exposure.

The victim completed the application of the liner inside of the van and turned off the spray machine. It is unknown where the victim disconnected his airline from his respirator at his hip; it was found near the rustproofing pedestrian door. It is unknown where the victim took off his respirator. It is thought that he exited the shop through the pedestrian northeast door by the rustproofing area. He walked outside around the north and west walls to the front door of the reception area. After waiting the 20 minutes as directed by the victim, his co-worker came upstairs from the apartment and saw the victim outside of the front door of the reception area on his knees gasping for breath with the respirator hanging around his neck.

The co-worker drove the victim to a nearby urgent care medical clinic and the co-worker went into the clinic to ask for assistance. When he returned to the vehicle, the victim was unconscious and not breathing. There was a nurse at the clinic and CPR was started right away. The ambulance was called at 7:36am and arrived at about 7:45am. The victim was transported to the hospital by ambulance, where he was declared dead at 8:31am.

The medical records of a visit for shortness of breath seven months before his death stated the deceased had inhaled chemicals two days prior at work while he was working with a bed-liner insert and wasn't wearing a breathing pack. He was exposed approximately 10 minutes and it became hard to breathe and within 10-15 minutes he couldn't catch his breath. He indicated he felt pain in his chest and couldn't quit coughing. It hurt for him to take a deep breath. The medical records confirmed that the victim smoked. At this time, he had a productive cough with white and green sputum. At the urgent care clinic, he received one nebulizer treatment. He reported his medical history to be right lumbar pain. He was given a steroid (Prednisone 20 mg a day), an antibiotic for seven days, cough syrup with codeine, and a bronchodilation. He refused a chest x-ray. There was nothing written in the chart about the advisability of continuing to do this type of work.

The victim was hired as the shop supervisor approximately one year prior to his death. The victim had worked at the detailing business for approximately 11 months as manager of the shop. He had previously worked at a vehicle paint repair and detailing business, but no information on the type of paint used at his previous job was available.

After the fatal incident occurred, employees informed the owner that the victim had routinely experienced breathing problems after application of the truck bed-liner product. Employees told the owner that the victim would cough and go to a fresh air location. They noticed the victim sitting in a vehicle with the air blowing in his face to get "fresh air" or that the employee would take a walk after spraying the product. The employer was also told that the victim had used an inhaler in the past.

The cause of death as described by the medical examiner was acute respiratory failure. The medical examiner opinion was that he "died of acute asthmatic reaction due to inhalation of chemicals". Toxicology results indicated that the blood contained pseudoephedrine, dipenhydramine, acetaminophen and caffeine, none of which were felt to contribute to his death.

Toxicology results were negative for ethanol and any illegal drugs.

Factors contributing to his death included inadequate exhaust ventilation, lack of an adequate respirator program, inadequate employer/employee knowledge of the hazards of the material, lack of medical monitoring and inadequate medical management by the health care provider.

This death illustrates the consequences of the proliferation of a new technology to multiple small business locations without adequate provision to disseminate health and safety information and equipment.

A representative of the OSHA Consultation Education and Training Division is currently visiting each spray-on bed-liner business in the State. Educational material is being provided and each business is being offered a free safety and health evaluation of their facility by an industrial hygienist. Preliminary results from these visits show a widespread problem in the industry but a reluctance to accept the free evaluation.

Discussion:

In our previous annual reports, we have emphasized the fact that the cases reported in Michigan's surveillance system are likely an undercount 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 (15%) of adults with asthma (1,6).

An average of 141 new people each year are reported to the Michigan Department of Labor and Economic Growth (DLEG) with confirmed work-related asthma. Based on responses from the 2001 BRFSS random sample of Michigan residents, we would estimate that there are a total of 62,693 (95% CI 42,011 - 83,375) Michigan adults with work-related asthma in the state. Based on the medical literature we would estimate that there are 97,500 Michigan adults with work-related asthma (1,6). Using capture-recapture analysis, we estimate 228 - 801 adults in Michigan develop work-related asthma each year (7).

As in the previous annual reports on work-related asthma in Michigan, the workers reported are generally young to middle age Caucasian men and women, with the greatest number being reported from the Detroit metropolitan area. The rate of work-related asthma in African Americans is 2.0 times greater than among Caucasians. Based on an analysis conducted for previous annual reports, factors from the work-related asthma surveillance data that would contribute to greater morbidity among African-Americans include: a greater likelihood to continue to be exposed to the allergen; having a longer time of exposure before leaving work; and being less likely to receive workers' compensation.

Individuals in the Michigan work force tend to develop their asthma from exposures to agents in the manufacturing sector, particularly automobiles, machinery, metals, chemicals, and rubber and plastics. The predominant causes of work-related asthma remain isocyanates (15.6%) and metal working fluids (12.0%). We have updated the table first presented in last year's report (Table 15) on the number of manufacturing workers potentially exposed to isocyanates. In some counties, more than 5% of the workforce may be exposed to isocyanates in manufacturing facilities: Montcalm (10%); Barry (8%); Mecosta (8%); Wexford-Missaukee (6%); Cass (6%);

and Clare (6%). Health care providers can use this information to heighten their awareness of potential exposure to isocyanates among their patients with asthma. We will consider ways to refine these estimates on isocyanates in future years and expand the listing to include more asthma-causing agents.

Asthma symptoms persist despite removal from the precipitating work exposures (Table 10). Studies have shown that the sooner an individual is removed from the exposure causing their asthma after symptoms develop, the more likely the individual's symptoms will resolve (5). On the average, among the 1,348 individuals no longer exposed, 2.9 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 is related to the physician not recommending that the individual leave the 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. It is possible that sampling was not conducted under similar enough working conditions as the exposures associated with the development of the index cases' asthma, such as incidents of spills or leaks. We identified 1,396 fellow workers with symptoms compatible with work-related asthma. Five hundred forty-eight individuals were listed on the Michigan OSHA log as having work-related asthma. There was only an overlap of nine individuals, although one might expect a greater overlap of the co-workers with symptoms to be reported on the log. Part of the reason for the lack of overlap is that 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 may not be sufficiently protective to ensure a safe workplace.

Reevaluations of some of the allowable exposure standards may be needed. These reevaluations might consider comprehensive workplace controls that 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 (7). The Occupational Health Standards Commission has created an advisory committee that is currently reviewing the need for a new standard for the Diisocyanates. The death in 2003 of a worker from exposure to isocyanates might have been prevented if standards for the use of isocyanates were in place. The death occurred in a small three-person shop and reflects the spread of the use of new technology without adequate information on safe work practices.

The percentages of individuals reported with work-related asthma that this surveillance system 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 leave 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 (8).

Ongoing vigilance in the identification of WRA, and using opportunities for education and intervention at many levels continues to be a priority in Michigan. For example, the Michigan Chapter of the American Lung Association, under contract to the Michigan Department of Community Health maintains a web site of resources on asthma called the Michigan Asthma Communication Network (MACN). The web site can be accessed at: www.getasthmahelp.com. Information on work-related asthma is included on this web site.

An example of an intervention involves a MIOSHA Local Emphasis Program (LEP) for welding fumes. This program identifies workplaces with welding fume exposures during MIOSHA enforcement inspections, and assesses the breathing health of workers exposed to those fumes. To date, 71 inspections have been completed under this LEP. Collection of information during these inspections will allow us to better understand the factors most associated with the development of breathing problems and work-related asthma from welding fume exposures.

An educational initiative that continued this past year provided workshops on asthma in the workplace for the MIOSHA safety and health field staff. The program was developed to increase awareness of asthma, the hazards commonly found in the workplace, and ways to help facilities control exposures that could cause or aggravate asthma among their employees. In the coming year, we plan to provide similar workshops to employers who use allergens.

Recognition of work-related asthma is critical in managing adults with asthma. The death in 2003 of an individual with work-related asthma is attributable to the lack of recognition of an association by the employer, employee and health care provider between the individual's respiratory problems and work exposure to isocyanates. The death of this Michigan worker underscores the importance of efforts aimed at the understanding and reduction of WRA in our state.

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 exposure levels, document the need for the development of new standards, identify new occupational allergens, and prevent co-workers from developing disease.

Given the potential that 15% or more of adults with asthma have work-related asthma, work-related asthma needs to be integrated into all asthma initiatives planned on surveillance and education, both for health care providers and the public.

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

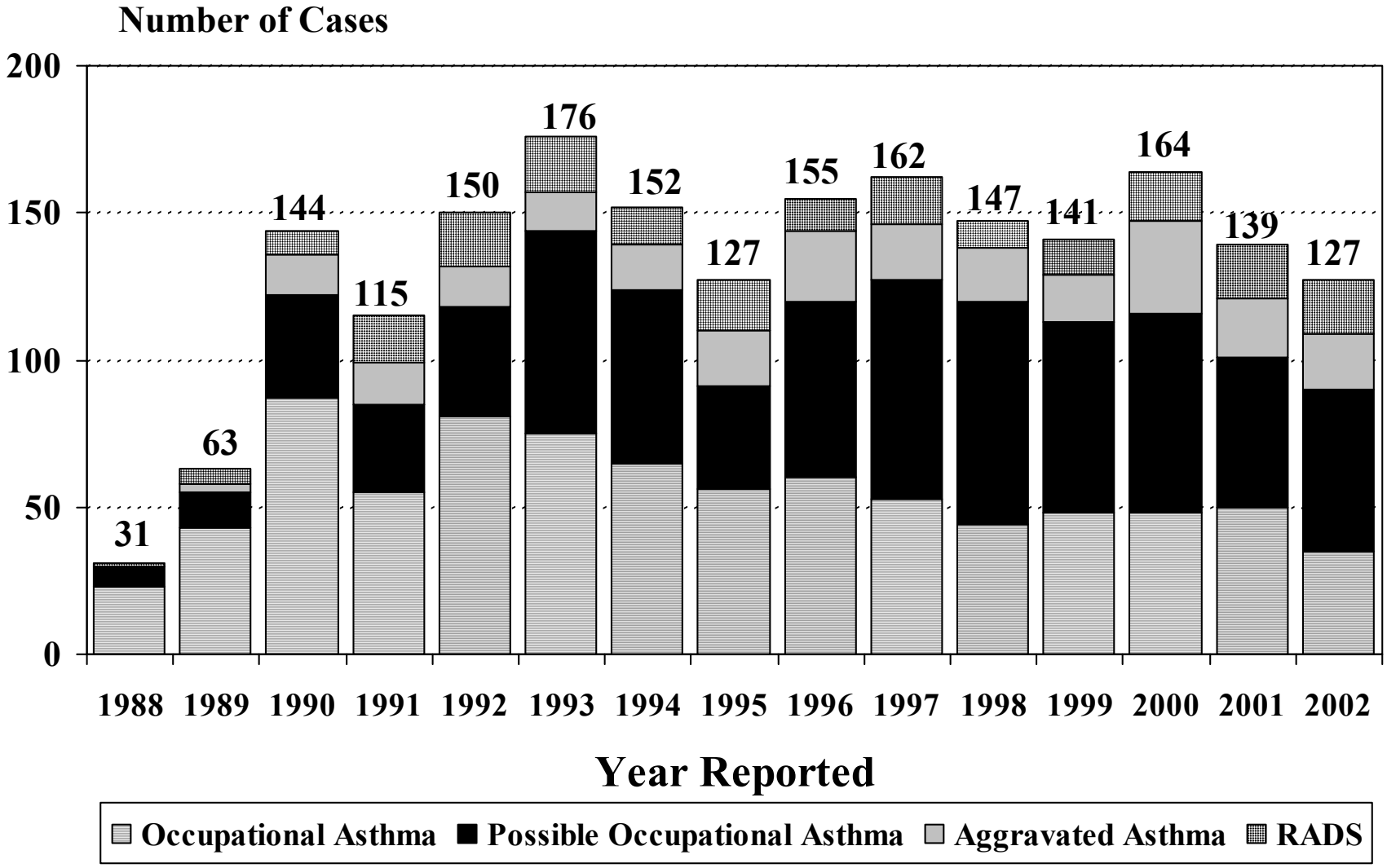


Figure 2. Overlap of Reporting Sources for Confirmed Work-Related Asthma Patients: 1988-2002*

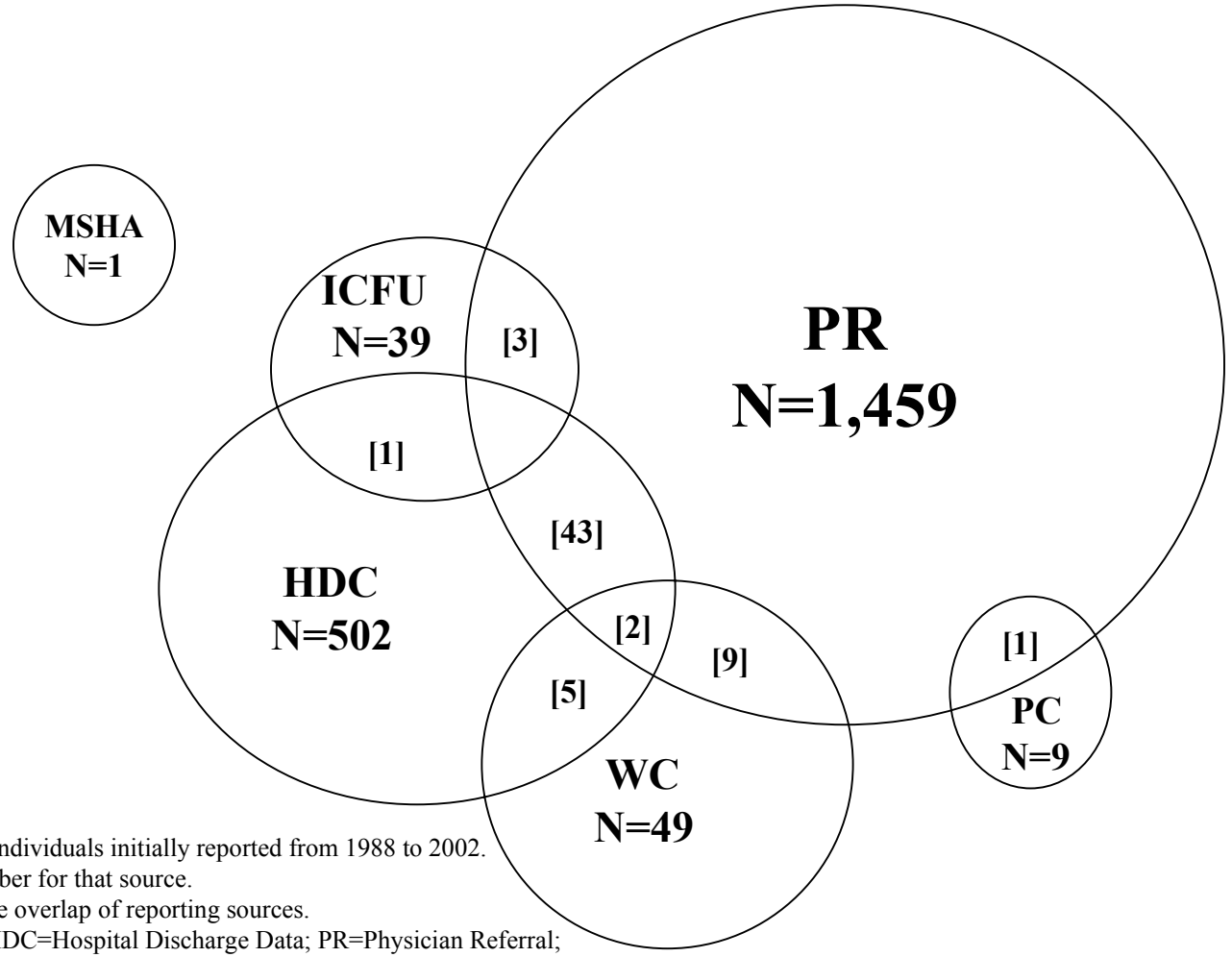
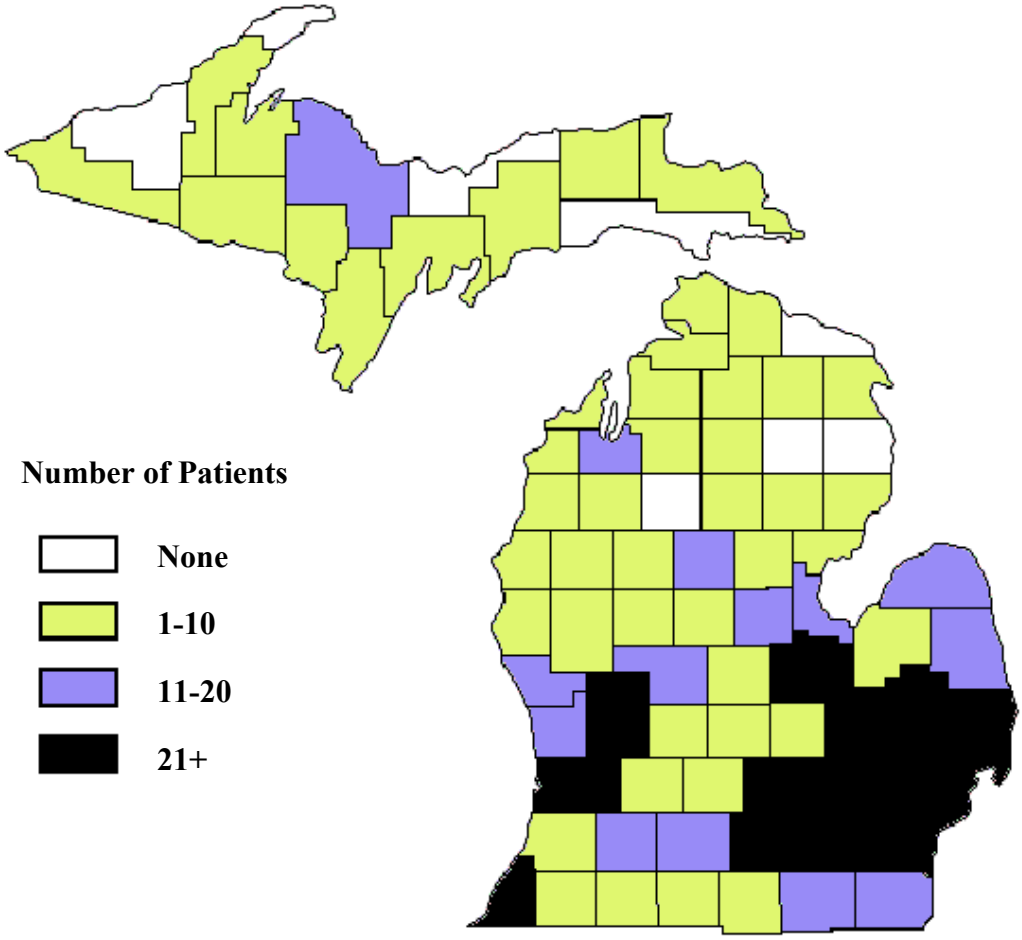


*Diagram represents 1,993 individuals initially reported from 1988 to 2002.
N's represent the total number for that source.
Numbers in [ ] represent the overlap of reporting sources.
Reporting Source Codes: HDC=Hospital Discharge Data; PR=Physician Referral;
WC=Workers' Compensation; ICFU=Index Case Follow Up; MSHA=Mine Safety and Health Administration; PC=Poison Control Center.

Figure 3. Distribution of Confirmed Work-Related Asthma Patients by County of Exposure: 1988-2003

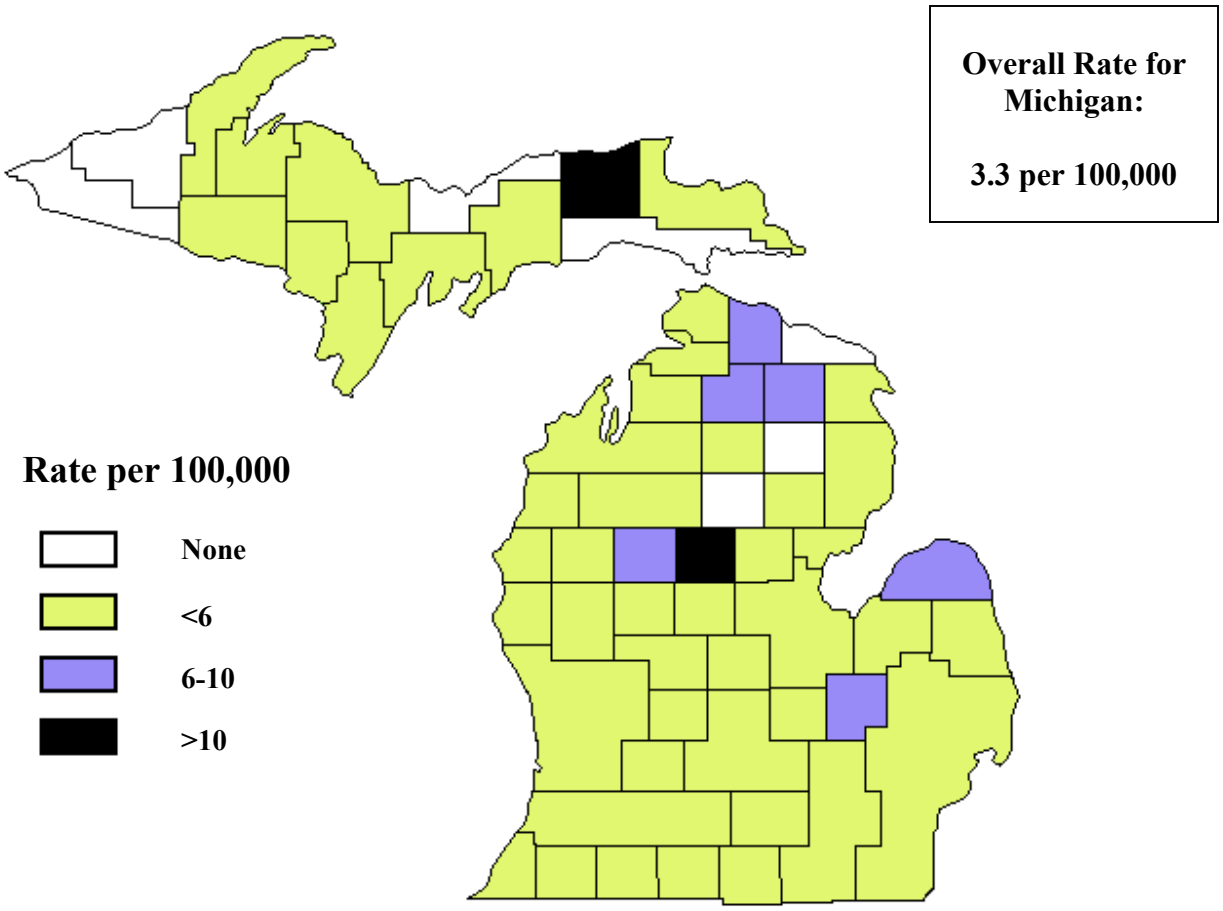


Total Michigan Patients: 2,025*

Oakland and **Wayne** counties had the highest number of work-related asthma patients, with 273 and 515 individuals, respectively.

*County of exposure was unknown for 12 patients. Thirty-seven patients were exposed out-of-state to an allergen.

Figure 4. Average Annual Incidence Rates of Work-Related Asthma Among Michigan Workers by County of Exposure: 1989-2001*



*Rate per 100,000 among Michigan workers. Source: MESC 1995 Annual Average Labor Statistics for Employment by Place of Work. In 1995, there were a total of 4,252,000 Michigan workers.

Figure 5. Major Industry Type for Confirmed Work-Related Asthma Patients: 1988-2003

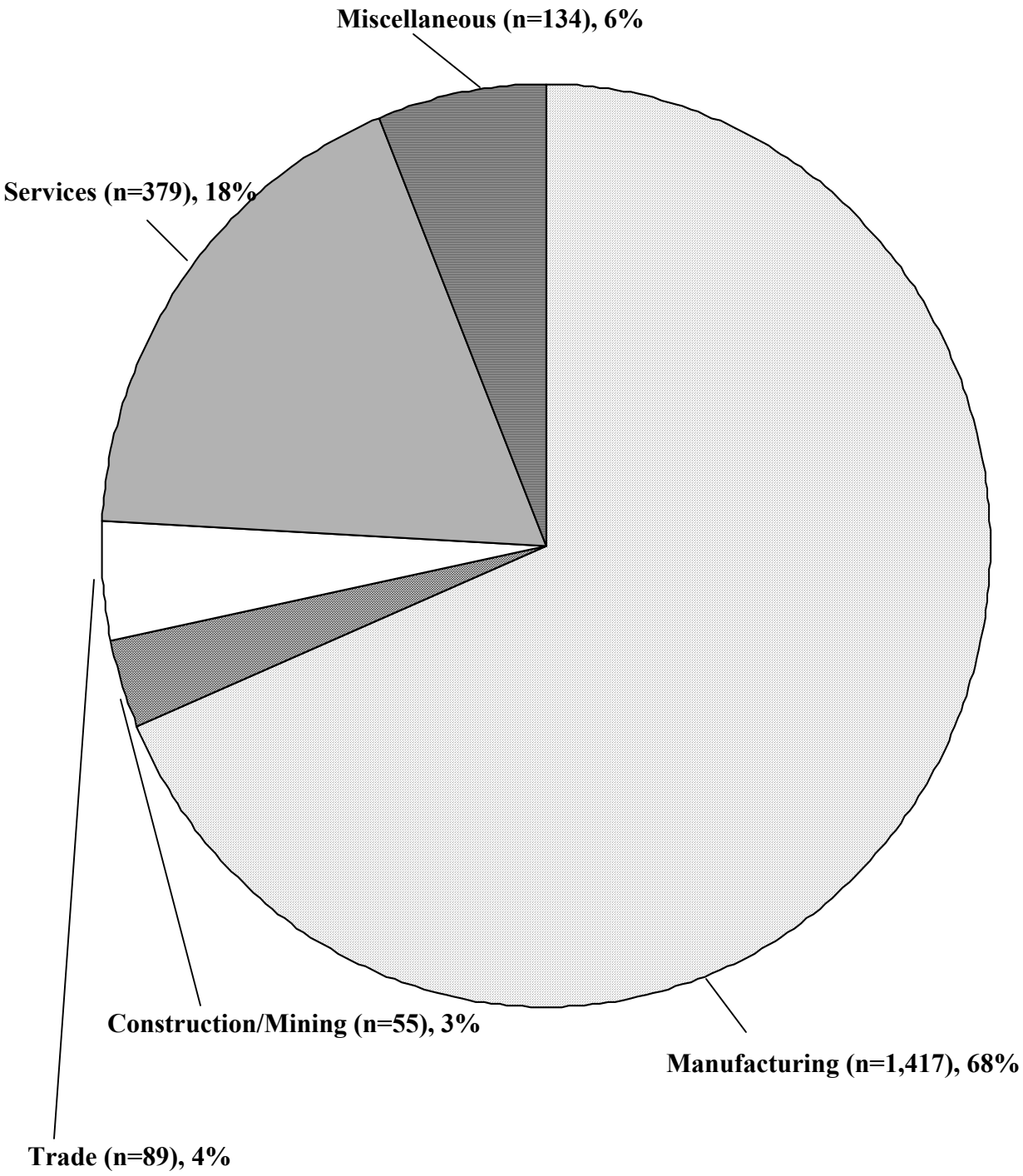


Table 1. Number of Confirmed Cases of Work-Related Asthma by Year and Type

	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	69	13	19	176
1994	65	59	15	13	152
1995	56	35	19	17	127
1996	60	60	24	11	155
1997	53	74	19	16	162
1998	44	76	18	9	147
1999	48	65	16	12	141
2000	48	68	31	17	164
2001	50	51	20	18	139
2002	35	55	19	18	127
2003	22	44	11	4	81
Total	845	777	250	202	2,074

*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: 1989-2001

County	Number of Employees	Avg. Annual Inc. Rate**	Total # Cases 1989-2001
Alcona and Iosco (0, 2 cases respectively)	11,100	1.4	2
Alpena	12,675	1.8	3
Antrim	5,225	2.9	2
Arenac	4,425	3.5	2
Baraga	3,450	4.5	2
Barry	11,200	1.4	2
Berrien	70,900	2.1	19
Branch	13,225	5.8	10
Cass	10,775	2.1	3
Charlevoix	9,850	3.1	4
Cheboygan	7,450	8.3	8
Chippewa	15,025	1.5	3
Clare	7,425	12.4	12
Clinton-Eaton-Ingham (4, 9, 54 cases respectively)	224,200	2.3	67
Crawford	4,425	3.5	2
Delta	14,725	1.6	3
Dickinson	13,825	5.0	9
Emmet	14,425	1.1	2
Genesee	180,600	6.1	143
Gladwin	4,925	1.6	1
Grand Traverse-Benzie-Kalkaska-Leelanau (10, 2, 5, 3 cases respectively)	56,075	2.7	20
Gratiot	13,775	2.8	5
Hillsdale	14,975	4.1	8
Houghton-Keweenaw (3,0 cases respectively)	14,400	1.6	3
Huron	12,850	6.6	11
Ionia	15,800	4.4	9
Iron	4,025	1.9	1
Isabella	24,575	1.6	5
Jackson	58,600	3.8	29
Kalamazoo-Calhoun-VanBuren (16, 15, 4 cases respectively)	204,600	1.3	35
Kent-Ottawa-Muskegon-Allegan (44, 16, 18, 20 cases respectively)	515,300	1.5	98
Lake	1,650	4.7	1
Luce	2,400	16.0	5
Manistee	7,300	1.1	1
Marquette	28,075	3.0	11
Mason	10,300	0.7	1
Mecosta	12,600	0.6	1
Menominee	9,375	0.8	1
Montcalm	19,100	4.0	10
Montmorency	2,175	7.1	2
Newaygo	9,875	3.9	5
Oceana	5,900	1.3	1
Ogemaw	6,125	1.3	1
Osceola	7,775	8.9	9
Otsego	10,400	6.7	9
Sanilac	12,750	3.6	6
Schoolcraft	2,675	2.9	1
Shiawassee	18,950	2.0	5
St. Joseph	25,050	1.5	5
Tuscola	13,800	5.6	10
Washtenaw-Lenawee-Livingston (114, 13, 26 cases respectively)	253,600	4.6	153
Wexford-Missaukee (3, 0 cases respectively)	16,525	1.4	3
Saginaw-Bay-Midland (61, 13, 15 cases respectively)	172,600	4.0	89
Detroit, MSA***	2,002,000	3.6	925
Out of State	---	---	30
Unknown	---	---	12
All Michigan Counties	**4,252,000**	**3.3**	**1,820**

*Source: MESC 1995 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 1989-2001, per 100,000 Michigan workers. *** MSA=Metropolitan Statistical Area and includes Lapeer (22 cases), Macomb (171 cases), Monroe (16 cases), Oakland (243 cases), St. Clair (18 cases) and Wayne (455 cases) counties.

Table 3. Annual Incidence Rates of Work-Related Asthma Among Michigan Workers by Major Metropolitan Area: 1990-2001

	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)	3.0 (115)
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 (153)
1995	2.2 (5)	1.2 (6)	1.7 (3)	3.4 (69)	3.0 (127)
1996	1.3 (3)	0.9 (5)	2.9 (5)	4.0 (91)	3.5 (154)
1997	2.2 (5)	1.1 (6)	4.5 (8)	3.7 (77)	3.6 (162)
1998	2.6 (6)	1.4 (8)	3.9 (7)	3.7 (79)	3.3 (147)
1999	0.9 (2)	1.7 (10)	5.5 (10)	2.7 (59)	3.1 (141)
2000	1.3 (3)	1.5 (9)	8.7 (16)	3.0 (66)	3.6 (164)
2001	3.0 (7)	0.9 (5)	6.2 (11)	2.9 (62)	2.7 (120)

*Rate per 100,000 Michigan workers. Rate, number of cases in parentheses.
Source: MDCD (formerly the MESC) Annual Average Labor Statistics for Employment by Place of Work, for each year 1990-2001 separately.

**MSA=Metropolitan Statistical Area. For the years 1990-1995, includes Lapeer, Livingston, Macomb, Monroe, Oakland, St. Clair, and Wayne counties. For 1996- 2001 does not include Livingston county because of a change in the counties associated with certain MSA's (including Detroit).

Table 4. Primary Industrial Exposure for Confirmed Work-Related Asthma Patients: 1988-2003

Industry (SIC Code)*	Number of Cases 1988-2003**		Number of Employees***	Ann. Average Incidence Rate 1989-2001****	
MANUFACTURING (20-39)					
Automobile (37)	861	(41.5)	294,000	20.3	(775)
Fabricated Metal Products (34)	85	(4.1)	129,000	4.5	(75)
Ind. & Comm. Mach. & Computer Equipment (35)	80	(3.9)	134,000	4.2	(74)
Rubber and Misc. Plastic Products (30)	70	(3.4)	66,000	7.8	(67)
Foundries (33)	67	(3.2)	37,000	12.3	(59)
Food and Kindred Products (20)	43	(2.1)	45,000	6.2	(36)
Printing and Publishing (27)	20	(1.0)	44,000	3.1	(18)
Lumber and Wood (24)	18	(0.9)	18,000	7.3	(17)
Paper and Allied Products (26)	17	(0.8)	22,000	5.6	(16)
Electrical Equipment (36)	16	(0.8)	34,000	3.2	(14)
Furniture and Fixtures (25)	8	(0.4)	39,000	1.6	(8)
Apparel Made from Fabric (23)	2	(0.1)	21,000	0.7	(2)
Other Durables (32,38,39)	49	(2.4)	44,000	8.0	(46)
Other Nondurables (22,28,29,31)	81	(3.9)	49,000	11.1	(71)
WHOLESALE AND RETAIL TRADE (50-59)					
Wholesale-Durable Goods (50)	15	(0.7)	137,000	0.8	(14)
Wholesale-Nondurable Goods (51)	14	(0.7)	74,000	1.4	(13)
Eating and Drinking Places (58)	18	(0.9)	279,000	0.3	(12)
Food Stores (54)	11	(0.5)	105,000	0.8	(11)
Automotive Dealers and Gasoline Services (55)	12	(0.6)	83,000	0.8	(9)
General Merchandise Stores (53)	8	(0.4)	128,000	0.4	(7)
Miscellaneous Retail (52, 56, 57,59)	11	(0.5)	194,000	0.4	(10)
SERVICES					
Health (80)	194	(9.4)	385,000	3.3	(165)
Education (82)	74	(3.6)	371,000	1.1	(54)
Business (73)	19	(0.9)	257,000	0.4	(15)
Automotive Repair (75)	14	(0.7)	36,000	2.1	(10)
Social Services (83)	13	(0.6)	81,000	0.9	(10)
Engineering, Accounting, etc. (87)	9	(0.4)	92,000	0.7	(8)
Other Services (70,72,76,79,81,86,89)	56	(2.7)	256,000	1.4	(48)
CONSTRUCTION AND MINING (10-17)					
Special Trade Construction (17)	42	(2.0)	106,000	2.6	(36)
Other Construction (15-16)	8	(0.4)	48,000	1.3	(8)
Mining (10-14)	5	(0.2)	8,000	3.8	(4)
MISCELLANEOUS INDUSTRIES					
Government (91-97)	59	(2.8)	274,000	1.4	(51)
Transportation and Utilities (40-49)	37	(1.8)	166,000	1.5	(32)
Finance, Insurance and Real Estate (60-67)	22	(1.1)	196,000	0.4	(11)
Agricultural Production and Services (01,02,07)*****	9	(0.4)	38,727	1.6	(8)
Unknown	7	(0.3)	–	–	(6)
TOTAL	**2,074**		**4,290,727**	**3.3**	**(1,820)**

*1987 Standard Industrial Classification code.
**Number of cases, percentages are in parentheses.
***Source:MESC 1995 civilian labor force and industrial employment estimates.
****Average annual incidence rate, total number of cases for 1989-2001 are in parentheses. Rates are based on average number of cases from 1989-2001 per 100,000 adult workers in each industrial category.
*****Source: Michigan Department of Career Development, Statewide Average Monthly Industry Employment, 1995.

Table 5. Primary Industrial Exposure for Confirmed Work-Related Asthma Patients: 1990-2001

	1990**	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
INDUSTRY (SIC code)*												
Manufacturing (20-39)												
Food (20)	20.0 (9)	6.7 (3)	2.3 (1)	-- (0)	2.3 (1)	4.4 (2)	6.8 (3)	4.9 (2)	7.5 (3)	2.6 (1)	8.1 (3)	8.1 (3)
Chemicals (28,29)	17.0 (8)	4.3 (2)	14.0 (7)	12.0 (6)	7.8 (4)	14.3 (7)	6.1 (3)	14.3 (7)	10.0 (5)	10.2 (5)	10.6 (5)	6.5 (3)
Rubber & Plastics (30)	9.3 (5)	19.6 (10)	-- (0)	7.3 (4)	11.3 (7)	15.1 (10)	10.4 (7)	13.2 (9)	4.5 (3)	5.8 (4)	6.2 (4)	1.6 (1)
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)	10.5 (4)	7.9 (3)	13.2 (5)	8.3 (3)
Fabricated Metals (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)	4.7 (6)	1.6 (2)	3.8 (5)	0.8 (1)
Industrial Mach. (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)	3.7 (5)	2.3 (3)	6.0 (8)	4.9 (6)
Transportation Equip. (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)	23.7 (65)	23.9 (65)	23.0 (70)	20.0 (57)
Other Durables (38,39)	19.2 (5)	8.0 (2)	4.9 (2)	9.8 (4)	-- (0)	-- (0)	6.7 (3)	4.4 (2)	6.5 (3)	8.9 (4)	10.6 (5)	4.4 (2)
Miscellaneous Industries												
Special Trade Const'n. (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)	2.4 (3)	2.3 (3)	1.4 (2)	3.6 (5)
Transp. & Util. (40-49)	0.6 (1)	1.3 (2)	1.9 (3)	4.5 (7)	2.5 (4)	1.2 (2)	-- (0)	0.6 (1)	0.6 (1)	1.7 (3)	1.6 (3)	1.7 (3)
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)	6.0 (22)	4.6 (17)	4.6 (18)	2.8 (11)
Education (82)	0.6 (2)	0.6 (2)	0.8 (3)	2.2 (8)	0.8 (3)	1.1 (4)	2.1 (8)	2.3 (9)	1.3 (5)	0.3 (1)	1.2 (5)	0.7 (3)
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)	0.5 (3)	0.2 (1)	0.7 (2)	0.7 (2)
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)	3.0 (147)	3.4 (141)	3.5 (164)	2.7 (124)

*1987 Standard Industrial Classification code.

**Annual incidence rate (number of cases for each year). Rates are based on the number of cases per 100,000 adult workers in MI for each year separately. Source: MI Department of Career Development, Employment Service Agency, Annual Average civilian labor force and industrial employment estimates (formerly the MESC).

Table 6. Occupational Agents Associated with 2,074 Confirmed Work-Related Asthma Patients: 1988-2003

Allergen	Number	Percent
Isocyanates	324	15.6
Metal Working Fluids	248	12.0
Unknown (Mfg.)	162	7.8
Cleaning Solutions	148	7.1
Unknown (Office)	144	6.9
Exhaust/Smoke/Fumes	117	5.6
Welding Fumes	100	4.8
Solvents	66	3.2
Latex/Rubber	52	2.5
Epoxy	50	2.4
Paint Fumes	48	2.3
Formaldehyde	47	2.3
Acids	40	1.9
Acrylates	34	1.6
Chlorine	30	1.4
Cobalt	26	1.3
Plastic Fumes	23	1.1
Styrene	20	1.0
Wood Dust	20	1.0
Flour	19	0.9
Ammonia	16	0.8
Chromium	13	0.6
Cigarette Smoke	13	0.6
Herbicide/Pesticide	12	0.6
Printing Inks	12	0.6
Animal Dander	11	0.5
Fiberglass	11	0.5
Amines	10	0.5
Chemicals Used in Construction	10	0.5
Glutaraldehyde	9	0.4
Grain Dust	9	0.4
Caustics	8	0.4
Cement Dust	7	0.3
Meat Wrapper's Asthma	7	0.3
Pickling Ingredients	6	0.3
1,1,1 Trichloroethane	5	0.2
Cosmetology Chemicals	5	0.2
Fire	5	0.2
Paper Dust	5	0.2
Asbestos	4	0.2
	4	0.2

Table 6, continued.

Enzymes		
Freon	4	0.2
Fungus	4	0.2
Nitrogen	4	0.2
Photo Developing Fluids	4	0.2
Rose Hips	4	0.2
Rust Inhibitor	4	0.2
Solder Fumes	4	0.2
Sulfonate	4	0.2
Sulfur Dioxide	4	0.2
Cadmium Solder	3	0.1
Colophony	3	0.1
Ethyl Alcohol Nickel	3	0.1
Lime Dust	3	0.1
Maleic Anhydride	3	0.1
Perfume	3	0.1
Phthalic Anhydride	3	0.1
Sand	3	0.1
Tar Fumes	3	0.1
Trichloroethylene	3	0.1
X-ray Developing Fluids	3	0.1
Other*	105	5.1
TOTAL	2,074	100.2**

* There were two cases each with the following exposures: Azodicarbamide, Copper Oxide, Drywall Dust, Ethylene Glycol Monobutyl Ether, Gas and Oil Refinery Exposures, Heat, Hydraulic Oil, Medications, Mold Release, Naptha, Nickel, Ozone, Pepper Gas, Phosgene, Polyester, Polyethylene, Polyvinyl Butyrate, Psyllium, Sodium Hydroxide, Sulfite, Teflon, Textile Lint, Zinc, Zinc Oxide.

There was one case each with the following exposures: 1,3, Dichloro-2-Propanol, 1,3 Dichloro 5 5-Dimethyl Hydrantoin, Ammonium Hydroxide, Anesthesia , Asphalt, Blood, Blue Prints, Cellulose, Chlorpyrifos, Citrus Spray, Coal Dust, Copier Toner, Cyanide, Ethylene Oxide, Exercise, Explosion, Fire Extinguisher Powder, Fireproofing Chemicals, Flares, Flux, Glaze, Gortex, Hair Remover, Heptane, Hydrogen Peroxide, Hydrogen Sulfide, Iodine, Lactase, Lavender Soap, Limone, Methamphetamine Lab, Methanol, Methylene Chloride, Monoammonium Phosphate, Natural Gas, Ninhydrin, Nylon-polyhexamethylene Adipamide, Odor, Perchloroethylene, Platinum, Poly Hexamethylene Biquanide, Potassium Aluminum Fluoride, Potassium Hydroxide, Premicide, Propylene, Sewage, Sludge, Soda Ash, Sodium Acetate, Soot, Stress, Tetrahydrofuran, Triethylamine, Tuberculosis Vaccine, Vinyl Acetate, Weeds, Zinc Borate

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

Table 7. Cigarette Smoking Status of Confirmed Work-Related Asthma Patients: 1988-2003

	Disease Status				
Smoking Status	**ALL***	**OA****	**POA**	**AA**	**RA**
Current Smoker	410 (20.4)	180 (21.7)	124 (16.4)	50 (21.6)	56 (28.9)
Ex-Smoker	792 (39.4)	324 (39.1)	319 (42.1)	71 (30.7)	78 (40.2)
Non-Smoker	809 (40.2)	325 (39.2)	314 (41.5)	110 (47.6)	60 (30.9)
Total	**2,011**	**829**	**757**	**231**	**194**

*Total number of cases: 2,011. Smoking status was missing on 63 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: 1988-2003

	Disease Status				
Family History of Allergies	**ALL***	**OA****	**POA**	**AA**	**RA**
YES	776 (42.6)	307 (39.8)	298 (43.1)	108 (56.0)	63 (37.5)
NO	1,047 (57.4)	464 (60.2)	393 (56.9)	85 (44.0)	105 (62.5)
Total	**1,823**	**771**	**691**	**193**	**168**

*Total number of cases: 1,823. Missing data on 251 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: 1988-2003

Personal History	Disease Status				
	ALL*	OA**	POA	AA	RA
YES	924 (44.6)	316 (37.4)	317 (40.8)	225 (90.0)	66 (32.7)
NO	1,150 (55.4)	529 (62.6)	460 (59.2)	25 (10.0)	136 (67.3)
Total	**2,074**	**845**	**777**	**250**	**202**

*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: 1988-2003

Exposure Status	Total*	*Breathing Problems Still Present* Yes	Less	*Still Taking Asthma Medications* Yes	Less
Still Exposed	553	531 (96.0)	172 (31.1)	478 (86.4)	109 (19.7)
No Longer Exposed	1,348	1,156 (85.8)	667 (49.5)	1,050 (77.9)	396 (29.4)
Total	**1,901**	**1,687**	**839**	**1,528**	**505**

*Total number of cases: 1,901. Information missing on 173 individuals. Number of patients, percentages are in parentheses.

Table 11. Status of Facilities Where 2,074 Patients with Confirmed Work-Related Asthma were Exposed to Allergens: 1988-2003

Inspection Status	Number of Patients Represented	Companies Number	Companies Percent
Inspections	963	588*	40.9
No Follow-up Planned	935	688	47.8
Scheduled for Inspection	17	16	1.1
Closed	51	46	3.2
No Longer Use Occupational Allergen	23	22**	1.5
Sent Company an Indoor Air Letter	36	31	2.2
Sent Company a Letter to Check Exposures	49	48	3.3
Total	**2,074**	**1,439*** **	**100.0**

*588 inspections were conducted in 512 different facilities.
**Eight companies that no longer use the allergen were previously inspected.
***Represents 1,363 different facilities.

Table 12. Results of 588 Industrial Hygiene Inspections in 512 Facilities Where Patients with Confirmed Work-Related Asthma were Exposed to Allergens: 1988-2003

Inspection Results	Number	Percent
Air Sampling - NIOSH Standard		
Above NIOSH Standard	60	10.2
Below NIOSH Standard	349	59.4
No NIOSH Standard	11	1.9
Unknown (no report yet)	2	0.3
Did Not Sample for an Allergen	9	1.5
Did Not Sample	157	26.7
Total	**588**	**100.0**
Air Sampling - MIOSHA Standard		
Above MIOSHA Standard	27	4.6
Below MIOSHA Standard	389	66.2
No MIOSHA Standard	3	0.5
Unknown (no report yet)	2	0.3
Did Not Sample for an Allergen	10	1.7
Did Not Sample	157	26.7
Total	**588**	**100.0**

Table 13. Symptoms Consistent with Work-Related Asthma Among Fellow Workers of the 2,074 Confirmed Work-Related Asthma Patients

	Disease Status of Index Patient				
Symptoms*	**ALL****	**OA**	**POA**	**AA**	**RA**
Daily or Weekly SOB, Wheezing or Chest Tightness	1,397 (16.5)	1,052 (17.2)	310 (15.0)	4 (16.0)	31 (12.9)
OSHA Log***	548 (19.6)	392 (23.6)	145 (13.6)	2 (12.5)	9 (9.5)
Total	**1,945********	**1,444*****	**455**	**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. Prevalence of Adults with Current Asthma Reporting an Association with Work in 3 States: California, Massachusetts, and Michigan Behavioral Risk Factor Surveillance System (BRFSS) Results, 2001

(Percentages with 95% confidence intervals)

	California n=4,188	Massachusetts n=8,268	Michigan n=3,830
Possible WRA (yes to either Q1 or Q2)			
All	7.4 ± 3.6	8.4 ± 2.2	9.7 ± 3.2
Male	9.8 ± 7.2		12.6 ± 6.8
Female	6.1 ± 3.9		8.1 ± 3.3
Childhood Onset*			
All	-	3.5 ± 2.9	5.3 ± 3.7
Male	-	1.0	5.7
Female	-	5.4	4.9
Adult Onset*			
All	-	11.8 ± 3.3	12.7 ± 4.9
Male	-	15.1	20.1
Female	-	10.2	9.9
Q1. Did you ever tell a doctor or other medical person that your asthma was related to any job you ever had?			
All	3.9 ± 2.4	4.7 ± 1.5	7.0 ± 2.9
Male	5.5 ± 5.1		10.4 ± 6.4
Female	3.1 ± 2.5		5.1 ± 2.8
Childhood Onset*			
All	-	1.6 ± 1.3	4.0 ± 3.3
Male	-	0.7	4.9
Female	-	2.3	3.2
Adult Onset*			
All	-	6.7 ± 2.5	9.3 ± 4.6
Male	-	7.3	18.0
Female	-	6.4	6.0
Q2. Were you ever told by a doctor or other medical person that your asthma was related to any job you ever had?			
All	5.8 ± 3.2	6.0 ± 2.0	5.8 ± 2.3
Male	8.4 ± 6.9		6.1 ± 4.0
Female	4.4 ± 3.3		5.6 ± 2.8
Childhood Onset*			
All	-	2.6 ± 2.6	3.4 ± 2.9
Male	-	1.0	3.6
Female	-	3.8	3.3
Adult Onset*			
All	-	8.4 ± 2.8	7.3 ± 3.3
Male	-	11.6	7.7
Female	-	6.9	7.1

Age of onset not asked in California

Table 15. Michigan Workers Exposed to Isocyanates by County, in Calendar Year 2002

County	# Workers Potentially Exposed to Isocyanates** Divided by Total # Workers in the County***	% Workers Potentially Exposed to Isocyanates	
Allegan, Kent, Muskegon, Ottawa	**10,875/ 576,300**	**2**	**COMPANIES*----------**
			Brunswick Bowling Counter Point Furniture Donnelly G P M H B Fuller Haworth Howard Miller Johnson Controls Interiors Knape & Vogt Meridian Auto Systems Purforms, Inc. Steelcase Wolverine World Wide
Barry	**1,040/ 12,900**	**8**	**COMPANIES----------**
			Bradford White
Bay, Saginaw, Midland	**8,349/ 174,600**	**5**	**COMPANIES----------**
			Bay Cast Delphi Saginaw Steering Dow Chemical Company Eaton Corporation Glastender GMC Saginaw Metal GM Powertrain/Saginaw Malleable Iron Lendell Manufacturing

Berrien	**2,800/ 71,000**	**4**	**COMPANIES----------** Bosch Braking Leco Tyler Refrigeration
Branch	**25/ 16,250**	**<1**	**COMPANIES----------** Acore Door
Calhoun, Kalamazoo, Van Buren	**1,823/ 213,800**	**1**	**COMPANIES----------** Arvco Container Azon USA Cello-Foil Checker Motors Comcast Urethane Degussa Construction Hayes Albion Corp. Special-lite
Cass	**600/ 10,625**	**6**	**COMPANIES----------** Georgie Boy Manufacturing
Charlevoix	**500/ 10,575**	**5**	**COMPANIES----------** East Jordan Iron Works
Clare	**470/ 7,950**	**6**	**COMPANIES----------** Louisiana Pacific Renosol
Dickinson	**550/ 14,775**	**4**	**COMPANIES----------** Grede Foundries

Eaton, Clinton, Ingham	**258/ 233,700**	**<1**	**COMPANIES----------**
			ASC Lansing Trim Axson Collins & Aikman Innovative Polymers Philips Products Vantico
Genesee	**500/ 159,300**	**<1**	**COMPANIES----------**
			Delphi Energy and Chassis Flint East
Hillsdale	**200/ 16,800**	**1**	**COMPANIES----------**
			Dow
Iosco	**60/ 10,125**	**1**	**COMPANIES----------**
			Tawas Industries
Isabella	**850/ 29,500**	**3**	**COMPANIES----------**
			Delfield Randell Manufacturing
Jackson	**929/ 62,700**	**1**	**COMPANIES----------**
			Adco Products Michigan Seat Tac Manufacturing

Lapeer, Macomb, Monroe, Oakland, St. Clair, Wayne	**18,364/ 2,105,000**	**1**	**COMPANIES----------**
			Armaly Sponge Autolign Manufacturing BASF Cass Polymers Collins & Aikman Daimler-Chrysler Jefferson Assembly Daimler-Chrysler McGraw Glass Plant Delta-ha Du Pont EFTEC H P Pelzer International Casting ITW Foamseal Johnson Controls Lear Lymantal International M & H Industries Plastomer Recticel Recycled Polymeric Materials, Inc. Romeo Rim Takata Petri US Farathane Visteon Visteon Utica Wolverine Bronze Woodbridge
Lenawee, Livingston, Washtenaw	**5,550/ 282,900**	**2**	**COMPANIES----------**
			Anderson Development Brighton Interiors (Ontegra) Collins & Aikman Ixtlan Technologies Pilkington Clinton Tecumseh Compressor Products Versatrim

			Visteon Saline Woodbridge
Mason	**300/ 10,700**	**3**	**COMPANIES----------** Great Lakes Casting
Mecosta	**1,000/ 13,225**	**8**	**COMPANIES----------** Wolverine World Wide
Montcalm	**2,000/ 19,500**	**10**	**COMPANIES----------** Electrolux Refrigerator Division
Ogemaw	**200/ 7,025**	**3**	**COMPANIES----------** Taylor Building Products
Sanilac	**150/ 12,975**	**1**	**COMPANIES----------** Numatics
Upper Peninsula	**760/ 126,800**	**1**	**COMPANIES----------** Emerson Tool Louisiana Pacific
Wexford, Missaukee	**1,080/ 18,200**	**6**	**COMPANIES----------** Four Winns Sport Hayes Lemmerz
TOTAL	**59,173/ 4,475,000**	**1**	

*Source: U. S Environmental Protection Agency. Toxics Release Inventory, Michigan Companies Using Isocyanates in 2002 (report generated June 24, 2004).
**Source: Michigan Manufacturer's Directory, 2002 and 2003.
***Source: Michigan Department of Career Development/Employment Service Agency. Annual Average 2002 Area Labor Statistics, Total Wage and Salary Employment by Place of Work (5/9/2002).