

## Work-Related Asthma in Wisconsin

Occupational Health Surveillance Program  
Bureau of Environmental and Occupational Health

## List of Abbreviations and Acronyms

BLS	Bureau of Labor Statistics
CDC	Centers for Disease Control and Prevention
CSTE	Council of State and Territorial Epidemiologists
DHS	Department of Health Services
ED	Emergency Department
FACE	Fatality Assessment and Control Evaluation
HD	Hospital Discharge
ICD-9	International Classification of Diseases, 9 <sup>th</sup> Revision
NAICS	North American Industry Classification
NIOSH	National Institute for Occupational Safety & Health
OA	Occupational Asthma
OHS	Occupational Health Surveillance
OSHA	Occupational Safety and Health Administration
SIC	Standard Industrial Classification
SOC	Standard Occupational Classification
WAA	Work-aggravated Asthma
WC	Workers' Compensation
WRA	Work-related Asthma

Henry Anderson, MD  
Chief Medical Officer  
[henry.anderson@wisconsin.gov](mailto:henry.anderson@wisconsin.gov)

Pamela Rogers, MPH  
Epidemiologist  
[pamela.rogers@wisconsin.gov](mailto:pamela.rogers@wisconsin.gov)

Wisconsin Department of Health Services  
Division of Public Health  
Bureau of Environmental & Occupational Health  
Occupational Health Surveillance Program  
P.O. Box 2659 Room 150  
Madison, WI 53701-2659  
Phone: 608-264-9829



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## Summary

Each year the Wisconsin Occupational Health Surveillance (OHS) Program releases a report to increase awareness of hazards in Wisconsin workplaces. Last year's report focused on the indicators of occupational health collected through surveillance activities. This year the focus is on one specific occupational health illness - work-related asthma (WRA).

Data for this report were obtained from four sources: workers' compensation claims; hospital discharge records; emergency department visit records; and death records. Data ranged from 1999 through 2006, depending on the data source. Additional data used include surveys and research conducted in Wisconsin and other states during various timeframes.

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."* However, confirming this finding through state-based surveillance data has been difficult. Recently the Wisconsin OHS Program has used available data sources to investigate the prevalence and characteristics of WRA in the state. A Wisconsin BRFSS survey conducted in 2006 found 11% of Wisconsin residents with asthma reported that they had been told by a doctor or health professional that their asthma was related to either a current job or to one they held in the past. Using those findings, as many as 71,000 Wisconsin residents may have work-related asthma.

There are different types of WRA. Workplace exposures may cause onset of new asthma from exposure to an allergen or an irritant that precipitates inflammatory changes, or they may exacerbate pre-existing asthma. Almost eighty percent of the workers' compensation claims for asthma involve the new-onset asthma. Over 300 agents or work processes have been associated with WRA. Nationwide, indoor air pollutants, dusts, cleaning materials, lubricants and diisocyanates are among the most frequently reported causes of WRA (Jajosky, 1999, CDC/NIOSH, 2008). In Wisconsin, dust, smoke, fumes, chemicals, and vapors are often cited as making breathing difficult at work. While exposures to allergens contributing to asthma exacerbations are occurring in a wide range of workplaces, air monitoring at these same facilities typically reveal that exposure to the suspected allergen or irritant is within existing workplace standards approximately 95% of the time, however, significant numbers of symptomatic individuals can be identified (Rosenman, 2006).

According to the Wisconsin data examined, WRA affects both men and women. While it most frequently affects those from the ages of 35-45 years, WRA has been reported in workers as young as 12 years of age and as old as 66 years of age. Most workers who report having WRA are Caucasian; however, when looking at the rate of this illness (the proportion of those affected to the number of workers), African-American workers are affected over twice as often as Caucasian workers.

In order to create awareness and prevent workplace exposures that can cause or exacerbate asthma, Wisconsin has implemented a series of mini-grants for work-related asthma research and interventions. Five projects will be completed by the end of June 2009. These include raising physician awareness of WRA; developing standard diagnosis criteria; raising employer and employee awareness of WRA; advocating for smoke-free workplaces, and researching bio-aerosol allergens in the dairy industry.

### Conclusions

- The work-related asthma (WRA) burden contributes approximately 11% to the overall asthma burden in Wisconsin
- There are two types of WRA – new-onset asthma and work-aggravated asthma
- African-American workers have a higher rate of WRA than Caucasians
- Indoor air quality is frequently cited as a cause of WRA in Wisconsin

# Introduction

Data collected in the 2006 Behavioral Risk Factor Surveillance Survey (BRFSS) show that 13% of Wisconsin adults report having asthma at sometime during their life. Asthma is a chronic lung disease characterized by ongoing airway inflammation that can result in episodic events of wheezing, shortness of breath, coughing and chest tightness. Individuals with asthma have increased airway reactivity often in response to stimuli such as environmental allergens and irritants, viral infections and cold air.

Asthma is identified as a statewide health status priority in the Wisconsin public health plan, *Healthiest Wisconsin 2010* (available at <http://dhs.wisconsin.gov/statehealthplan/>). The Wisconsin Department of Health Services (DHS) seeks to comprehensively address the burden of asthma, including work-related asthma, through surveillance, partnerships and interventions. To do so the *Wisconsin Asthma Plan* (available at <http://dhs.wisconsin.gov/eh/Asthma/WAP.htm>) was developed as a blueprint for addressing this public health priority.

Work-related asthma is a common occupational respiratory disease in all industrialized countries. (CDC/NIOSH, 2004). Irritants and allergens in the workplace can cause asthma or make existing asthma worse. Nationwide it is estimated that work-related asthma (WRA) accounts for at least 10% of all adult asthma. (Youakim, 2001)

## Types of work-related asthma

Asthma related to the workplace is generally categorized into two subsets: *work aggravated asthma* and *new-onset asthma*.

### Work-aggravated asthma

Persons with *work-aggravated asthma* have a history of preexisting asthma. Asthmatic episodes can be triggered in the workplace by stressors such as allergens, dusts, abnormal temperatures, poor indoor air quality, and physically strenuous work or chemicals. A study of the prevalence of work-aggravated symptoms in clinically established asthma cases in Finland found that the prevalence of work-aggravated asthma is common among employed adults with asthma and that the prevalence increases with age (Saarinen, 2003). A study in of work-aggravated asthma the United States found that the risk of work-aggravated asthma was the highest in industries classified as public administration (Goe, 2004; Henneberger, 2007).

### New-onset asthma

*New-onset asthma* develops as a direct result of some workplace exposure. Two forms of new-onset asthma generally are recognized - reactive airway dysfunction syndrome (RADS) and allergic occupational asthma (OA).

RADS usually develops after a single high dose of an irritant chemical, often the result of an accident, spill or equipment failure. In

RADS, workers usually develop asthma symptoms, such as difficulty breathing, and wheezing, within 24 hours of an exposure event such as an unscheduled chemical release. The Department of Health Services' Hazardous Substance Emergency Events Surveillance (HSEES) program tracks these events. As an example, a summary of a 15-year period of ammonia release in Wisconsin including the counties in which they occurred is included in this report.

Occupational asthma is a result of repeated exposure to an agent in the workplace. With repeated exposure a worker becomes sensitized or allergic to that substance. Eventually exposure will manifest as broncho-spasms and airway inflammation. The time it takes to develop symptoms can be as short as several weeks or as long as 30 years. Table 3 lists known allergens and industries where they are found. There are over 300 allergens found in the workplace. A comprehensive list can be found on the Asmapro website at <http://www.asmanet.com/asmapro/accueil-cd.html>. An abbreviated listing was compiled by New Jersey and can be accessed at: <http://nj.gov/health/eoh/survweb/wra/documents/asthmagens.pdf>.

## Type and Sub-type of work-related asthma

Type	Sub-Type	Key Elements
Work-aggravated	None	<ul style="list-style-type: none"> <li>• Previous asthma diagnosis</li> <li>• Recurrent episodes</li> <li>• Triggered by workplace</li> </ul>
New-onset	Reactive airway dysfunction syndrome (RADS)	<ul style="list-style-type: none"> <li>• Single high-dose exposure</li> <li>• Symptoms occur within 24 hours of exposure</li> <li>• Direct lung irritation</li> </ul>
	Occupational asthma	<ul style="list-style-type: none"> <li>• Repeated sensitizing exposure</li> <li>• Symptoms develop after a variable latent period</li> <li>• Allergic reaction causes lung dysfunction</li> </ul>

## Agents of Reactive Airways Dysfunction Syndrome (RADS)

Agent	Industry
2-diethylaminoethanolamine	Plastics manufacturing
Acetic acid	Dairy and food manufacturing
Anhydrous ammonia	Refrigeration manufacturing and repair
Bleaching agents	Building maintenance (cleaning), painting, adhesive use and manufacturing
Burned paint fumes	Cleaning and restoration, fire fighters
Chlorine gas	Cleaning, water treatment
Floor sealant	Maintenance, construction
Hydrochloric acid	Battery manufacture and installation, paper manufacture
Hydrogen sulfide	Agriculture, maintenance
Automotive or diesel exhaust	Auto repair
Phosgene	Plastic production, pesticide manufacture and application, maintenance
Phosphoric acid	Fertilizer, detergent, flooring, food and pharmaceutical production
Silicon	Glass, concrete and cement manufacture and grinding
Silo gas	Agriculture
Smoke (inhaled)	Fire protection, hospitality
Sodium hydroxide	Paper, textile and detergent manufacture, maintenance, water treatment
Sulfuric acid	Chemical manufacturing, ore processing, wastewater treatment
Toluene diisocyanate	Polyurethane product manufacture, maintenance
Welding fumes (NO, CO, MnO <sub>2</sub> )	Welding
Zinc chloride	Textile and chemical manufacturing, welding

## Occupational Asthma Allergens and Occupations Affected

Type of Allergen	Allergen	Occupation
Animal	Urine and other protein	Animal handler, research scientist
	Grain mite	Farmers, grain store workers
	Shellfish	Seafood processors
	Egg protein	Egg production workers
Plant	Grain dust	Grain storage workers
	Flour, wheat, soy or rye	Bakers, millers
	Latex	Healthcare workers
	Green coffee beans	Coffee roasters
	Henna	Hairdressers
	Gum acacia	Printers
Enzymes	Protease from <i>B. subtilis</i>	Detergent industry workers
	Pancreatin, papain, pepsin	Pharmaceutical industry workers
	Fungal amylase	Bakers
Wood dusts or bark	Western red cedar, iroko, cinnamon, oak, mahogany, redwood, African apple	Sawmill workers, joiners, carpenters
Drugs	Penicillians, psyllium, cimetidine, salbutamol, intermediates	Pharmaceutical and healthcare workers
Other	Oil mists	Tool setters

**HAZARDOUS SUBSTANCES EMERGENCY EVENTS SURVEILLANCE (HSEES)  
FIFTEEN-YEAR PERIOD: JANUARY 1, 1993 THROUGH DECEMBER 31, 2007**

TOTAL AMMONIA EVENTS

The number of ammonia events meeting the surveillance definition of the HSEES System during this 15-year period totaled **719** (12% of total events).

EVENTS, VICTIMS AND EVACUEES\*

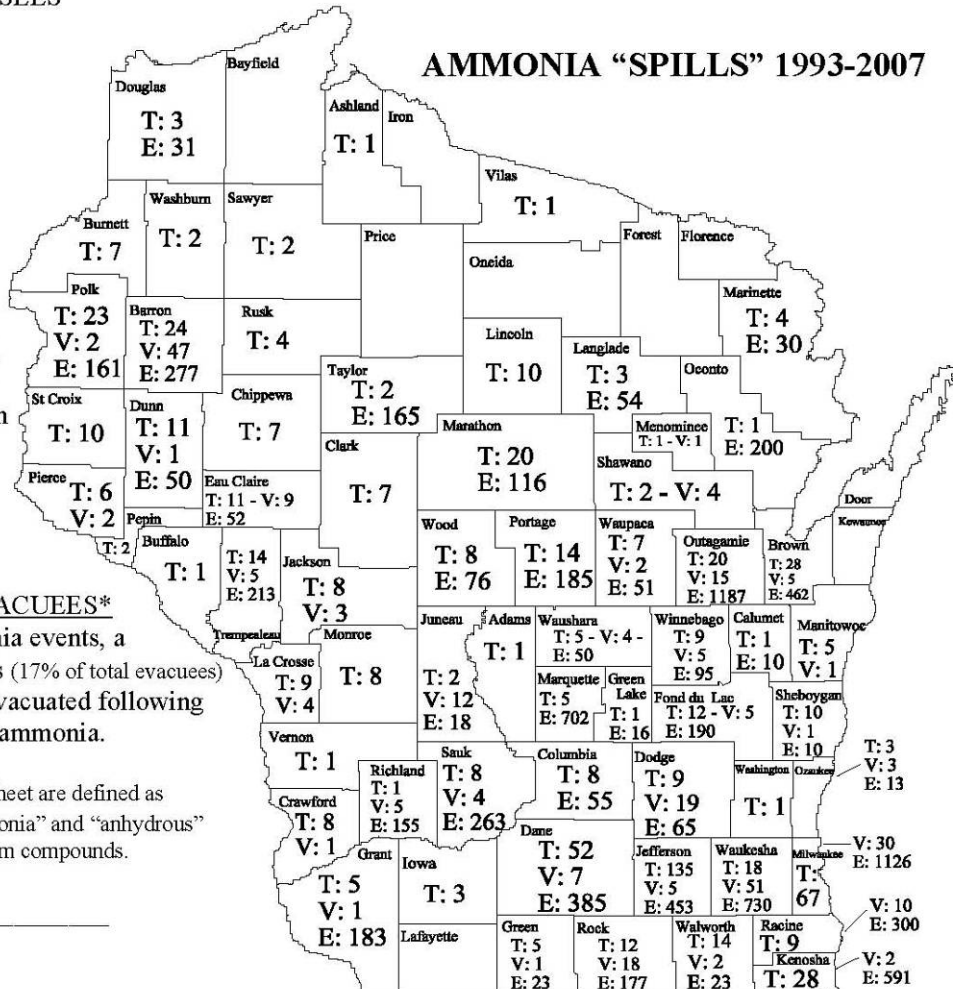
AMMONIA EVENTS WITH VICTIMS

Of the 719 total ammonia events, **102** events resulted in a total of **287** victims (19% of total victims), with each person suffering from at least one verifiable injury resulting from exposure to ammonia.

AMMONIA EVENTS WITH EVACUEES\*

During 174 of the 719 total ammonia events, a minimum total of **8,943** individuals (17% of total evacuees) were ordered to evacuate, or self-evacuated following a release (or threatened release) of ammonia.

Note: Total Ammonia Events in this fact sheet are defined as only those including the descriptors "ammonia" and "anhydrous" and do not include, for example, ammonium compounds.



Note: The HSEES system does not include events where only petroleum products have been released

ABBREVIATION KEY: MAP

T: TOTAL AMMONIA EVENTS

V: AMMONIA VICTIMS

E: AMMONIA EVACUEES

\* (Persons ordered and self-evacuated)

**SUMMARY OF AMMONIA EVENTS IN WISCONSIN  
BY CALENDAR YEAR**

YEAR	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	Cum. Totals
<u>EVENTS</u>	54	46	61	53	46	41	38	30	39	74	68	62	55	29	23	<b>719</b>
<u>VICTIMS</u>	3	10	7	40	18	12	27	5	13	78	22	11	22	17	2	<b>287</b>
<u>EVACUEES</u>	420	294	565	1,039	641	442	1,238	1,060	427	346	173	823	359	332	784	<b>8,943</b>

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## Data Sources

Data and information used in this report came from six data sources – the Behavioral Risk Factor Surveillance Survey (BRFSS), inpatient hospital discharge billing data, emergency department visit billing data, death records, workers' compensation claims data, and national information published in research reports. Use of such administrative datasets has both strengths and limitations. The main strength is their availability. No new data collection is required, and access can be easily obtained. However, administrative data has limitations. In most cases, the primary purpose of assembling such data is not public health surveillance; as such, fields collected for purposes other than billing may be incomplete or not thoroughly checked for accuracy. These data seldom tell the whole story and further analysis is necessary to understand the nature of the problem. Because of these data limitations one must be cautious in their comparison and interpretation. The material that follows includes a more detailed description of the data sources and their use in this report.

### Workers' Compensation Data

The Workers' Compensation (WC) program is an insurance program designed to cover medical expenses and lost income of workers who become injured or ill during the course of doing work activities. Claimant disease and injury information is captured in an incident narrative. The Wisconsin Occupational Health Surveillance (OHS) program receives a select subset of these data in order to conduct surveillance for asthma in the workplace. Data examined only claims that have been paid for days away from work. The most meaningful measures for these data are rates of occurrences per number of workers (incidence rate) or per number of hours worked (frequency rate) and the costs associated with injury occurrence.

Strengths of these data include the large number of records in the database, as well as the collection of industry and occupation through standard codes.

Weaknesses include incomplete data. While the collection of industry and occupation is a strength of these data, only 44% of the WC data used in our analysis had complete information. Other weaknesses include underreporting of accidents and illness because of claim suppression and contestation, the omission of events not resulting in missed time at work, and the lack of racial or ethnicity information.

### Hospitalization Discharge Data

Wisconsin keeps records of all patients admitted to medical facilities in the state including, acute care and non-federal hospitals, and other institutions such as general medical/surgical, psychiatric, alcohol and other drug abuse (AODA), and rehabilitation facilities. Hospital inpatient discharge records are reported quarterly to the Wisconsin Hospital Association as required by Wisconsin statute and administrative code.

This administrative dataset was developed primarily for billing purposes, but these data have been used by researchers, analysts and planners for a broad range of other purposes as well. Specifications for the data elements reported are based on the Uniform Billing Form (UB-92) and include patient demographic data, admission and discharge data, charge and payer data, and ICD-9 CM-coded diagnostic and procedure information.

Hospital discharge records are extensively checked and edited for quality and completeness, and hospitals are required to verify or correct all invalid codes and missing or inconsistent items. These data, however, have not been audited by comparisons to actual source hospital billing and medical records. To use hospital discharge data effectively, it is necessary to have denominator data for the areas and populations that will be examined. Hospital utilization is generally expressed as a rate (e.g. admissions or discharges per 100,000 area population).

Strengths of use of these data include easy accessibility, timeliness, and completeness, allowing for use of these data repeatedly over time to identify trends.

The weaknesses of this dataset include the inability of comparison to the larger population due to bias of physician interpretation of diagnosis and other variations from hospital to hospital in the quality of medical records coding. Using hospital discharge data as a tool for occupational health surveillance may not capture all relevant cases. This is true for several reasons. First, only the most severe cases are admitted to the hospital for treatment and hospitalizations of Wisconsin residents occurring in other states are not captured in the Wisconsin Hospital Association's database. Additionally, data from the state's three federal VA hospitals in Wisconsin are also excluded. In many cases, patient bills for work-related illness and injury may be paid by private insurance rather than by workers' compensation.

Criteria for Using Hospital Discharge Records
<ul style="list-style-type: none"><li>• Payer = Workers' Compensation</li><li>• Principal diagnosis (ICD-9) code = 493.0-493.9</li><li>• Zipcode = zipcode of Wisconsin residence</li></ul>

### Emergency Department Visits

This source of data contains individual-level data for visits to the emergency department of Wisconsin hospitals (general medical-surgical, psychiatric, alcohol and other drug abuse, rehabilitation, and state hospitals). Data elements received include hospital identifiers, diagnosis and procedure codes, expected total charges, the expected payer of those charges, the source and type of admission, and the patient discharge destination. Physician license numbers are not included; however the Physician-Enhanced Emergency Department Dataset links discharge data with physician information.

Use of these electronic datasets is a relatively recent development. Collection and distribution began in 2002. Because of its recent development, some potential problems with data quality persist. For purposes of this report, the ED visit records were used as a measure of prevalence and severity. Although emergency department visit data were used as a surrogate

for the severity of exposure or injury, it is difficult to determine the magnitude of the exposure; if multiple workers are exposed in the same workplace and obtain treatment in different facilities and their treatment may not be recognized as a consequence of the same event.

For purposes of WRA surveillance the selection criteria used with ED visit data are the same as hospital discharge selection criteria with workers' compensation listed as the payer. As with all other datasets, analysis of administrative data cannot provide a causal explanation for a high rate. ED data, however, can be of use in the analysis of patterns among population subgroups and geographic areas.

Strengths and weaknesses of this dataset are the same as the hospital discharge data.

### Behavioral Risk Factor Surveillance System

The Behavioral Risk Factor Surveillance System (BRFSS) is a random-digit-dialed telephone survey of the US civilian, non-institutionalized population aged 18 years and older with telephones. Survey respondents are randomly selected to ensure that the survey data will be representative of all adults in Wisconsin. Survey data are adjusted or "weighted" by age and sex distribution for Wisconsin's population so that the resulting estimates can be generalized to the state's entire population, not just those who responded to the survey. The BRFSS asks respondents about their health and health behaviors. For work-related asthma, a separate, additional survey, the asthma follow-up survey, is offered for administration to any respondent who claims to have had asthma.

Data for the 2006 follow-up survey were examined and used to provide an estimate of the prevalence of work-related asthma in Wisconsin. The major strengths of the BRFSS include its ease in collecting a large amount of state-specific data. Since the survey has been conducted for more than two decades, there is a wealth of experience in data collection as well as showing trends over time.

Weaknesses include that the exclusion of subjects without home telephones, the self-reported nature of the data, and the inability to link follow-up survey data to original survey results.

### 2006 BRFSS Asthma Call-Back survey responses for work-relatedness

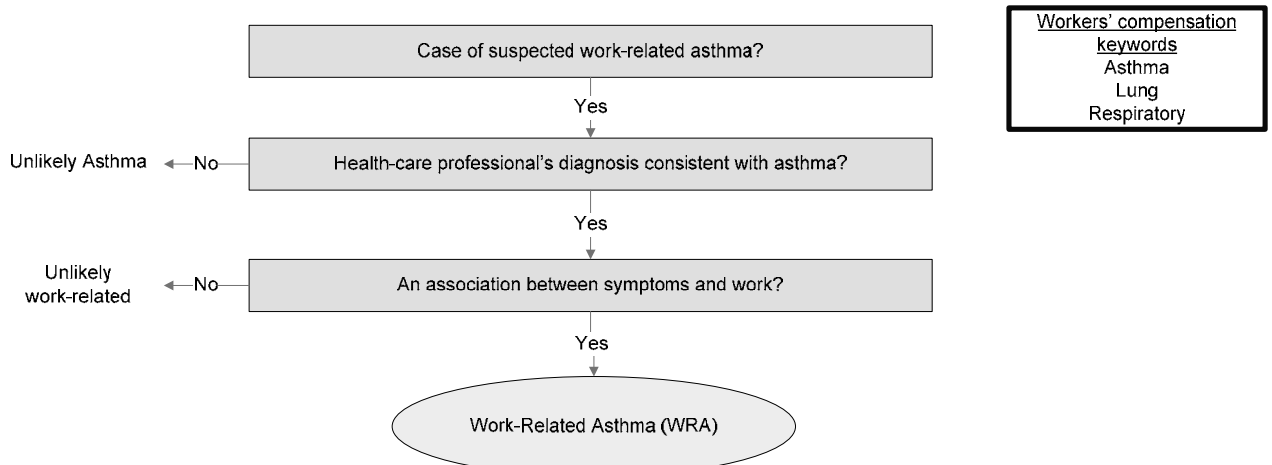
Measure	Criteria	Numerator	Denominator	Result
Lifetime Prevalence or work-related asthma	Told by a medical professional that their asthma was related to any job they ever had	# answered YES	# who've ever had a job and report having asthma	11%
Severity	Changed or quit a job because chemicals, dust or fumes at work caused or made asthma worse	# answered YES	# who've ever had a job and report having asthma	7.4%

### 2004 Union survey responses for work-relatedness

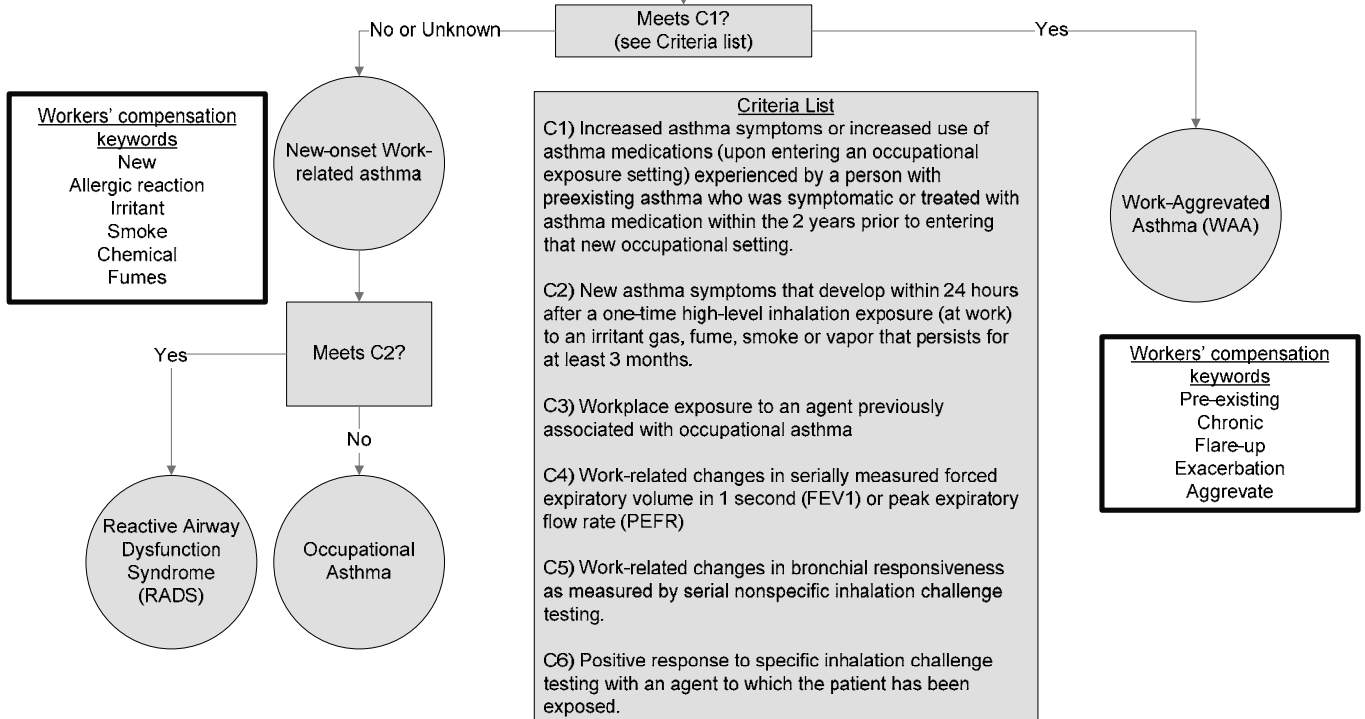
Measure	Criteria	Numerator	Denominator	Result
Lifetime Prevalence of work-related asthma	Told by a medical professional that their asthma was related to any job they ever had	# answered YES	# who've ever had a job and report having asthma	13.6%

# Work-related Asthma Case Definition and Case Classification

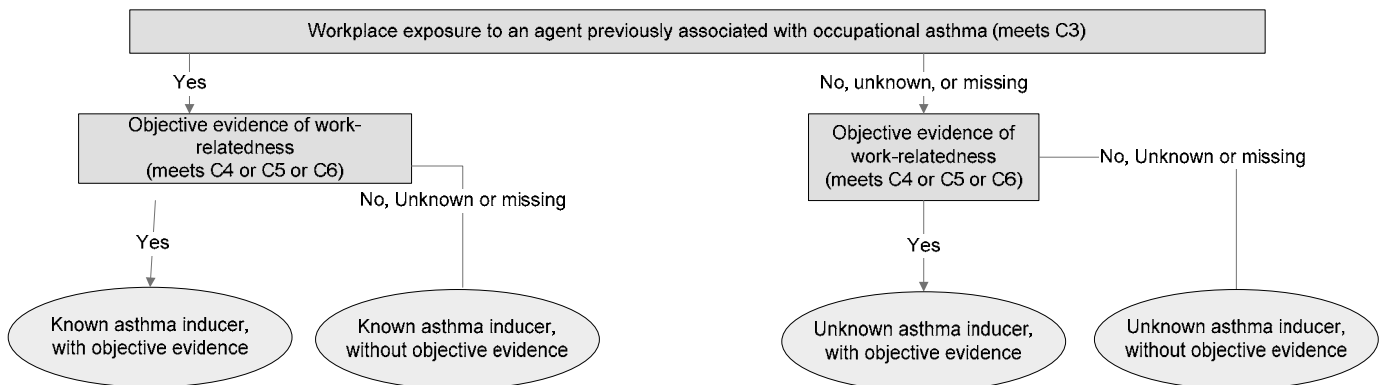
## Case Identification



## WRA Case Classification



## Occupational Asthma Subclassification



## Vital Records/Death Records

Among the first administrative databases used to understand the nature and extent of health and safety issues were vital statistics records. Vital records are records of life events such as births, deaths, marriages and divorces. Deaths in Wisconsin are reported by the county vital records offices and by two city health offices to DHS. Death records are completed by physicians, coroners, funeral directors or county or city health officers. These records are by DHS' Bureau of Health Information and Policy (BHIP). While death records may include the occupation and industry of the deceased, this information is not keyed as part of the electronic record. As such, drawing conclusions from death records about the entire population can be problematic.

Strengths of this dataset include the richness of data. Information on race/ethnicity, education is included. Zip-code-level analysis often can provide findings of interest to planners and policymakers.

One weakness of these data is the relatively small number of records. In some cases, data may be aggregated to protect confidentiality. This makes it difficult to associate the findings to the general population.

## Other Data Sources

### Surveys

A survey is another type of non experimental descriptive study where inferences about behavior are made from data collected via interviews or questionnaires. If large enough, surveys are likely the best way to obtain the most accurate information about the prevalence of work-related asthma in Wisconsin. Surveys are particularly useful for assessing events that are difficult to directly observe and when it is desirable to sample a large number of subjects. The major limitation of survey data is in the methodology used to collect the data. Surveys rely on self-reporting, and intentional deception, poor memory or misunderstanding of the questions asked can all contribute to inaccuracies and bias in the data. Furthermore, the descriptive nature of survey data may make assessments of causality difficult.

Between 2003 and 2004, the occupational health surveillance program conducted a survey of

unionized workers to gather information about asthma diagnosis and allergen exposures in Wisconsin workplaces. A total of 1,837 surveys were completed and analyzed (Islam, 2004).

### Environmental Information

It is known that other environmental factors can exacerbate and contribute to the severity of asthma while at work. These include smoking, exposure to environmental tobacco smoke, particulate matter, and ozone. Particulate matter and ozone can be significant environmental asthma triggers. Data on these pollutants can be obtained from the Wisconsin Department of Natural Resources real-time mapping website for particulate matter and ozone, which is at <http://dnrmaps.wisconsin.gov/imf/imf.jsp?site=wisards>

### Census Information

To determine the denominator for crude rates, the 2000 census Wisconsin population for those over 18 was used. Age-adjusted rates were also determined using the 2000 census data for each age category. Information specific to counties was obtained from the Wisconsin county profiles available at [http://dwd.wisconsin.gov/oea/county\\_profiles/archived.htm](http://dwd.wisconsin.gov/oea/county_profiles/archived.htm).

### Scientific Literature

The experience of others' research, especially of states similar to Wisconsin can be a good starting point to estimate or investigate WRA, by applying findings to Wisconsin.

CDC/NIOSH. Worker Health Chartbook, 2004.

Goe, SK, Henneberger PK, Reilly MJ, Rosenman KD, et al. A descriptive study of work aggravated asthma. 2004. *Occup Environ Med Jun*; 61(6):512-7

Saarinen, K., Karjalainen, A., Martikainen, R. et.al. Prevalence of work aggravated symptoms in clinically established asthma. 2003 *Eur Respir J* 22:305-309

Youakim, Sami, 2001. Work-Related Asthma. *Am Fam Physician Vol* 64, No 11, December 12, 2001, 1839-1848.

Wisconsin Department of Health and Family Services. 2007. Burden of Asthma in Wisconsin

## Results

National studies suggest that up to 23% of workers who have asthma have been confirmed as having work-related asthma by their medical provider. The *2007 Burden of Asthma in Wisconsin* reports that the 2005 lifetime prevalence rate for asthma for individuals aged 18 years and older in Wisconsin is 13% of the population, or approximately 550,000 individuals. If an average of 15% of those who have asthma have work-related asthma, we can estimate that approximately 71,000 adult residents of Wisconsin can be considered to have *work-related* asthma.

Because no single data source can accurately capture all the information needed to for comprehensive surveillance for work-related asthma, a number of data sources were used to obtain the results used for this report. Timeframes for each dataset may differ, therefore, care must be taken to ensure that accurate comparison and interpretation. While the use of multiple data sources may improve prevalence estimates, these surveillance values likely represent a significant underestimate of health events in Wisconsin that are attributable to work-related asthma.

**Workers' compensation data summary:** From 1999 to 2006 the total number of workers' compensation claims submitted has gone down, as has the number of claims for asthma. However the proportion (rate) of workplace asthma claims has increased. From 1999 to 2006, the rate increased from 57/100,000 claims to 75/100,000 claims. According to 1999-2006 WC data, 59% of claims for asthma caused or exacerbated by work were reported for women. Workers in the manufacturing and services industry were the most likely to submit a claim.

**Hospital discharge data summary:** The number of Wisconsin hospitalizations for asthma that were paid by workers compensation was low and varied from year to year. 1999 had the highest number with six. That number has decreased through the years studied to two hospitalizations for asthma paid by workers compensation in 2006, the last year studied. Caucasian females have been hospitalized with asthma with workers compensation paying the bill. The age group most often hospitalized is 45-54 years old.

**Emergency department visit data summary:**

In Wisconsin a similar pattern was found to the hospital discharge records. Since 2002 when emergency department visit data became available through 2006, the number of visits to the emergency department for asthma treatment paid by workers compensation varied by year and ranged from 1-6 visits. The majority of visits to the emergency department were initiated by the patients (79%) as opposed to having a physician referral. As shown with

other datasets, most workers who visit the emergency department for asthma are white women; however, those seen in the emergency department tend to be younger, with 64% of patients younger than 45 years of age.

**BRFSS data summary:**

In Wisconsin, according to the 2006 BRFSS survey data, 11% of individuals who report having asthma report being told that their asthma was work-related. Of those, over 7% had asthma symptoms at work that were severe enough to make them quit their job or be placed in another position.

**Vital records data summary:** In Wisconsin, during the years 2000-2006, there were two fatalities that occurred in the workplace where the primary or the contributing cause of death was asthma. One occurred in 2000 and one in 2005.

**Union survey data summary:** 10.8% of survey respondents had a confirmed asthma diagnosis at some point in their life. Of those with asthma, 13.6% met our definition of occupational asthma. Of the general population in Wisconsin, the WRA prevalence rate was 1.4%. Prevalence of asthma was higher in females; however, WRA diagnoses were equally distributed between genders. The mean age at diagnosis of WRA was 40 years. Among those diagnosed with WRA, 40% worked in the service industry and 56% worked in the manufacturing industry (Islam). Survey data showed that more than 50% of those with WRA used a respirator. The Wisconsin OHS Program is beginning a project to assess the work and health experiences of those who have been diagnosed with asthma and are required to wear respirators at work.

## Discussion

This report makes use of available data to learn about the occurrence of WRA in Wisconsin – who is affected, when and where it occurs. The estimate of WRA in Wisconsin is consistent with the national average estimate of 15% of those with asthma can be considered to have WRA. All of the information obtained for this report can be utilized to provide the basis for developing and evaluating prevention activities and public health practices in order to reduce its occurrence. Recognition of WRA is also critical to manage adults with asthma.

### Prevalence

Using the 2006 BRFSS survey data we find that the lifetime prevalence of WRA is 11% of those who report having asthma. This estimate is supported by the 2004 Wisconsin Union Survey which found 13.6% of workers with asthma were diagnosed as having work-related asthma. This is in alignment with data found in other states and in national literature.

### Severity

Between 2002 through the end of 2006 there were 10 hospitalizations in the state for asthma paid by Wisconsin workers compensation. These ranged from 1 – 3 hospitalizations a year. Emergency department visits ranged from 1-6 visits a year during this time period.

### Trends

Wisconsin workers compensation claims submitted have continued to decline between 1999 through 2006 the years included in this report. For asthma specifically, workers compensation claims paid for asthma in the workplace have also decreased. The rate of workers compensation claims for asthma declined from 57 per 100,000 claims in 1999 to 37 per 100,000 claims in 2006.

### Costs

Total costs associated with paid workers compensation asthma claims in Wisconsin during this period is about \$4.2 million with an average annual cost of about \$520,000. Costs for individual claims ranged from \$28 - \$257,924 with a mean payment of \$21,300.

### Gender

According to the 2007 *Burden of Asthma* report, boys have higher asthma prevalence than

girls, while women have higher asthma prevalence than men. Workers compensation asthma claims are more common for women than men, a rate of 113 per 100,000 claims. This is also supported by hospitalization and emergency department visit data which show a higher rate for asthma-related visits paid for by workers compensation higher in women than in men.

### Age

Ages of those hospitalized for asthma and whose visit was paid for by workers' compensation ranged from 12 to 66, with the most asthma hospitalizations paid by workers' compensation reported for workers between the ages of 35 – 54 years. Workers who sought treatment in emergency departments for their asthma symptoms were of a median age of 41 years old. The median age for WRA inpatient hospitalizations was 46.

### Race

In sheer numbers, most workers who seek treatment for asthma paid by workers compensation are white, not of Hispanic decent. However, when calculating crude rates for each racial category, a ratio of the number of occurrences in each racial category to the number of workers in each racial group, we see that Wisconsin's African-American workers have a higher rate of hospitalizations, emergency room visits and workers' compensation claims for asthma paid by workers' compensation than other racial groups.

### Allergens

In Wisconsin, according to the 2004 *Union Survey* (Islam, 2004), more than 50% of the respondents identified dust, smoke and fumes as responsible for making breathing difficult in

their place of work. Others reported that physical conditions such as poor ventilation (18%), chemicals, vapor or gas (13%) or other non-identified (19%) substances caused their asthma or made their pre-existing asthma worse when they worked.

Others' research has shown that substances like flour and wood dust can become major health hazards when individuals are exposed to them in the workplace. By identifying and controlling exposures, WRA can be prevented. Studies have shown that diisocyanates (e.g. truckbed liners), natural rubber latex (e.g. medical gloves), glutaraldehyde (e.g. disinfectants), molds, epoxy resins and cleaning agents are the most common substances that cause WRA. Some reports suggest that the total number of asthma sensitizers is increasing with many new substances being identified in the

workplace. A short list of these substances has been compiled and is listed at <http://nj.gov/health/eoh/survweb/wra/documents/asthmagens.pdf>

### Industries

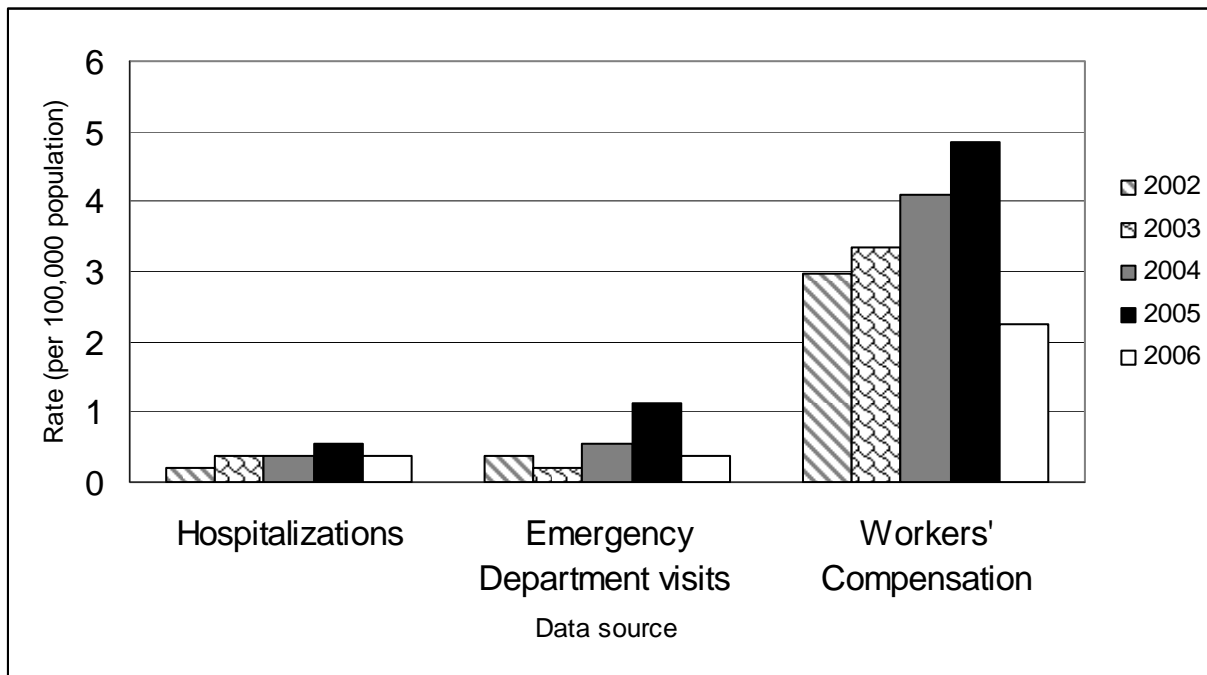
In Wisconsin, most WRA workers' compensation claims submitted come from workers in the manufacturing and services industries. Other asthma claims come from agriculture, public administration, managerial and transportation industries.

Research in three states in 1995 concurred with our findings in that the majority of allergen exposure occurring in the manufacturing and services industry (includes health and hospitality services) (CDC. MMWR, 1995).

Number of WI workers' compensation claims by asthma type, 1999-2005

	# of All Claims	Number of Asthma Claims			
		# New-onset asthma Claims	# Work-Aggregated Claims	# All Asthma Claims	
Total # claims 1990-2006	325,078	155	41	196	
Annual Average # claims	40,635	19	5	25	
Year	1999	50,762	25	4	29
	2000	49,461	32	11	43
	2001	45,145	24	8	30
	2002	40,522	13	3	16
	2003	37,540	16	2	18
	2004	35,554	18	4	22
	2005	34,379	18	8	26

Rate of asthma paid by WI workers' compensation by data source, 2002-2006



### WI Workers compensations claim cost for asthma, 1990-2006

	All Claims	Asthma Claims		
		All Asthma	New-onset	Work-aggravated
Total claims	325,078	196	155	41
Total cost		\$4,174,766	\$3,738,623	\$436,143
Annual average cost		\$521,846	\$467,328	\$54,518
Mean		\$21,300	\$24,120	\$10,638
Minimum		\$28	\$36	\$28
25th percentile		\$638	\$631	\$683
Median		\$2,404	\$5,000	\$1,076
75th percentile		\$30,000	\$35,000	\$5,000
Maximum		\$257,924	\$257,924	\$120,000

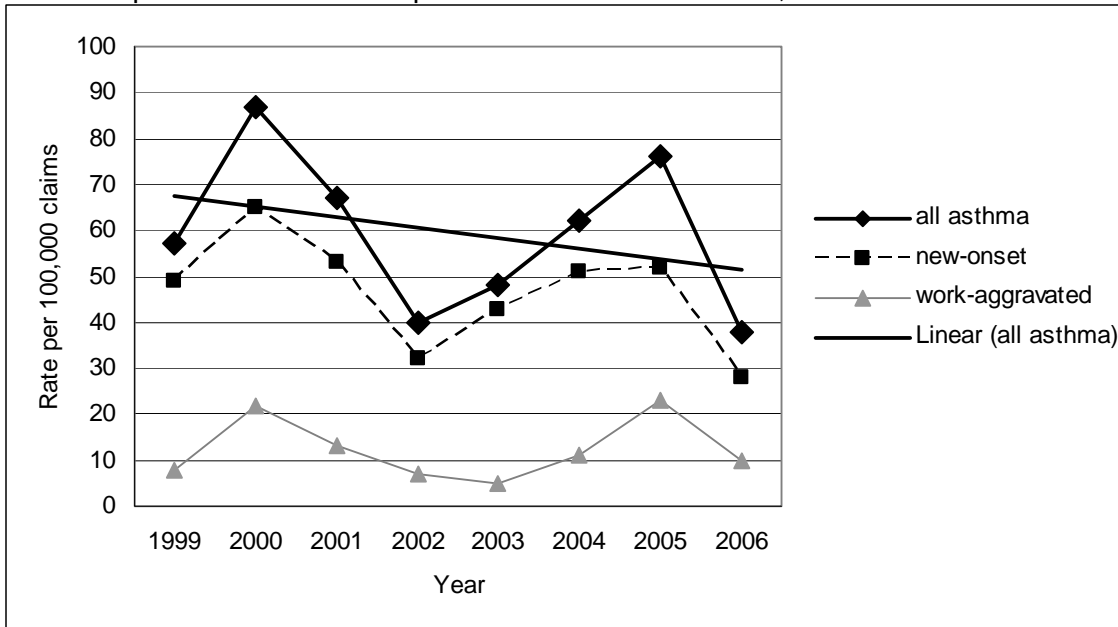
P-value = 0.03 using Kruskal-Wallis test

### Number of hospitalizations and emergency department visits for asthma paid by WI workers' compensation, 1999-2005

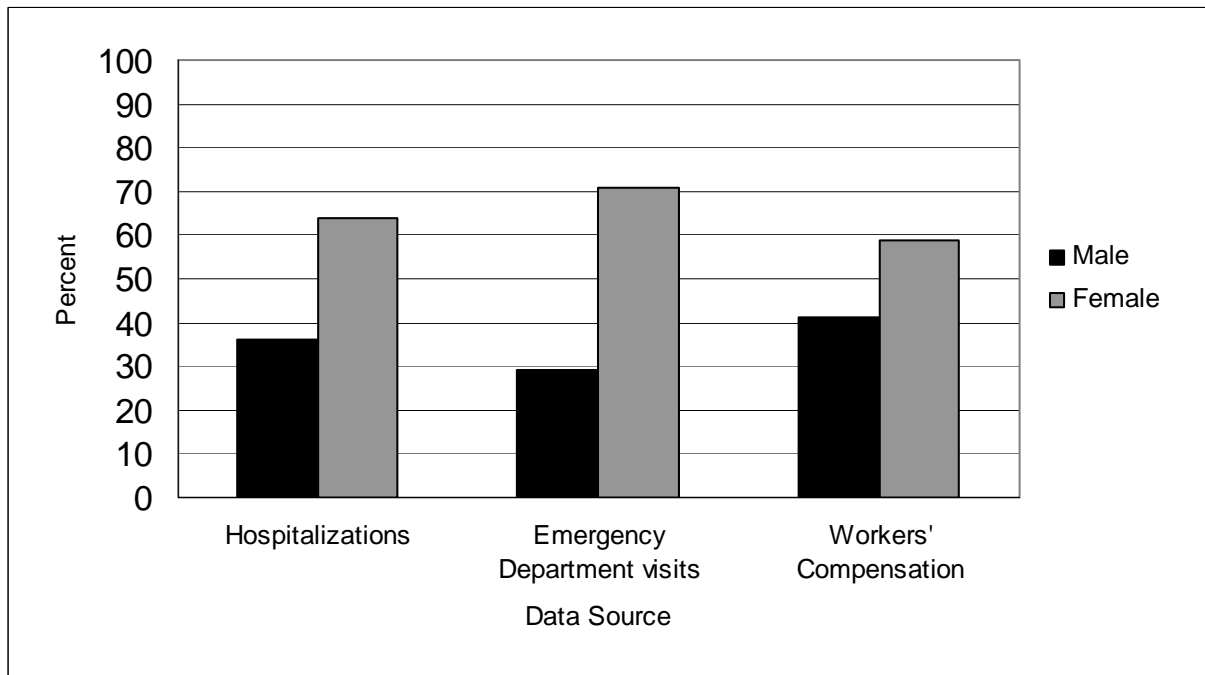
Year	1999	All Hospitalizations	Asthma hospitalizations	Work-related asthma hospitalizations	Asthma emergency dept. visits	Work-related asthma emergency dept. visits
	1999	621,236	6,007	6	Data not available	Data not available
	2000	635,166	5,685	3		
	2001	648,015	5,417	0		
	2002	651,919	5,149	1	22,474	2
	2003	663,298	5,954	2	23,117	1
	2004	670,247	5,256	2	21,401	3
	2005	674,508	5,417	3	21,937	6

Source: WI hospital discharge data and emergency department visit data

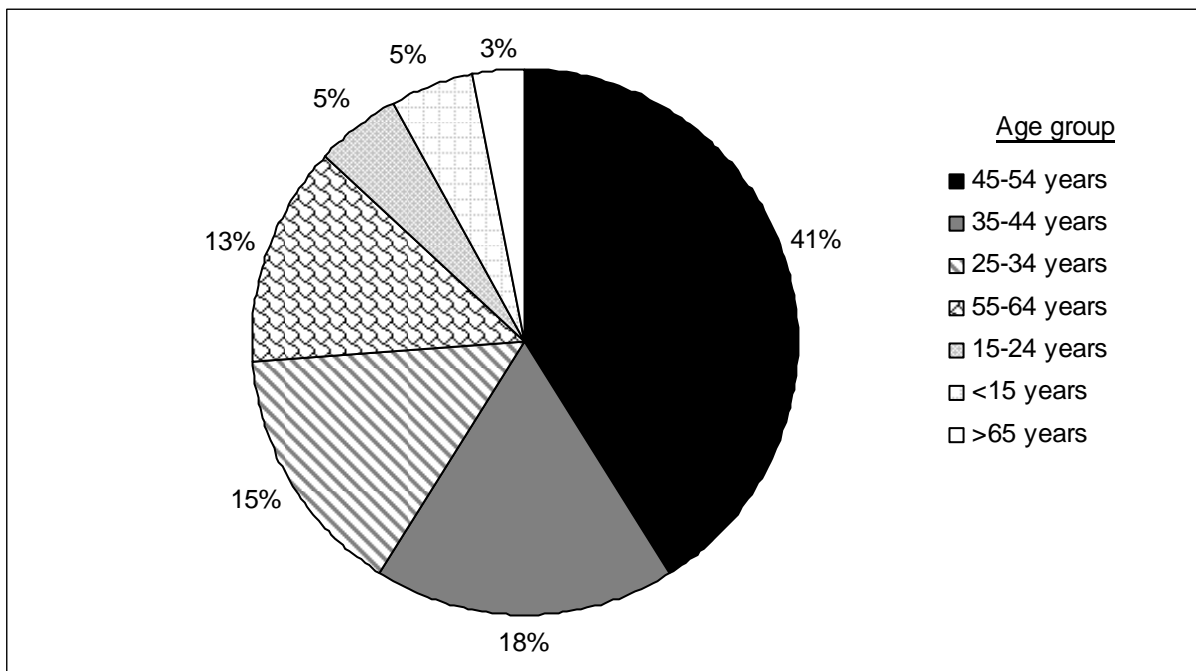
### Rate of paid WI workers' compensation claims for asthma, 1999-2006



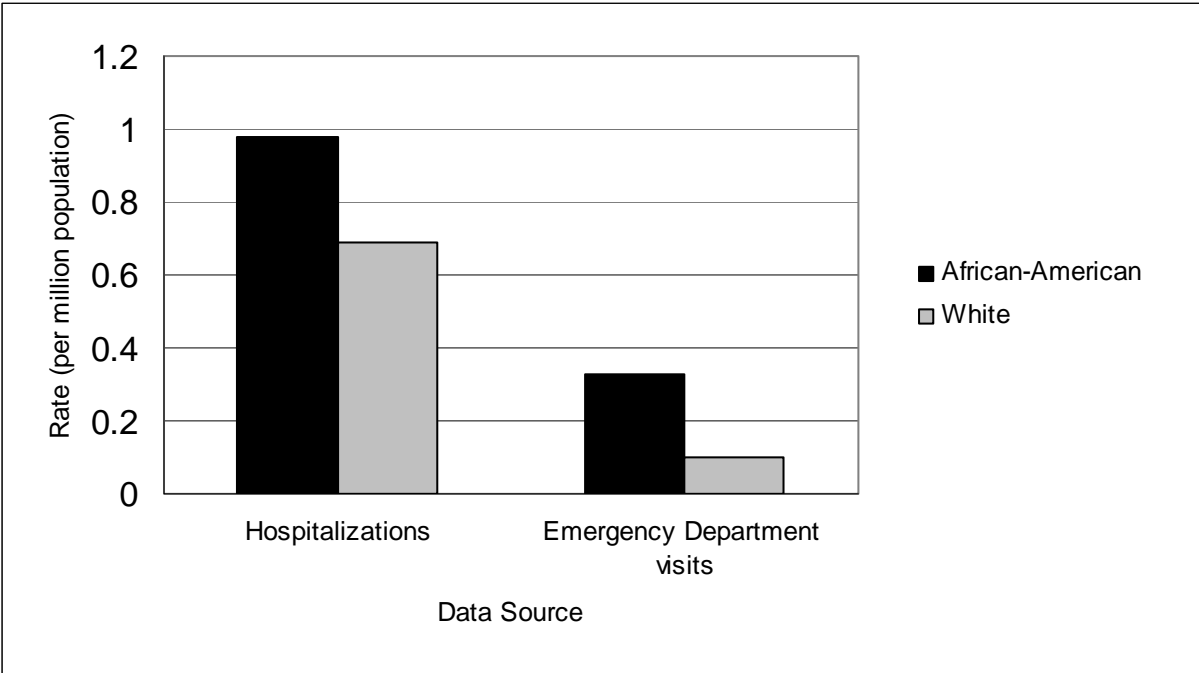
Percentage of asthma visits or claims paid by WI workers' compensation by gender and data source, 2002-2006



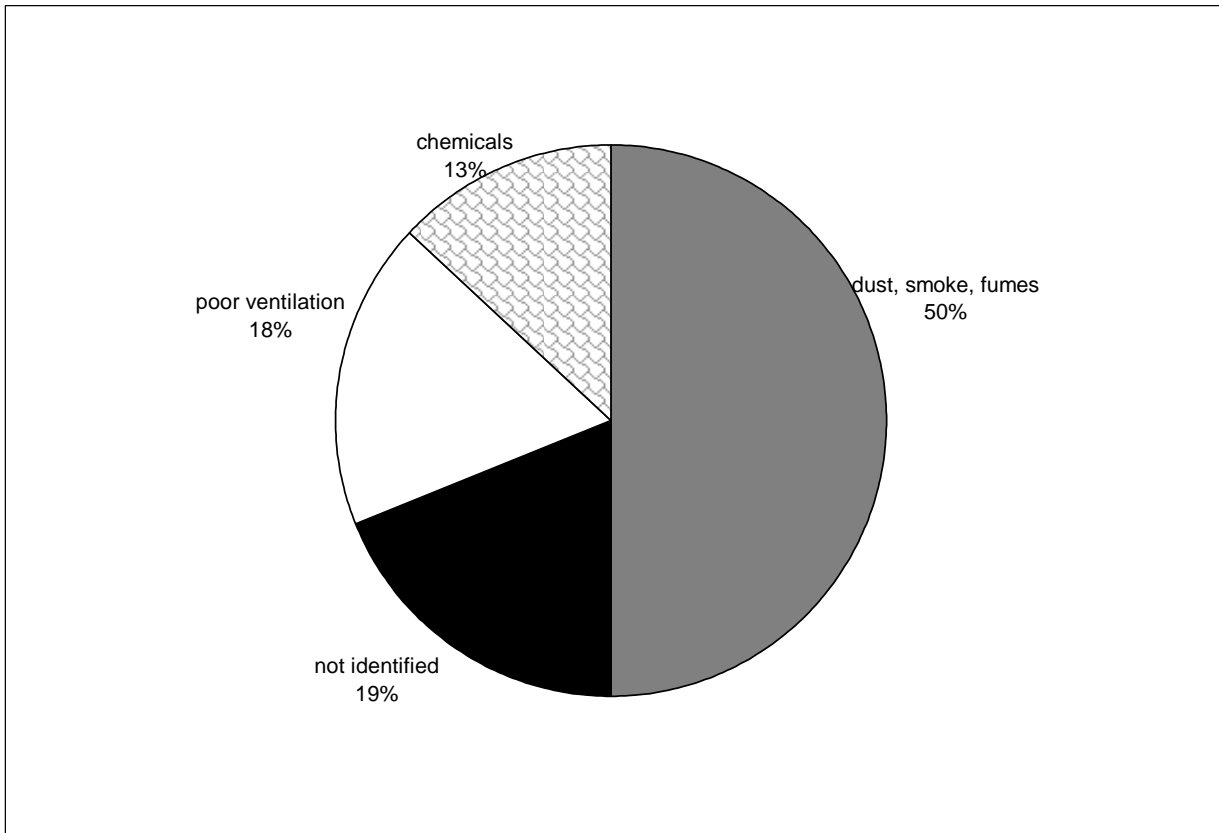
Percent of asthma hospitalization claims paid by WI workers' compensation by age group, 1991-2006



Race-specific rate of asthma hospitalizations and emergency department visits paid by WI workers' compensation, 2002-2006

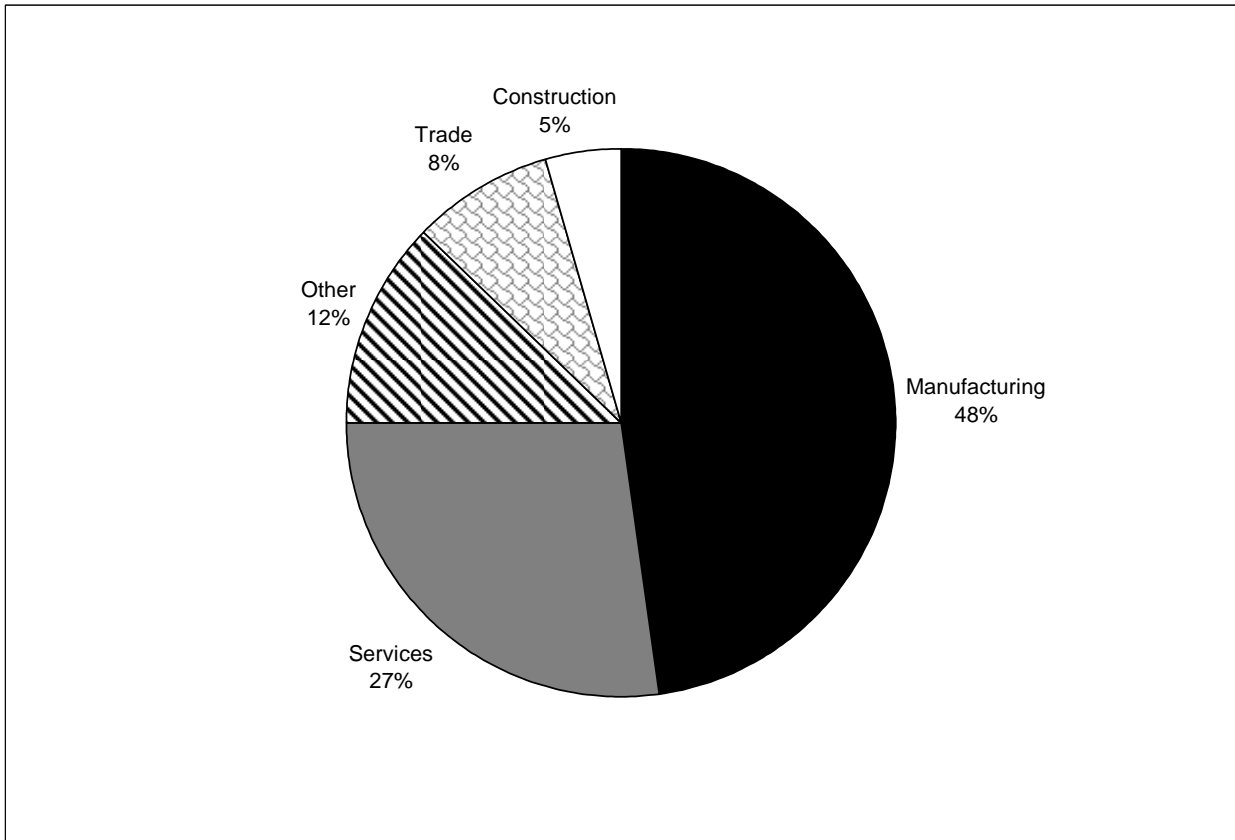


Common allergen exposures reported by unionized workers in Wisconsin, 2004



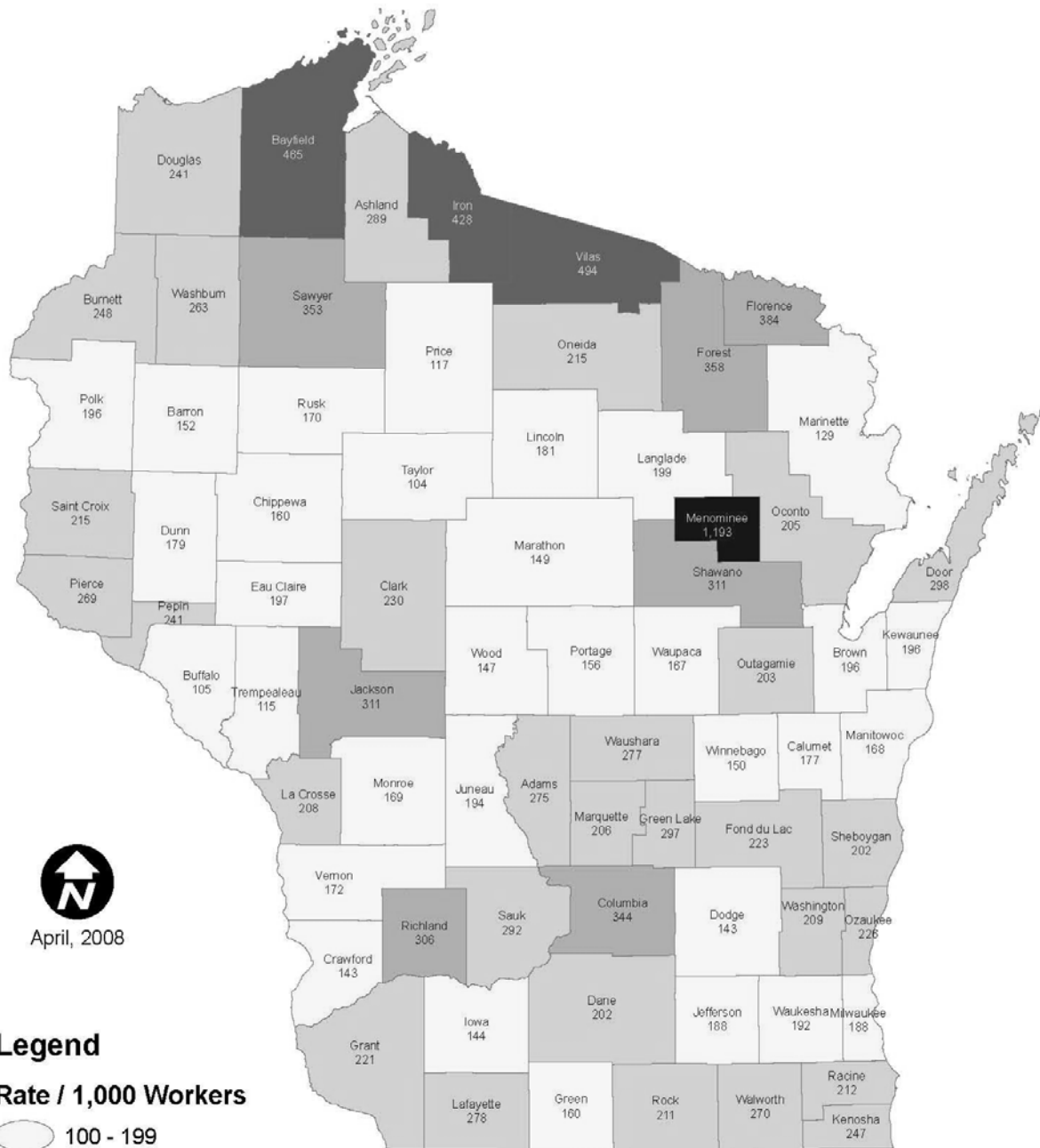
Source: 2004 WI Union Survey

Industries where Wisconsin workers' compensation claims for asthma were paid, 1999-2006



Source: 2004 WI Union Survey

## Rate of Industry Workers at Risk for Asthmagen Exposure State of Wisconsin



### Legend

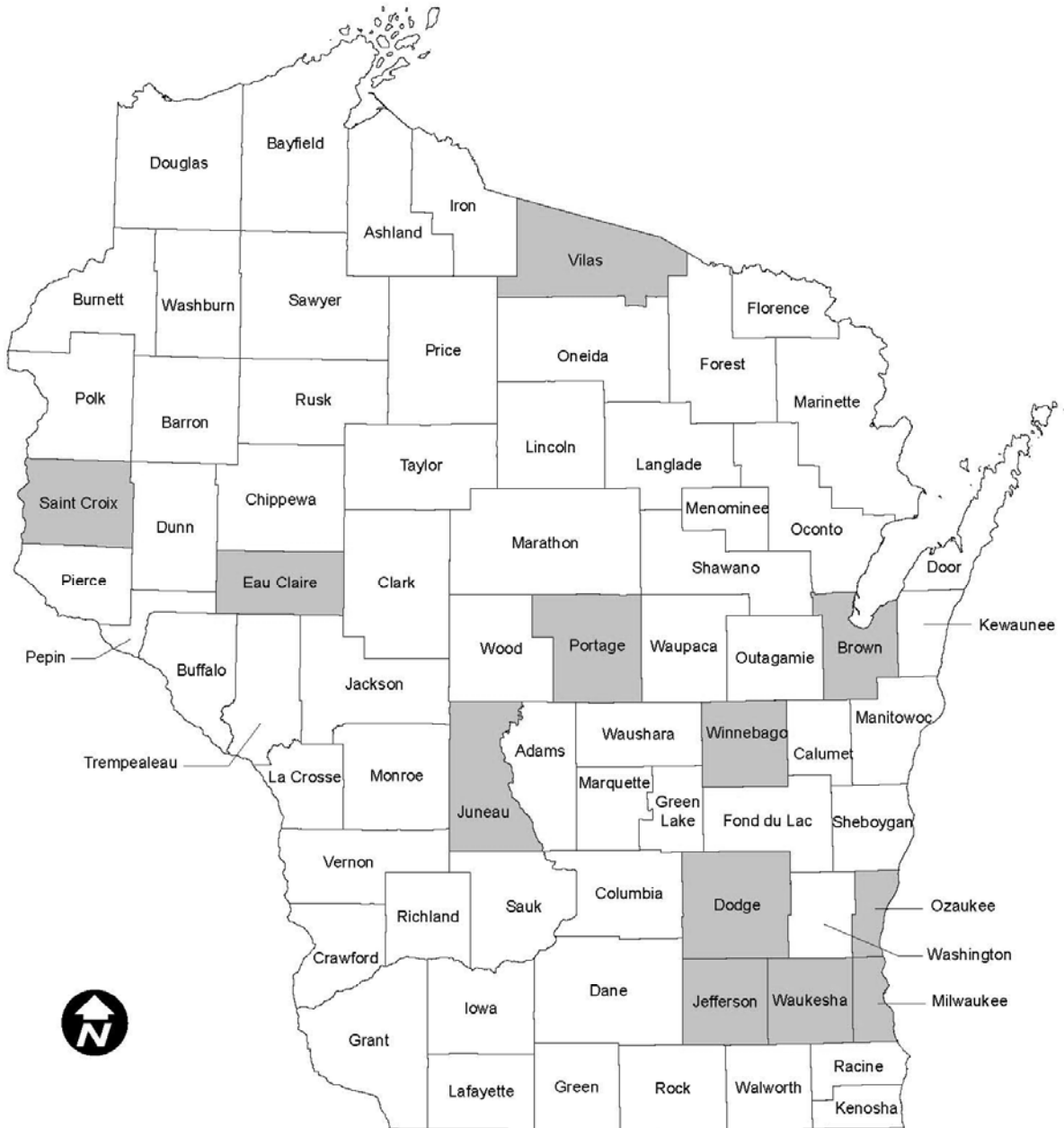
#### Rate / 1,000 Workers

- 100 - 199
- 200 - 299
- 300 - 399
- 400 - 499
- 500 - 1,193

**Data Source:** 2008 DWD workforce profiles; NHANES III  
**Methodology:** 1. The top eight industries for WRA estimated by the NHANES III study was used to designate industries where workers are "at-risk" of asthmagen exposure (Arif, 2002)  
 2. Rates were calculated based on the number of county workers in each "at-risk" industry in Wisconsin.  
 3. The denominator is the number of workers in each county.  
**Limitations:** individual workers may hold multiple part-time positions and be counted more than once.

Location of counties where emergency room visits occurred for asthma and were paid by workers' compensation, 2002-2006

## Emergency Room Visits for Work-Related Asthma, 2002 through 2006



### Work-Related Asthma Visits to Emergency Rooms

- Visits to ER Occurred
- No Visits to ER Occurred

**Data Source:** WI emergency department visit data  
**Limitations:** This map does not depict the number of visits – just that a visit did occur. Individuals may seek treatment in bordering states and not be counted in Wisconsin data. County of visit is the county where the patient resides and does not necessarily reflect the county of exposure.

Source: Bureau of Environmental and Occupational Health, Division of Public Health, Wisconsin Department of Health Services

## Case Reports

A health hazard evaluation (HHE) is a study of a workplace conducted by NIOSH. It is done to learn whether workers are exposed to hazardous materials or harmful conditions. When an HHE is done, NIOSH staff visit the workplace to tour the facility, review records, measure exposure, interview or survey employees and they may do medical testing. These activities happen during one or more visits. At the end of this evaluation, NIOSH will provide a written report to the employer and to the employee representatives. An HHE can take from a few months to a few years to complete depending on the type of evaluation.

An employee can request an HHE if he or she is currently employed at the workplace of concern and has the signatures of two other employees. If the workplace has three or fewer employees, the signature of only one employee is enough. An officer of a labor union that represents employees for collective bargaining can request an HHE. Any management official may request an HHE on behalf of the employer. For anyone who submits a request, NIOSH will not reveal to the employer the names of the persons who made the request if they indicate this on the request form.

The following final report summaries are taken directly from NIOSH health hazard evaluation (HHE) reports of investigations in Wisconsin workplaces.

### Chemicals in Manufacturing

#### Case 1. Report: HETA-2005-0243-3016

On May 17, 2005, the National Institute for Occupational Safety and Health (NIOSH) received a confidential request from three employees at ACH Foam Technologies in Fond du Lac, Wisconsin. The requestors expressed concerns about potential long-term effects from exposure to smoke and chemicals generated while manufacturing polystyrene and cutting polyethylene sheeting and expandable polystyrene (EPS) foam. On August 31, 2005, NIOSH investigators sampled for chemical byproducts from the EPS processes at the ACH facility. Personal breathing zone (PBZ) and area air samples were collected for pentane, styrene, volatile organic compounds (VOCs), and respirable and total dust. Air samples collected on thermal desorption tubes identified pentane, styrene, acetophenone, ethylbenzene, and xylene as predominant chemicals. The charcoal tubes used to sample for VOCs were submitted for laboratory analysis for acetophenone, ethylbenzene, and xylene. Area concentrations of carbon monoxide, a potential byproduct from the EPS processes, were measured in several departments with a direct reading instrument. All sample results were below applicable occupational exposure limits. NIOSH investigators conclude that a health hazard did not exist on the day of this evaluation. Employees were not exposed over applicable

occupational exposure limits to carbon monoxide, pentane, styrene, acetophenone, ethylbenzene, xylene, respirable dust, or total dust while molding and cutting EPS products. Recommendations in this report include providing local exhaust ventilation in the hot wire cutting area, repairing damaged duct work in the Recycling department, and improving communication between supervisors and employees.

A full NIOSH report can be found at: <http://www.cdc.gov/niosh/hhe/reports/pdfs/2005-0243-3016.pdf>

#### Case 2. Report: HETA-2005-0029-2923

On October 18, 2002, the National Institute for Occupational Safety and Health (NIOSH) received a confidential employee request for a health hazard evaluation (HHE) at Ward Brodt Music Mall in Madison, Wisconsin. The request centered on workers' exposures to acids and solvents during musical instrument repair operations, the adequacy of the ventilation in the chemical room, and reported symptoms of sore throat, sinus headaches, congestion, asthma, persistent cough, allergies, sneezing, and watery eyes. On January 14, 2003, NIOSH investigators conducted an exposure assessment and interviewed repair shop workers. Between the time of the HHE request and the site visit, local exhaust ventilation was installed in the chemical

room. Personal breathing zone and general area air samples were collected and analyzed for inorganic acids (hydrochloric, nitric, and sulfuric) and volatile organic compounds (VOCs). Thermal desorption tubes were used qualitatively to determine the compounds to analyze. A ventilation assessment consisted of “smoke” tube observations and velometer measurements. Hydrochloric acid concentrations ranged from not detected (ND) to 0.049 milligrams per cubic meter (mg/m<sup>3</sup>) and nitric acid concentrations ranged from ND to 0.035 mg/m<sup>3</sup>. Sulfuric acid concentrations could not be determined due to analytical problems. Based upon thermal desorption tube results, the VOC samples were analyzed for toluene, trichloroethylene (TCE), and total VOCs (reported as octane). Toluene concentrations ranged from 0.06 to 0.29 parts per million (ppm), TCE concentrations ranged from trace to 0.99 ppm, and total VOC concentrations ranged from trace to 0.35 ppm. All of these results were far below applicable occupational exposure limits. Ventilation testing using visual “smoke” indicated little air movement over the workbenches and around mechanical equipment. A ventilation assessment of the slot hood in the chemical room found it within recommended standards. Although no applicable standards exist for the ventilation systems in the buffing and lacquer rooms, each area was under negative pressure in relationship to the repair shop.

Confidential interviews were conducted with repair shop employees. Of the seven brass and woodwind shop employees interviewed, three had experienced upper and/or lower respiratory symptoms they felt were related to acid mist exposure from the chemical room. Two of the three had complete resolution of their symptoms after a new ventilation system was installed. At least two of the seven have had mild to moderate skin irritation related to their work. These symptoms reportedly improved with skin moisturizers and glove use. Employees’ reports of upper and lower respiratory symptoms could be related to the low concentrations of air contaminants measured. It is possible that the reported symptoms were related to higher concentration of the irritants that may have been present in the repair shop prior to installation of the new ventilation system. Recommendations are provided to further reduce employees’ exposures to these chemicals by increasing the level of personal protection for workers in the

repair shop, and improving ventilation and work practices in the facility.

Keywords: SIC Code 7699 (Repair Shops and Related Services, Not Elsewhere Classified), musical instrument repair, inorganic acid, hydrochloric acid, sulfuric acid, nitric acid, toluene, trichloroethylene, TCE, sore throat, headaches, congestion, asthma, cough, allergies, sneezing, watery eyes, upper respiratory symptoms, lower respiratory symptoms, skin irritation.

A full NIOSH report can be found at: <http://www.cdc.gov/niosh/hhe/reports/pdfs/2003-0029-2923.pdf>

## Bioaerosols

### Case 1. Report HETA 99-0091-2846

On January 29, 1999, the National Institute for Occupational Safety and Health (NIOSH) received a confidential employee request for a Health Hazard Evaluation (HHE) at the Plover, Wisconsin, facility of McCain Foods, Inc., a plant which produces frozen potato products. The requesters expressed concern regarding possible health effects, especially respiratory problems, which they believed were associated with exposures to carbon monoxide (CO), chlorine gas (Cl<sub>2</sub>), and unknown chemicals. On March 30, 1999, a preliminary NIOSH investigation focused on the potential for Cl<sub>2</sub> and CO exposures. Screening tests for the presence of both chemicals in air were negative. However, informal worker interviews suggested that health problems might be widespread. During a July 25-26, 1999, site visit, NIOSH researchers investigated whether the health effects were related to bioaerosols, such as bacteria, fungi, or their products (especially endotoxins, which are components of the coats of gram-negative bacteria). A questionnaire survey of workers was conducted to determine the frequency of respiratory and other health symptoms and full-shift, personal breathing zone (PBZ) samples were collected to estimate time-weighted average (TWA) concentrations of airborne particulates and endotoxin. Data was categorized by whether it was collected in the potato processing areas or in the packaging areas of the plant. The questionnaire survey of 115 of 185 workers found the prevalence of chest tightness was more than 2.5 times greater in the processing workers than the packaging workers (39% versus 14%, prevalence rate [PR] = 2.8, 95% confidence interval [CI]: 1.36-5.75). Processing employees also had twice the prevalence of shortness of breath (43% versus 18%, PR = 2.4, 95% CI: 1.29-4.63), twice the prevalence of pneumonia or chest flu episodes (48% versus 25%, PR = 2.0, 95% CI: 1.16-3.33), and one and one-half times the prevalence of eye, nose, or throat irritation (55% versus 33%, PR = 1.7, 95% CI: 1.07-2.57) compared to packaging employees. These findings remained statistically significant after controlling for the confounding factors of age and cigarette smoking. Airborne endotoxin concentrations in

the processing area greatly exceeded those in the packaging area. PBZ endotoxin concentrations in the processing area of the plant averaged 168 endotoxin units per cubic meter (EU/m<sup>3</sup>), but those in the packaging area were less than the lower limit of detection (0.018 EU/m<sup>3</sup>). A likely source of bacteria, and, therefore, endotoxins, is a wastewater gutter system located throughout the processing area of the plant.

**Case 2.** A Health Hazard Evaluation (HHE) was conducted on April 14–16, 1997, by the National Institute for Occupational Safety and Health (NIOSH) at Especially for You, Limited, located in Coloma, Wisconsin. This HHE was conducted following a confidential employee request regarding styrene vapor and sanding dust exposure in the Resin and Finishing department. The company manufactures a variety of home decorative items including plastic articles by curing polyester resin in preformed molds.

Air monitoring was conducted during the manufacturing activities for volatile organic compounds (VOCs), styrene, Stoddard solvent, methyl ethyl ketone peroxide (MEKP) as well as respirable and total dust. Personal breathing zone (PBZ) samples collected when workers were mixing and pouring liquid resin revealed that full-shift exposure concentrations to styrene ranged from 15 to 46 parts per million (ppm); some of the exposures exceeded the American Conference of Governmental Industrial Hygienists (ACGIH) Threshold Limit Value® (TLV) for styrene of 20 ppm and approached the NIOSH Recommended Exposure Limit (REL) of 50 ppm. In addition, short-term PBZ exposure to styrene during resin mixing exceeded both the ACGIH 15-minute Short-Term Exposure Limit (STEL) of 40 ppm and the NIOSH STEL of 100 ppm. Gas chromatography-mass spectrophotometry (GC-MS) analyses identified other VOCs present in the air as a mixture of aliphatic hydrocarbons which produced a chromatogram pattern resembling Stoddard solvent. However, PBZ exposure to Stoddard solvent was determined to be well below relevant occupational health criteria. Area samples collected for MEKP did not detect this compound at “worst-case” locations when the (MEKP) accelerator was added to the resin. Full-shift exposure concentrations to total particulates during

sanding and finishing tasks ranged from 1.7 to 8.0 mg/m<sup>3</sup>.

Although these dust exposures were below the ACGIH TLV, the use of a paint spray booth for exhaust of belt sander dust may not always be effective for control of workers' dust exposure. NIOSH investigators concluded that a potential health hazard exists from exposure to styrene vapor during resin mixing and mold pouring activities. A number of recommendations are provided including improved local exhaust ventilation, periodic exposure monitoring, a more effective respiratory protection program, and safer chemical storage methods.

### What can be done about WRA in Wisconsin?

Minimizing or eliminating worker exposures to asthma-causing agents can prevent work-related asthma. This can be done by:

- minimizing exposure;
- substituting chemicals known to cause asthma for those that do not cause asthma;
- improving ventilation in the work area;
- using engineering controls such as equipment that does not produce smoke or fumes;
- use effective respiratory protection equipment;
- training on the correct use of protective equipment;
- recognizing asthma-causing substances;
- recognizing the signs of breathing problems
- participate in medical screening and tracking programs, and;
- report to your physician any breathing problems.

For more information go to:

<http://www.cdc.gov/niosh/topics/asthma/OccAsthmaPrevention-primer.html>

### Myths About Work-Related Asthma

**Myth:** "It's their own cigarette smoking habits that caused their work-related asthma."

**Fact:** Smoking does not increase the risk of getting work-related asthma. Some studies have found a shorter time to the development of asthma in smokers but both smokers and non-smokers have developed work-related asthma.

**Myth:** "The company says they've done air testing and they are within OSHA limits – it must not be work-related asthma."

**Fact:** Workplace standards have not been developed for all substances that could cause work-related asthma. Work-related asthma may also develop by small exposures over time.

**Myth:** A proper pre-screening would prevent people from being hired into workplaces where they develop work-related asthma."

**Fact:** To date, no combination of pre-placement testing (medical history, skin testing, or breathing tests) has been able to adequately predict who will develop work-related asthma. Also, because of the way this testing is designed, it would exclude a large number of people from working with substances that could cause work-related asthma, but these people would never actually develop work-related asthma.

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## Bibliography

- American Thoracic Society. 2003. Consensus Statement Bardana EJ Jr. Reactive airways dysfunction syndrome (RADS): guidelines for diagnosis and treatment and insights into likely prognosis. *Ann Allergy Asthma Immunol* 1999;83:583-6
- Arif, A A, Whitehead, LW, Delclos GL, Tortolero, Lee ES. Prevalence and risk factors of work related asthma by industry among United States workers: data from the third national health and nutrition examination survey (1988-94). *Occup Environ Med* 2002;59:505-511
- Blanc PD, Toren K. How much adult asthma can be attributed to occupational factors? *Am J Med* 1999; 107.
- CDC/NIOSH. Work-related Lung Disease (WoRLD) Surveillance System. Available at: <http://www2a.cdc.gov/drds/WorldReportData/FigureTableDetails.asp?FigureTableID=992>
- CDC/NIOSH. Preventing Asthma and Death from Diisocyanate Exposure: A NIOSH Alert. Available at <http://mtn.niosh.cdc.gov/eid/rmca/polstmt/pdfdoc/PSZY33B.pdf>
- CDC/NIOSH. Preventing Allergic Reactions to Natural Rubber Latex in the Workplace. Available at <http://www.cdc.gov/niosh/latexalt.html>
- CDC/NIOSH Preventing Asthma in Animal Handlers: A NIOSH Alert. Available at <http://mtn.niosh.cdc.gov/eid/rmca/critdoc/criteria/doc/239.pdf>
- CDC/NIOSH. Worker Health Chartbook, 2004.
- Chan-Yeun M, Malo JL. Tables of major inducers of occupational asthma. In: Bernstein IL, Chan-Yeung M, Malo JL, Bernstein DI, eds. *Asthma in the Workplace*. 2<sup>nd</sup> ed. New York: Dekker, 1999:683-720.
- Glazer, C., Pacheco, K. 2008. Making the Diagnosis of Occupational Asthma: When to Suspect it and what to do. *Prim Care Clin Office Pract* 35 (2008):61-80
- Goe, SK, Henneberger PK, Reilly MJ, Rosenman KD, et al. 2004. *Occup Environ Med* Jun; 61(6):512-7
- Islam, KM, Lins, M. 2004. Wisconsin Asthma Questionnaire Work-related asthma survey: Final report. Wisconsin Department of Health and Family Services.
- Henneberger, Paul K. Work-exacerbated asthma. *Curr Opin Allergy Clin Immunol*. 2007. Apr; Vol 9 (2): 146-51.
- Jajosky RA, Harrison R, Reinish F, et. al. 1999. Surveillance of work-related asthma in selected US states using surveillance guidelines for state health departments – California, Massachusetts, Michigan, and New Jersey, 1993-1995. *Morb Mortal Wkly Rep* 48:1-20.
- Milton DK, Solomon GM, Rosiello RA, Herrick RF. Risk and incidence of asthma attributable to occupational exposure among HMO members. *AM J Ind Med* 1998;33:1-10.
- National Center for Health Statistics. Plan and operation of the third national health and nutrition examination survey, 1988-94. National Center for Health Statistics 1994;1:32
- Quint, Julia, Beckett, W., Campleman, S., et al. 2008. Primary Prevention of Occupational Asthma: Identifying and Controlling Exposures to Asthma-Causing Agents. *AM J Ind Med* 51:447-491.
- Rosenman, Kenneth, Kalinowski, D. 2006 Annual Report on Work-Related Asthma in Michigan.
- Saarinen, K., Karjalainen, A., Martikainen, R. et.al. 2003 *Eur Respir J* 22:305-309

Toren K, Brisman J, Olin AC, Blanc PD. 2000  
Asthma on the job: work-related factors in new-  
onset asthma and in exacerbations of pre-  
existing asthma. *Respir Med* 94 (6):529-535

Youakim, Sami, 2001. Work-Related Asthma.  
*Am Fam Physician* Vol 64, No 11, December  
12, 2001, 1839-1848.

Wisconsin Department of Health and Family  
Services. 2007 Burden of Asthma in Wisconsin