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2015
ANNUAL REPORT

**TRACKING WORK-RELATED
ASTHMA IN MICHIGAN**



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Work-Related Asthma Surveillance Program

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Michigan State University Department of Medicine

West Fee Hall
909 Fee Road, Room 117
East Lansing, MI 48824
517.353.1846

Kenneth D. Rosenman, MD
Mary Jo Reilly, MS

Michigan Department of Licensing & Regulatory Affairs (LARA)

PO Box 30649
Lansing, MI 48909
517.284.7777

Barton G. Pickelman
Director MIOSHA

There are many resources available to help employers, employees, health care professionals and others understand more about work-related asthma. Links to these resources can be found at: www.oem.msu.edu.

Acronyms

OA Occupational Asthma

AA Work-Aggravated Asthma

POA Possible Occupational Asthma

RADS Reactive Airways Dysfunction Syndrome

LARA MI Department of Licensing & Regulatory Affairs

MIOSHA Michigan Occupational Safety & Health Administration

NAICS North American Industrial Classification System

NIOSH National Institute for Occupational Safety & Health

PEL Permissible Exposure Limit

REL Recommended Exposure Limit



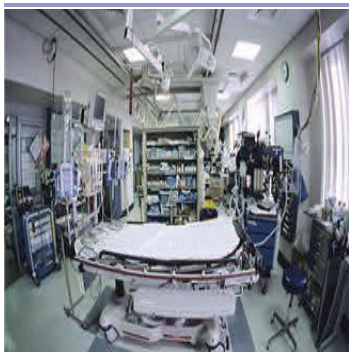
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We sincerely appreciate the commitment of those health care providers who understand the public health significance of diagnosing a patient with an occupational illness, as well as the Michigan employees who took the time to share their experiences about their work and subsequent development of work-related asthma.

Summary

This is the 25th annual report on work-related asthma (WRA) in Michigan.

In 2010, in a publication in the Journal of Asthma, researchers found that in a random sample of Michigan adults, 54.1% self-reported that their asthma was caused or aggravated by their work, and yet only 22% reported having a discussion with their health care provider about their concern about the effect of work on their asthma¹. These same individuals were more symptomatic and had more health care usage than other Michigan adults with asthma. This study highlights the importance of health care providers considering whether their patients with asthma have work-related triggers.



There are over 300 known asthma-causing agents used in the workplace. Thousands more substances have not been evaluated for their asthma-causing potential. The Association of Occupational & Environmental Clinics (AOEC) has a web site with an on-line look-up feature to identify asthma-causing agents. <http://www.aoecdata.org/ExpCodeLookup.aspx>

Part 56 of the Michigan Public Health Code requires reporting of all known or suspected occupational illnesses or work-aggravated health conditions to the Michigan Department of Licensing & Regulatory Affairs within 10 days of discovery.

Summary, continued...

- ◆ Since 2006, the number of cases identified each year has been less than the overall average of 130.
- ◆ From 1988-2015, 3,417 WRA cases have been identified with MI's tracking system.
- ◆ We estimate there are 65,000-97,000 adults in MI with WRA.
- ◆ 82% of the MI WRA patients have new-onset asthma; 18% have pre-existing asthma aggravated by an exposure at work.
- ◆ MIOSHA enforcement inspections at the facilities where individuals reported with WRA worked revealed that, on average, one out of every six of the fellow workers have asthma or respiratory symptoms compatible with asthma.
- ◆ Cleaning agents-12.3% and Isocyanates-12.2%, are the most commonly reported exposures causing WRA in MI.
- ◆ ~1% of the MI workforce is employed in manufacturing where isocyanates are used.
- ◆ The average incidence rate of WRA among African Americans is 1.7 times greater than that of Caucasians.

Background

In 1988, the State of Michigan instituted a tracking program for WRA with financial assistance from NIOSH. This is a joint project of MIOSHA (LARA) and Michigan State University (MSU), Department of Medicine, Division of Occupational and Environmental Medicine.

The reporting of an index patient is a sentinel health event that may lead to the identification of employees from the same facilities who are also at risk of developing asthma or who have developed similar breathing problems. The goal is to prevent WRA through the identification and workplace follow-up of these index patients.

Work-Related Asthma Tracking Procedures...

SOURCES TO IDENTIFY PATIENTS

- Patients are identified through mandatory reporting of any known *or suspected* occupational illnesses, including WRA.
- ◆ **Health Care Providers** Private practice, working for industry
 - ◆ **Hospitals** ICD-9 506.0-.9 & 493, Workers' Compensation payer
 - ◆ **Workers' Compensation Agency**
 - ◆ **Poison Control Center**
 - ◆ **Reports from Co-Workers or MIOSHA Field Staff** confirmed by a health care provider
 - ◆ **Death Certificates**
 - ◆ **Clinical Laboratories for specific IgE Allergy Testing**

WRA Tracking Procedures in Michigan

STEP 1. IDENTIFY PATIENTS — Occupational Disease Reports submitted to LARA are reviewed. Any known or suspected WRA cases are identified. A letter is sent to the patient to invite them to participate in a telephone interview.

STEP 2. INTERVIEW PATIENTS — A telephone interview with the suspected WRA patient is conducted, and medical records are obtained, including any pulmonary function test results. A physician who is board-certified in internal medicine and occupational medicine reviews all collected information.

STEP 3. CONFIRM DIAGNOSIS OF WRA* — The diagnosis of WRA requires **A)** Physician diagnosis of asthma and **B)** Onset of respiratory symptoms associated with a particular job that resolve or improve away from work and **C)** Work with a known allergen, or an association between the work exposure and a decrease in peak flow or spirometry.

STEP 4. WORKPLACE INSPECTION — After the patient interview is completed and the work-relatedness is determined, an onsite MIOSHA workplace enforcement inspection may be conducted. **During an Inspection:** Co-workers are interviewed to determine if other individuals are experiencing similar breathing problems from exposure to the allergen. Air monitoring for any suspected allergens may be conducted. The company's health and safety program is reviewed, including its Injury & Illness log and medical program.

STEP 5. FOLLOW-UP ACTIVITIES — After the investigation is complete, a report of air sampling results and any recommendations is sent to the company and made available to workers. A copy of the report is also sent to the reporting physician. Letters are sent to any workers who reported breathing problems in relation to work, or new-onset asthma since working at the facility. The letters recommend they seek medical care to determine the cause of their breathing problems.

STEP 6. ADDITIONAL FOLLOW-UP — Outreach, educational activities, and recommendations may be developed based on the findings. An annual report summarizing the activity is completed each year.

*THESE ARE THE SUBCATEGORIES OF WRA

New Onset

- 1) Occupational Asthma (OA) if A), B), and C) are met.
- 2) Possible WRA (POA) if only A) and B) are met.
- 3) Reactive Airways Dysfunction Syndrome (RADS) if symptoms develop after an acute exposure.²

Exacerbation

- 4) Work-Aggravated Asthma (AA) if had asthma in the 2 years prior to job, but asthma worsens at work.

Results

The following sections report the cumulative results of WRA surveillance from 1988 to-date.

REPORTS

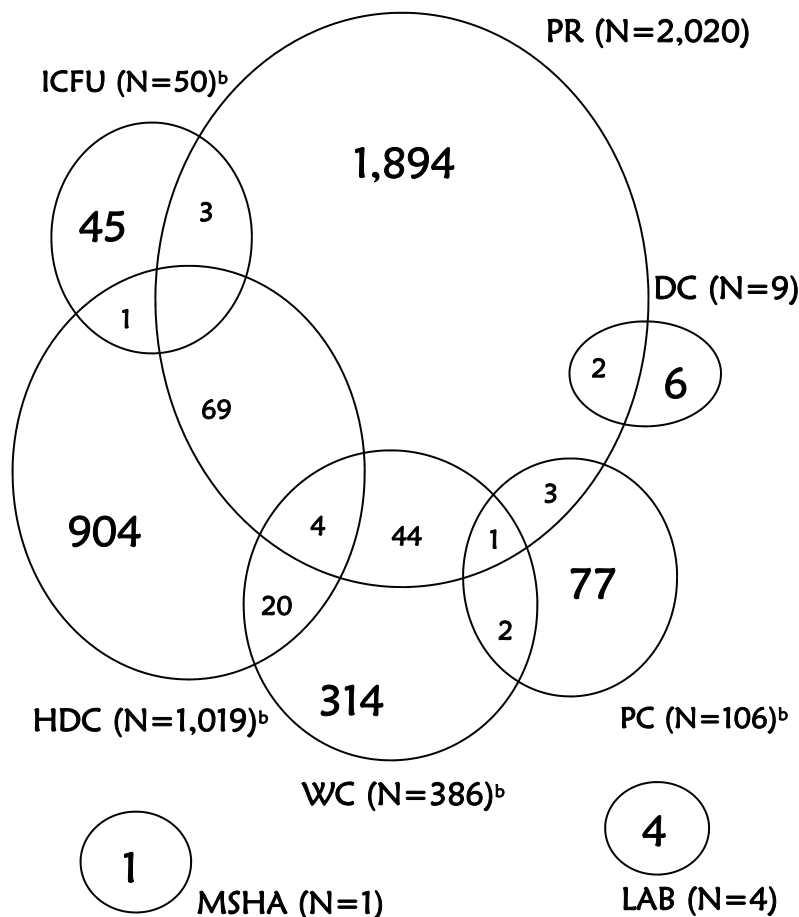
Table 1 shows that 3,417 people were confirmed with WRA between 1988—2015. The reports are divided into: occupational asthma (OA), possible occupational asthma (POA), aggravated asthma (AA) and Reactive Airways Dysfunction Syndrome (RADS). Eighty-four additional patients have been confirmed since last year’s report (one for 2012, six for 2013, seven for 2014 and 70 for 2015). Figure 1 shows the overlap of the patients by reporting sources for 1988—2015.

TABLE 1
Number of Confirmed Cases of Work-Related Asthma by Year and Type
 Disease Status

YEAR	OA	POA	AA	RADS	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	82	36	14	18	150
1993	75	69	13	19	176
1994	65	59	15	13	152
1995	57	34	19	17	127
1996	61	59	24	11	155
1997	53	74	19	16	162
1998	46	74	18	9	147
1999	48	65	16	12	141
2000	49	67	31	17	164
2001	50	51	20	19	140
2002	39	59	24	21	143
2003	29	64	28	23	144
2004	39	61	37	30	167
2005	43	66	21	23	153
2006	34	61	29	14	138
2007	20	41	34	28	123
2008	16	53	25	16	110
2009	20	41	31	8	100
2010	16	41	30	16	103
2011	19	26	19	3	67
2012	17	19	35	10	81
2013	15	28	36	6	85
2014	17	21	26	2	66 ^a
2015	16	19	24	11	70 ^a
Total	1,134	1,272	619	392	3,417

^aReports are still being processed for calendar years 2014 and 2015; an increase in these totals will be reflected in next year’s annual report.

FIGURE 1
Overlap of Reporting Sources for 3,417 Confirmed Work-Related Asthma Patients: 1988-2015^a



^a Ns represent the total number for that source. Reporting Source: HDC=Hospital Discharge; PR=Physician Referral; DC=Death Certificate; WC=Workers’ Compensation; ICFU=Index Case Follow-Up; MSHA=Mine Safety & Health Administration; PC=Poisson Control Center; LAB= Laboratory IgE.

^b There was an overlap of PC-HDC for 20 individuals and of one individual for PC-ICFU, one individual for DC-PC, and WC-PC-HDC for one individual each.

Demographics-Trends

This year, in addition to the analyses conducted for the annual report, extra analyses were added for select variables, to look at trends over time. The data are divided into 1988-1997, 1998-2007 and 2008-2015. There were 1,274 individuals reported with work-related asthma from 1988-1997, 1,461 individuals reported from 1998-2007 and 682 reported from 2008 to 2015. The trend analyses can be found along with the tables that present the overall statistics. The CHANGE column on select tables indicates whether there was an increase or decrease from 1988 to 2015 greater than or less than 10%.

GENDER: Table 2 shows a slightly higher percentage of women were reported with work-related asthma compared to men. Over time, the percentage of women reported with WRA has increased, while the percentage of men has decreased accordingly.

RACE: Table 3 shows there was an increase over time in the percentage of Hispanic cases of WRA, and a decrease in the percentage of Caucasian cases of WRA. The percentages of other races remained unchanged over time, although the numbers of cases of other races were quite low. The Annual Incidence Rate for African Americans was 2.63 per 100,000 compared to 1.56 per 100,000 for Caucasians; this was a 1.7 times greater incidence (95% CI 0.97, 2.94).

TABLE 2 Gender of Work-Related Asthma Patients by Time Period					
	Time Period				
	All years	1988-1997	1998-2007	2008-2015	Change
Gender	# (%)	# (%)	# (%)	# (%)	
Female	1842 (54)	626 (49)	800 (55)	416 (61)	+ 24%
Male	1575 (46)	648 (51)	661 (45)	266 (39)	- 24%

TABLE 3 Race of Work-Related Asthma Patients by Time Period					
	Time Period				
	All years	1988-1997	1998-2007	2008-2015	Change
Race	# (%)	# (%)	# (%)	# (%)	
Caucasian	2517 (74)	973 (76)	1074 (74)	470 (69)	<10%
African American	637 (19)	239 (19)	271 (19)	127 (19)	None
Hispanic	76 (2)	24 (2)	27 (2)	25 (4)	+ 100%
Alaskan/Am Indian	26 (1)	10 (1)	13 (1)	3 (0.4)	- 60%
Asian	14 (<1)	4 (0.3)	7 (0.5)	3 (0.4)	+ 33%
Other	37 (1)	11 (1)	20 (1)	6 (1)	None
Unknown	110 (3)	13 (1)	49 (3)	48 (7)	N/A



The sooner an individual with WRA is diagnosed and removed from the agent associated with their asthma, the better the prognosis for improvement in symptoms.

Location in State-Trends

Table 4 and Figure 2 show the annual average incidence rates of WRA among the working population, by county. The highest rates were in Luce (11.9 cases per 100,000), Clare (8.2 cases per 100,000), Huron (5.2 cases per 100,000), Osceola (5.1 cases per 100,000), Genesee (5.1 cases per 100,000), and Saginaw (4.9 cases per 100,000).

TABLE 4
Average Annual Incidence Rates of Work-Related Asthma
Among Michigan Workers by County of Exposure: 1989-2013^a

County	Avg Annual		Cases 1989-2013	County	Avg Annual		Cases 1989-2013
	# EE's ^b	Inc Rate ^c			# EE's ^b	Inc Rate ^c	
Alcona	3,701	1.1	1	Keweenaw	934	4.3	1
Alger	4,082	2.0	2	Lake	4,078	2.0	2
Allegan	51,890	3.5	45	Lapeer	41,930	3.1	32
Alpena	13,883	3.2	11	Leelanau	10,451	1.5	4
Antrim	10,773	1.1	3	Lenawee	47,409	2.5	30
Arenac	6,827	2.3	4	Livingston	86,477	1.7	37
Baraga	3,466	3.5	3	Luce	2,678	11.9	8
Barry	28,195	0.7	5	Mackinac	5,996	1.3	2
Bay	51,280	1.9	24	Macomb	396,836	2.9	283
Benzie	7,828	1.5	3	Manistee	11,000	1.1	3
Berrien	73,886	1.6	29	Marquette	31,306	2.6	20
Branch	21,410	4.1	22	Mason	13,628	0.9	3
Calhoun	65,736	2.6	42	Mecosta	17,904	1.8	8
Cass	24,866	0.8	5	Menominee	12,260	0.3	1
Charlevoix	12,704	2.5	8	Midland	39,455	2.6	26
Cheboygan	11,260	4.6	13	Missaukee	6,220	2.6	4
Chippewa	15,632	1.0	4	Monroe	72,714	1.5	28
Clare	11,718	8.2	24	Montcalm	27,030	2.5	17
Clinton	34,384	0.9	8	Montmorency	3,781	3.2	3
Crawford	6,164	3.2	5	Muskegon	78,772	1.3	26
Delta	18,237	2.0	9	Newaygo	20,992	2.5	13
Dickinson	13,230	3.6	12	Oakland	613,059	2.7	412
Eaton	55,075	0.9	12	Oceana	12,255	1.3	4
Emmet	17,085	1.2	5	Ogemaw	8,852	3.6	8
Genesee	194,623	5.1	249	Ontonagon	3,234	1.2	1
Gladwin	10,067	0.8	2	Osceola	10,174	5.1	13
Gogebic	7,230	1.1	2	Otsego	11,317	3.5	10
Grand Traverse	42,943	1.7	18	Ottawa	123,438	0.8	25
Gratiot	18,133	2.6	12	Roscommon	9,630	2.9	7
Hillsdale	21,637	2.2	12	Saginaw	90,666	4.9	111
Houghton	15,701	1.8	7	Sanilac	19,843	4.0	20
Huron	15,387	5.2	20	Schoolcraft	3,448	2.3	2
Ingham	144,855	3.4	122	Shiawassee	33,207	0.7	6
Ionia	27,764	1.6	11	St. Clair	78,702	2.7	54
Iosco	9,639	2.1	5	St. Joseph	28,518	1.4	10
Iron	5,278	2.3	3	Tuscola	26,543	3.2	21
Isabella	33,403	2.4	20	Van Buren	36,707	0.8	7
Jackson	72,768	2.5	45	Washtenaw	178,274	3.8	171
Kalamazoo	123,404	1.5	45	Wayne	851,213	3.6	773
Kalkaska	7,816	4.1	8	Wexford	13,447	1.8	6
Kent	294,931	1.1	83	All Michigan Counties^d	4,702,000	2.7	3,175

^a 1989 through 2013 represent complete years of reporting. Reporting in 1988 was begun mid-year and is incomplete. Reporting for 2014 and 2015 is not yet complete. Therefore, 1988, 2014 and 2015 reports are not included in this table.

^b Source: MI Dept of Tech, Mgt, & Budget, Labor Market Information, Annual Unemployment Statistics (LAUS) by County, 2002. Accessed 12-17-2015.

^c Rates are based on the average number of cases per year from 1989-2013 (25 years), per 100,000 Michigan workers.

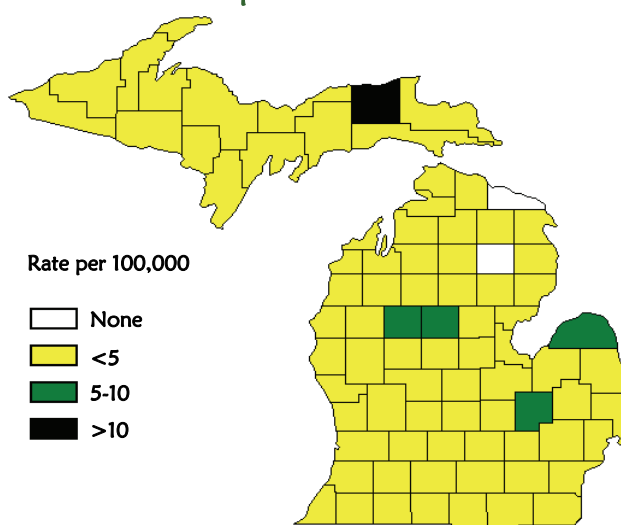
^d Fifty-three cases had an out-of-state exposure and 22 had an unknown county of exposure, for the 1989-2013 reporting period.

Location in State-Trends



TOP 10 COUNTIES: Table 5 shows the top 10 counties with the highest overall rates of WRA that had more than one case during the 1989-2013 time period. All but one of the top 10 counties with the highest overall rates of WRA had a decrease in the rate of WRA over time. Many of the rates increased during the 1998-2007 time period but then decreased during the 2008-2015 time period.

FIGURE 2
Average Annual Incidence Rate of WRA by County of Exposure: 1989-2013^a



^a 1989 through 2013 represent complete years of reporting. Reporting in 1988 was begun mid-year and is incomplete. Reporting for 2014 and 2015 is not yet complete. Therefore, 1988, 2014 and 2015 reports are not included in this figure.

TABLE 5
Average Annual Incidence Rate of Work-Related Asthma by County and Time Period

	Time Period										
	All years	1988-1997		1998-2007			2008-2015			Change	
County	Rate	# Cases	# EE's	Rate	# Cases	# EE's	Rate	# Cases	# EE's		Rate
Branch	4.1	7	17699	4.0	12	21340	5.6	4	17032	2.9	- 28%
Cheboygan	4.6	8	9658	8.3	2	11422	1.8	3	9277	4.0	- 52%
Clare	8.2	8	9100	8.8	11	11761	9.4	8	10570	9.5	<10%
Genesee	5.1	83	179394	4.6	132	191377	6.9	41	163453	3.1	- 33%
Huron	5.2	7	14941	4.7	8	15499	5.2	5	15104	4.1	- 13%
Kalkaska	4.1	4	6188	6.5	4	7932	5.0	0	6604	—	- 23%
Luce	11.9	4	2021	19.8	2	2660	7.5	2	2112	11.8	- 40%
Osceola	5.1	2	9343	2.1	10	9938	10.1	1	8996	1.4	- 33%
Saginaw	4.9	31	91307	3.4	67	90388	7.4	17	80771	2.6	- 24%
Sanilac	4.0	5	17992	2.8	12	19452	6.2	3	17315	2.2	- 21%
All MI Counties	2.7	1274	4258000	3.0	1461	4702000	3.1	682	4198000	2.0	-33%

Type of Industry-Trends

Table 6 shows the Michigan industries by NAICS codes, where exposures to occupational allergens occurred from 1988 to 2015. The main industries were in manufacturing (58%) and health care and social assistance (12%).

The incidence rate of WRA by industry ranges from 0.1 cases per 100,000 in management of companies to a high of 10.0 cases per 100,000 in manufacturing. Industries with the next highest annual average incidence rates were: mining with 5.6 cases per 100,000 workers and health care and social assistance with 3.1 cases per 100,000 workers.

Table 7 shows the average annual incidence rates for WRA cases *within manufacturing*.

INDUSTRIES OVER TIME: Table 8 shows distribution across all industries for the WRA cases by time period. There was a large decrease in the percentage of WRA cases in manufacturing, dropping from 71.6% in 1988-1997 to 36.7% in 2008-2015. Increases in the percentages of cases with WRA occurred in many industry sectors, including: retail trade, administrative and support and waste management, health care and social assistance, and accommodation and food services.

TABLE 6
Number of Work-Related Asthma Patients, 1988-2015 by Primary Industrial Exposure and Annual Average Incidence Rate per 100,000 Workers, 1989-2013 (Years of Complete Reporting)

2002 North American Industry Classification System		WRA Cases		Number of Employees ^a	Ann. Average Incidence Rate ^b	
		1988-2015			Rate	# Cases
		#	%			
11	Agriculture, Forestry, Fishing, & Hunting	23	0.7	81,664	1.0	20
21	Mining	13	0.4	8,600	5.6	12
22	Utilities	19	0.6	35,300	1.8	16
23	Construction	91	2.7	199,800	1.7	84
31-33	Manufacturing	1,971	57.7	761,400	10.0	1,896
42	Wholesale Trade	40	1.2	175,400	0.9	38
44-45	Retail Trade	96	2.8	530,700	0.7	90
48-49	Transportation & Warehousing	68	2.0	92,900	2.8	65
51	Information	24	0.7	70,400	1.3	22
52	Finance & Insurance	29	0.8	157,700	0.7	28
53	Real Estate & Rental & Leasing	16	0.5	55,700	1.1	16
54	Professional, Scientific & Technical Services	28	0.8	258,700	0.4	28
55	Management of Companies & Enterprises	1	<0.1	73,600	0.1	1
56	Administrative & Support & Waste Management	73	2.1	267,000	1.0	68
61	Educational Services	157	4.6	332,000	1.8	146
62	Health Care & Social Assistance	409	12.0	499,300	3.1	390
71	Arts, Entertainment & Recreation	30	0.9	53,500	2.1	28
72	Accommodation & Food Services	102	3.0	345,200	1.1	94
81	Other Services (except Public Administration)	79	2.3	256,100	1.1	72
92	Public Administration	135	4.0	390,400	1.3	124
00	Unknown	13	0.4	--	--	12
Total		3,417	100.2^c	4,568,564	2.8	3,250

^aSource: MI Dept of Tech, Mgt & Budget, Labor Market Information, Industry Employment (CES), 2002. Accessed 12-17-2015. The total non-farm employment in MI, 2002: 4,486,900. Agriculture: 2002 U.S. Census of Agriculture-State Data. Selected Operator Characteristics by Race: 2002.

^bReporting in 1988 was begun mid-year, and reporting for 2014 and 2015 is not yet complete. Therefore, 1988, 2014 and 2015 reports are not included in the calculation of the annual average incidence rate. Rates are based on the average number of cases by industry from 1989-2013 (25 years), per 100,000 Michigan workers.

^cPercentage does not add to 100 due to rounding.

Type of Industry-Trends

TABLE 7
1,896 Work-Related Asthma Patients from Manufacturing Industries:
1989-2013^a

	2002 North American Industry Classification System	WRA Cases #	Ann Avg Rate ^a	# Employees ^b
311	Food Mfg	65	8.2	31,900
323	Printing & Related Support Activities	19	3.8	20,200
325	Chemical Mfg	100	11.8	33,800
326	Plastics & Rubber Products Mfg	100	9.2	43,700
327	Nonmetallic Mineral Product Mfg	18	4.1	17,600
331	Primary Metal Mfg	66	9.3	28,300
332	Fabricated Metal Product Mfg	106	5.0	84,500
333	Machinery Mfg	141	7.1	79,700
334	Computer & Electronic Product Mfg	14	2.7	21,100
336	Transportation Equipment Mfg	1,130	15.2	296,900
337	Furniture & Related Product Mfg	14	1.8	31,000
	Miscellaneous Mfg (*includes NAICS: 312-16,321-322,324,335,339)	123	6.8	72,700

^aAverage annual incidence rate, based on cases from 1989-2013 (25 years) per 100,000 adult workers in Michigan in each industrial category, and represents years with complete reporting. Reporting in 1988 was begun mid-year and is incomplete. Reporting for 2014 and 2015 is not yet complete. Therefore, 1988, 2014 and 2015 reports are not included in this table.

^bSource: Michigan Department of Technology, Management and Budget, Labor Market Information, Industry Employment (CES), 2002. Accessed 12-17-2015.

Safety Data Sheets (SDS) can be used to identify ingredients in products that may cause asthma. However, a physician may have to write the company to find out about trade secret ingredients not specifically listed on the SDS.

TABLE 8
Industry of Work-Related Asthma Patients by Time Period

NAICS	Industry	Time Period						Change
		1988-1997		1998-2007		2008-2015		
		#	%	#	%	#	%	
11	Agriculture, Forestry, Fishing, & Hunting	4	0.3	12	0.8	7	1.0	+ 23%
21	Mining	5	0.4	6	0.4	2	0.3	- 25%
22	Utilities	3	0.2	5	0.3	11	1.6	+ 700%
23	Construction	32	2.5	37	2.5	22	3.2	+ 28%
31-33	Manufacturing	912	71.6	809	55.4	250	36.7	- 49%
42	Wholesale Trade	23	1.8	14	1.0	3	0.4	- 78%
44-45	Retail Trade	15	1.2	48	3.3	33	4.8	+ 300%
48-49	Transportation & Warehousing	14	1.1	35	2.4	19	2.8	+ 155%
51	Information	6	0.5	11	0.8	7	1.0	+ 100%
52	Finance & Insurance	2	0.2	17	1.2	10	1.5	+ 650%
53	Real Estate & Rental & Leasing	2	0.2	11	0.8	3	0.4	+ 100%
54	Professional, Scientific & Technical Services	9	0.7	16	1.1	3	0.4	- 43%
55	Management of Companies & Enterprises	0	—	1	0.1	0	—	N/A
56	Administrative & Support & Waste Management	10	0.8	27	1.8	36	5.3	+ 563%
61	Educational Services	40	3.1	73	5.0	44	6.5	+ 110%
62	Health Care & Social Assistance	105	8.2	194	13.3	110	16.1	+ 96%
71	Arts, Entertainment & Recreation	5	0.4	11	0.8	14	2.1	+ 425%
72	Accommodation & Food Services	19	1.5	49	3.4	34	5.0	+ 233%
81	Other Services (except Public Administration)	22	1.7	31	2.1	26	3.8	+124%
92	Public Administration	44	3.5	46	3.1	45	6.6	+ 89%
00	Unknown	2	0.2	8	0.5	3	0.4	N/A

Type of Exposure-Trends

Table 9 shows the exposures associated with WRA among Michigan workers. The most frequent exposures reflect the importance of the vehicle manufacturing industry in the State, and the widespread use of cleaning products across all industry sectors. Most frequently identified exposures include: cleaning products, associated with 419 (12.3%) of Michigan's WRA patients, and isocyanates (MDI, TDI, HDI and others) accounting for 417 (12.2%) of the WRA case exposures. Metal working fluids (coolants) accounted for 322 (9.4%) of Michigan worker exposures.

There is ongoing interest in ingredients in cleaning products that can cause new-onset asthma and aggravate existing asthma. These products, used both in the home and in all industry sectors (services, manufacturing, etc.) can contain disinfectants, often in the form of quaternary amines, which have been repeatedly shown to cause asthma among workers who either use them or are in the area when they are being used. The Michigan WRA Tracking Program has developed a brochure on the hazards of cleaning agents. It is available at: www.oem.msu.edu, and can be found under the **Resources Section**.

Welding is the fifth most common cause of work-related asthma in Michigan. Both welders themselves as well as individuals who work in the same area may be affected by welding fume. A 2011 publication highlights the morbidity and high health care costs from asthma associated with welding³.

TOP EXPOSURES OVER TIME: Table 10 shows the trends among the top exposures by time period. Isocyanates decreased from 19.3% of all the WRA exposures in 1988-1997 to 6.6% in 2008-2015. Cleaning agents increased from 4.6% of all the WRA exposures in 1988-1997 to 21.6% in 2008-2015. Metalworking fluids, solvent and latex rubber also decreased over time, while there was an increase in exposure to fungus over time.

Figure 3 represents another way to look at exposures over time. It shows the number of individuals with work-related asthma by type of exposure from 1988-2015. Trends are shown for the five most common causes of WRA and all other exposures that could be grouped as either low molecular weight (i.e. chemicals, metals) or high molecular weight (i.e. organic material, plant or animal) agents. The data is grouped into 2-year time categories to give more stability to smaller numbers of cases in a single year. The number of individuals with WRA caused by metalworking fluids and other chemicals with low molecular weights appears to be trending downward. Diisocyanates were decreasing until 2010-2011. Office, and animal or plant products with high molecular weights appear unchanged. Cleaning agents appear to be trending upward until 2006-2007 and then decreasing since that time. Manufacturing has been decreasing over time.



Workers can be exposed to sensitizing agents in any type of industry.

TABLE 9
Top Workplace Exposures Associated with
Confirmed WRA Patients: 1988-2015

<u>Exposure Agent</u>	<u>#</u>	<u>%</u>
Cleaning Solutions	419	12.3
Isocyanates	417	12.2
Metal Working Fluids	322	9.4
Unknown (Mfg.)	254	7.4
Unknown (Office)	202	5.9
Exhaust/Smoke/Fumes	164	4.8
Welding Fume-Stainless & Other	150	4.4
Solvents	112	3.3
Paint Fumes	84	2.5
Epoxy	75	2.2
Fungus	73	2.1
Formaldehyde	66	1.9
Acids	65	1.9
Latex/Rubber	61	1.8
Chlorine	50	1.5
Fire	50	1.5
Plastic Fumes	46	1.3
Chemicals Used in Construction	43	1.3
Acrylates	39	1.1
Animal Dander	36	1.1
Cobalt	32	0.9
Flour	28	0.8
Wood Dust	27	0.8
Fragrances	26	0.8
Ammonia	23	0.7
Styrene	23	0.7
Cigarette Smoke	21	0.6
Herbicide/Pesticide	21	0.6
Fiberglass	19	0.6
Aldehydes	19	0.6
Chromium	15	0.4
Amines	14	0.4
Cosmetology Chemicals	14	0.4
Caustics	13	0.4
Cement Dust	13	0.4
Plants/Organic Matter	13	0.4
Medication	13	0.4
Grain Dust	12	0.4
Printing Inks	12	0.4
Rust Inhibitor	12	0.4
Anhydrides	11	0.3
Asphalt	11	0.3
Fire Extinguisher Powder	9	0.3
Insecticides	9	0.3
Meat Wrapper's Asthma	8	0.2
<u>Other^a</u>	<u>271</u>	<u>7.9</u>
Total	3,417	100.3^b

^AThere were 7 cases with exposure to: Paper Dust, Polyurethane.

There were 6 cases each w/exposure to: Azodicarbonamide, Heat, Enzymes, Freon, Nitrogen, Pickling Ingredients, Sewage, Solder Fume, Sulfur Dioxide, Textile Lint.

There were 5 cases each w/exposure to: 1,1,1 Trichloroethane, Coal Dust, Photo Developing Fluids.

There were 4 cases each w/ exposure to: Asbestos, Drywall Dust, Lime Dust, Mold Release Spray, Rose Hips, Sand, Sulfonate, Trichloroethylene, X-Ray Developing Fluids.

There were 3 cases each w/exposure to: Cadmium Solder, Coal Tar, Cold Air, Colophony, Cooking Oil, Copier Toner, Explosion, Hydraulic Oil, Kerosene, Natural Gas, Nickel, Ozone, Pepper Gas, Polyethylene, Sludge, Zinc, Zinc Oxide.

There were 2 cases each w/exposure to: Ammonium Chloride, Cellulose, Concrete Sealer, Copper Oxide, Exercise, Fertilizer, Fireproofing Chemicals, Flux, Gas and Oil Refinery Exposures, Glaze, Methamphetamine Lab, Perchloroethylene, Phosgene, Polyester, Polyvinyl Butyrate, Silicone, Sulfite, Talcum Powder, Teflon, Vinyl Acetate Acrylic.

There was 1 case each w/exposure to: 1,3-Dichloro-2-Propanol, 1,3 Dichloro 5 5-Dimethyl Hydrantoin, Ammonium Bifluoride, Barbeque Smoker, Benzoate Esters, Blood, Blue Prints, Calcium Carbonate, Calcium Chloride (used in Cherry Brine), Capsaicin, Car Window Sealant, Carbon Dioxide, Catheter Demonstration Chemical, Ceramic Powder, Crude Oil, Cyanide, Deck Stain, Desert Storm, Dry Ice, Eggs, Ethylene Oxide, Flares, Gortex, Heated Polyvinyl Chloride, Heated Vinyl, Iodine, Isopropyl Alcohol, Methanol, Mica, Monoammonium Phosphate, Ninhydrin, Nonylphenol polyethylene glycol ether, Nylon-polyhexamethylene Adipamide, Odor, Phenol, Pigment, Plasma Cutting, Plating Chemicals, Platinum, Polyolefin, Potassium Aluminum Fluoride, Polybutadiene, Soda Ash, Sodium Acetate, Sodium Chlorite, Soot, Stress, Swimming Pool Shock, Tetrahydrofuran, Titanium Tetrachloride, Tuberculosis Vaccine, Wastewater Treatment Chemicals, White Lithium, World Trade Center Exposure, Zinc Borate.

^bPercentage does not add to 100 due to rounding.

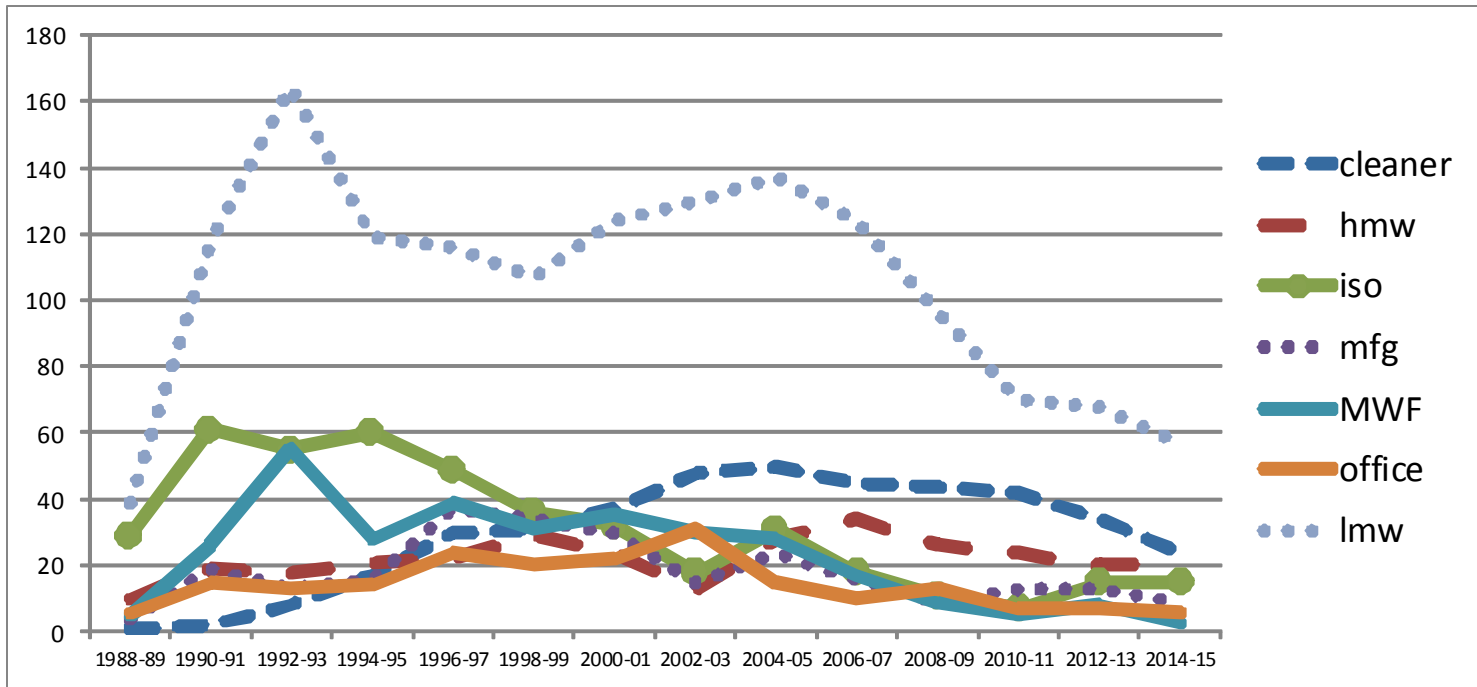
TABLE 10
Top Workplace Exposures of Work-Related Asthma Patients by Time Period

Exposure Type	Time Period				
	All Years	1988-1997	1998-2007	2008-2015	Change
	# (%)	# (%)	# (%)	# (%)	
Cleaning Agents	419 (12.3)	59 (4.6)	213 (14.6)	147 (21.6)	+ 370%
Isocyanates	417 (12.2)	246 (19.3)	126 (8.6)	45 (6.6)	- 66%
Metalworking Fluids	322 (9.4)	153 (12.0)	144 (9.9)	25 (3.7)	- 69%
Welding Fume	150 (4.4)	63 (4.9)	62 (4.2)	25 (3.7)	- 24%
Solvents	112 (3.3)	51 (4.0)	52 (3.6)	9 (1.3)	- 68%
Paint	84 (2.5)	18 (1.4)	49 (3.4)	17 (2.5)	+ 79%
Epoxy	75 (2.2)	33 (2.6)	28 (1.9)	14 (2.1)	- 19%
Fungus	73 (2.1)	0	41 (2.8)	32 (4.7)	+ 68%
Formaldehyde	66 (1.9)	33 (2.6)	19 (1.3)	14 (2.1)	- 19%
Acids	65 (1.9)	27 (2.1)	24 (1.6)	14 (2.1)	None
Latex/Rubber	61 (1.8)	25 (2.0)	33 (2.3)	3 (0.4)	- 80%



FIGURE 3

WRA Patients by the Five Most Common Types of Exposures* and All of the Other High and Low Molecular Weight Compounds, Trend by 2-Year Time Periods: 1988-2015



*Cleaner=cleaning agents, hmw=high molecular weight agents, iso=diisocyanates, mfg=manufacturing agents, MWF=metal working fluids, office=office exposures, lmw=low molecular weight agents.

Medical Results-Trends

SMOKING STATUS Table 11 shows patients’ cigarette smoking status. Slightly less than 20% of patients were smoking when their asthma developed. This is slightly lower than the state average (21.2%) (source, 2014 BRFSS Annual Report at www.michigan.gov). **SMOKING STATUS OVER TIME:** Table 12 shows the change in cigarette smoking status over time. There was an increase in the percentage of WRA patients who never smoked over time, corresponding with decreases among those who ever or currently smoked cigarettes.

ALLERGIES AND ASTHMA Forty-four percent of WRA patients had a family history of allergies (data not shown). Fifteen percent of the asthma patients had a personal history of allergies and asthma (Table 13). Forty-seven percent had no history of allergies or asthma.

HEALTH CARE USAGE Sixty-five percent of the WRA patients had at least one visit to the Emergency Department in their lifetime, and 35% had at least one hospitalization for their work-related asthma (Table 14). The average number of ED visits was 5.6 and the average number of hospitalizations was 3.8.

WORK-RELATED ASTHMA DEATHS: Fortunately, a very small percent (0.01-0.02%) of asthma patients die from asthma. From 2003 to 2008, we have identified eight work-related asthma deaths.

There were no work-related asthma deaths identified in calendar years 2009 through 2014. There was one work-related asthma death in 2015. Case ID OA3828 in the Case Narratives Section (page 33) details the events of this WRA death. In addition, we have published articles on some of the work-related asthma deaths^{4,5}.

TABLE 11
Cigarette Smoking Status of 3,299^a
Confirmed WRA Patients: 1988-2015

	Smoking Status						TOTAL
	Current		Ex-Smoker		Non-Smoker		
	#	%	#	%	#	%	
OA	234	21.0	430	38.7	448	40.3	1,112
POA	190	15.4	507	41.0	540	43.7	1,237
AA	117	20.4	160	27.9	296	51.7	573
RADS	105	27.9	141	37.4	131	34.7	377
All	646	19.6	1,238	37.5	1,415	42.9	3,299

^aMissing data on 118 patients.

TABLE 12
Cigarette Smoking Status of Work-Related Asthma Patients by Time Period

	Time Period				
	All Years	1988-1997	1998-2007	2008-2015	Change
Smoking Status	# (%)	# (%)	# (%)	# (%)	
Current	646 (20)	243 (20)	295 (21)	108 (17)	- 15%
Ex-Smoker	1238 (38)	540 (43)	479 (34)	219 (34)	- 21%
Non-Smoker	1415 (43)	463 (37)	632 (45)	320 (49)	+ 32%
Total		1246	1406	647	

The percentage of Michigan adult smokers has varied over time, from a high of 27.4% in 1998, to a low of 20.5% in 2010, an increase in 2011 to 23.3%, and a decrease to 21.2% in 2014.

Sources:
www.cdc.gov,
www.michigan.gov

Medical Results-Trends

TABLE 13
Personal History of Allergies or Asthma Among 3,079^a Confirmed WRA Patients: 1988-2015

	Personal History of...							
	Allergies & Asthma		Asthma Only		Allergies Only		No Allergies or Asthma	
	#	%	#	%	#	%	#	%
OA	57	5.5	47	4.5	306	29.5	629	60.5
POA	84	7.4	42	3.7	384	34.0	620	54.9
AA	313	53.1	247	41.9	11	1.9	18	3.1
RADS	24	7.5	28	8.7	77	24.0	192	59.8
All	478	15.5	364	11.8	778	25.3	1,459	47.4

^aMissing data on 338 patients.

TABLE 14
Health Care Usage Among Confirmed WRA Patients: 1988-2015

Lifetime History of Health Care Usage			
ED Visit ^a		Hospitalized ^b	
Yes	No	Yes	No
# (%)	# (%)	# (%)	# (%)
2,085 (65)	1,119 (35)	1,066 (35)	1,985 (65)
Range		Range	
1-300 visits		1-200 hospitalizations	
AVG 5.6 ±15.2		AVG 3.8 ±10.1	
^a Missing data on 213 patients.			
^b Missing data on 366 patients.			

SYMPTOMS

Two thousand seven hundred thirty-five of the patients with WRA had persistence of their asthma symptoms (Table 15). Higher percentages of those *still exposed* continued to have breathing problems and take asthma medicine compared to those *no longer exposed*. Higher percentages of those *no longer exposed* had improved breathing and were taking less medicine.

SYMPTOMS OVER TIME: Among those still exposed to the agent associated with their WRA, there was a trend of less symptom improvement for those still experiencing breathing problems (Table 16). During 1988-1997, 34% of those with breathing problems reported their symptoms were improving, compared to 50% among those no longer exposed; during 2008-2015, 24% of those still exposed reported an improvement in symptoms, compared to 48% among those no longer exposed. Also among those still exposed, there was a decrease among those reporting the need for less asthma medication among those still exposed, with 21% reporting the need for less asthma medication during 1988-1997 compared to 30% among those no longer exposed, and 16% reporting the need for less asthma medication during 2008-2015, compared to 33% among those no longer exposed.

TABLE 15
Persistence of Symptoms and Medication Use in 3,107 Confirmed WRA Patients: 1988-2015

Still Exposed?	Total	Breathing Problems Still Present?				Still Taking Asthma Medications?			
		Yes		Less		Yes		Less	
		#	%	#	%	#	%	#	%
Yes	906	869	95.9	268	29.6	789	87.1	164	18.1
No	2,201	1,866	84.8	1,057	48.0	1,737	78.9	637	28.9
Total	3,107 ^a	2,735		1,325		2,526		801	

^aInformation missing on 310 individuals.

Individuals with work-related asthma are often exposed to low levels of a sensitizer for a long period of time before their breathing problems develop.

Medical Results-Trends

TABLE 16
Persistence of Symptoms and Medication Use in Confirmed Work-Related Asthma Patients
by Time Period

Time Period	Still Exposed?	Total	Breathing Problems Still Present?				Still Taking Asthma Medications?			
			Yes #	%	Less #	%	Yes #	%	Less #	%
1988-1997	Yes	339	326	96.2	116	34.2	288	85.0	72	21.2
	No	852	705	82.7	422	49.5	633	74.3	251	29.5
	Total	1191	1031		538		921		323	
1998-2007	Yes	389	376	96.7	109	28.0	336	86.4	64	16.5
	No	923	828	89.7	432	46.8	760	82.3	246	26.7
	Total	1312	1204		541		1096		310	
2008-2015	Yes	178	167	93.8	43	24.2	165	92.7	28	15.7
	No	426	333	78.2	203	47.7	344	80.8	140	32.9
	Total	604	500		246		509		168	
Change	Yes			-3%		-29%		+9%		-26%
	No			-5%		-4%		+9%		+12%

OBJECTIVE MEDICAL TESTING

The percentage of WRA patients who had different types of pulmonary function testing over all and by time period is listed below (Table 17). There was a decrease in the percentage of patients who had a methacholine challenge test or specific antigen challenge over time, an increase of patients who had peak flow monitoring at home and work, no appreciable change in the percentage of patients with pre-post bronchodilatation, and a slight increase for patients having pre-post work shift breathing tests.

TABLE 17
Objective Medical Testing of Work-Related Asthma Patients by Time Period

Test Type	Time Period				
	All Years (%)	1988-1997 (%)	1998-2007 (%)	2008-2015 (%)	Change
Pre-post Bronchodilatation	54	54	54	53	<10%
Methacholine Challenge	19	25	16	14	- 44%
Peak Flow Monitoring at Work & Home	4	3	3	5	+ 67%
Pre-post Work-shift	3	2	4	3	+ 50%
Specific Antigen Challenge	<1	0.9	0.3	—	- 66%

Workplace Investigations-Trends

WORKERS' COMPENSATION

About half of the WRA patients applied for workers' compensation benefits; about a third of those who applied for benefits were awarded compensation for their breathing problems. Over all the years of reports, 49% applied for benefits; among those, 37% were awarded, 17% were denied and 46% were pending approval.

WORKERS' COMPENSATION OVER TIME: The percentage of WRA patients who applied for workers' compensation benefits did not change at all across the time periods: 1988-1997, 1998-2007 and 2008-2015. All time periods showed 49% of patients applying for workers' compensation benefits. However, there were differences in the outcomes of applying for benefits, with an increase in the percentage awarded benefits increasing over the three time periods from 37% to 33% to 45% in the most recent time period. The percentage of claims denied also increased over the time periods, from 16% to 17% to 22% in the most recent time period. Accordingly, the percentage of claims pending approval decreased from 48% to 50% to 33% in the most recent time period.

INDUSTRIAL HYGIENE

A total of 792 workplace inspections have been conducted since 1988 (Table 18); 123 of those facilities had been inspected more than once. Seven inspections have been completed since last year's report.

Air sampling for allergens was conducted during 572 inspections (Table 19); 30 (5.3%) of the 565 facilities with a MI-OSHA standard for the allergen were above the enforceable permissible exposure limit.

TABLE 18

Status of Facilities Where Confirmed WRA Patients Were Exposed to Allergens: 1988-2015

<u>Inspection Status</u>	<u># Patients Represented</u>	<u>Companies</u>	
		<u>#</u>	<u>%</u>
Inspected	1,244	792 ^a	32.3
No Follow-up Planned	1,949	1,450	59.2
Scheduled for Inspection	15	15	0.6
Out of Business	79	70	2.9
No Longer Use Occupational Allergen	27	26 ^b	1.1
<u>Sent Company Letter to Check Exposures^d</u>	<u>103</u>	<u>96</u>	<u>3.9</u>
Total	3,417	2,449^c	100.0

^a792 inspections were conducted in 669 different workplaces.

^bEight companies that no longer use the allergen were previously inspected.

^cRepresents 2,326 different facilities.

^dThe company was sent information on how to address potential exposures including indoor air issues in their workplace that may be causing respiratory health problems.

It is difficult to track illness among temporary workers, due to the transient nature of their work and the ambiguity of responsibility for reporting their occupational illnesses.



Workplace Investigations-Trends

TABLE 19
Air Monitoring Results from 792
Workplace Inspections: 1988-2015

<u>Air Sampling – NIOSH Standard</u>	<u>#</u>	<u>%</u>
Above NIOSH Standard	69	8.7
Below NIOSH Standard	474	59.8
No NIOSH Standard	31	3.9
Unknown (no report yet)	2	0.3
Did Not Sample for an Allergen	29	3.7
<u>Did Not Sample</u>	<u>187</u>	<u>23.6</u>
Total	792	100.0

<u>Air Sampling – MIOSHA Standard</u>	<u>#</u>	<u>%</u>
Above MIOSHA Standard	30	3.8
Below MIOSHA Standard	535	67.6
No MIOSHA Standard	7	0.9
Unknown (no report yet)	2	0.3
Did Not Sample for an Allergen	31	3.9
<u>Did Not Sample</u>	<u>187</u>	<u>23.6</u>
Total	792	100.1^a

^aPercentage does not add to 100 due to rounding.

AIR MONITORING

Table 20 shows the allergens that were above the NIOSH and/or MIOSHA limits. The top four allergens found to be above the NIOSH REL were:

- ◆ Formaldehyde
- ◆ Cobalt
- ◆ Styrene
- ◆ Metal Working Fluids

The top four allergens found to be above the MIOSHA enforceable PEL were:

- ◆ Welding Fume
- ◆ Cobalt
- ◆ Styrene
- ◆ Glutaraldehyde

TABLE 20
Allergens Above the MIOSHA Permissible Exposure Limit (PEL) and/or
NIOSH Recommended Exposure Limit (REL): Michigan 1988-2015

<u>Asthma-Causing Agents</u>	<u>Above NIOSH REL</u>		<u>Above MIOSHA PEL</u>	
	<u>#</u>	<u>%</u>	<u>#</u>	<u>%</u>
Formaldehyde	28	41.8	1	3.4
Cobalt	8	11.9	6	20.7
Styrene	6	9.0	4	13.8
Metal-Working Fluids	5	7.5	1	3.4
Glutaraldehyde	4	6.0	3	10.3
HDI	4	6.0	No PEL	--
MDI	3	4.5	0	--
Wood Dust	3	4.5	2	6.9
Chromic Acid	1	1.5	1	3.4
Ethylene Oxide	1	1.5	0	--
Phthalic Anhydride	1	1.5	1	3.4
Starch	1	1.5	0	--
Total Dust (Dry Plant Materials)	1	1.5	0	--
Total Dust (Grinding on Fiberglass)	1	1.5	1	3.4
Welding Fume (Total Particulate)	No REL	--	7	24.1
<u>Flour Dust</u>	<u>No REL</u>	<u>--</u>	<u>2</u>	<u>6.9</u>
TOTAL	67	100.2^a	29	99.7^a

^aPercentages do not add to 100 due to rounding.

Workers exposed to asthma-causing agents BELOW permissible limits are developing work-related asthma.

Co-Worker Interviews at Workplace Investigations-Trends

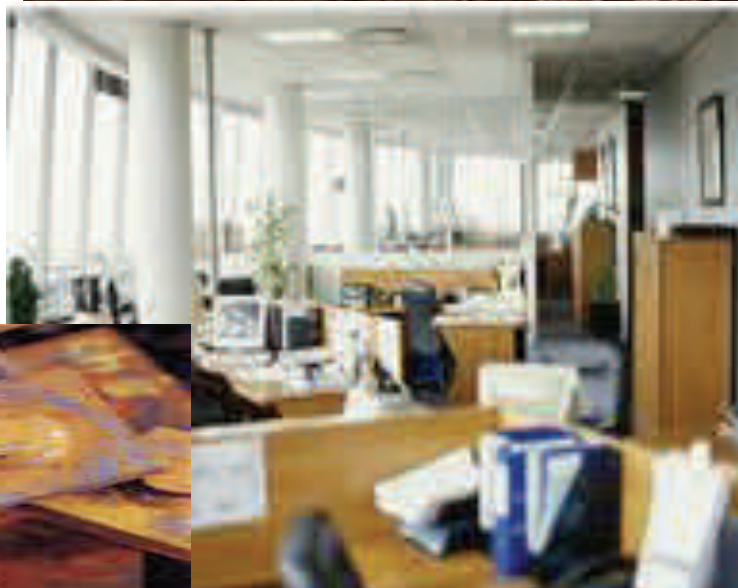
Co-workers were interviewed during 610 of the 792 inspections. Workers had daily or weekly breathing symptoms associated with work or new onset asthma since beginning to work at 395 of the 610 (65%) companies. The average percentage of co-workers with symptoms in these 395 companies was 20.4%. All 1,660 co-workers from the remaining 215 companies reported no daily or weekly breathing symptoms associated with work. One thousand five hundred ninety of the 10,290 (15.5%) co-workers interviewed had symptoms consistent with work-related asthma (Table 21). Over time, the percentage of co-workers with breathing problems has decreased.

The MIOSHA Injury and Illness Logs (Form 300) kept by employers listed 583 workers from 135 companies with asthma or asthma-like symptoms. Only 10 workers identified in the interviews with daily or weekly chest tightness, shortness of breath or wheezing were also listed on the MIOSHA Log. Combining the information from the interviews and Injury and Illness Log, a total of 2,173 symptomatic workers were identified during the 792 MIOSHA enforcement inspections.

TABLE 21
Breathing Symptoms Among Co-Workers of the 3,417 Confirmed WRA Patients: 1988-2015 and by Time Period

<u>Symptoms</u>	<u>ALL</u>	
	<u>#</u>	<u>%</u>
Daily or Weekly SOB, Wheezing or Chest Tightness	1,590	15.5
Workers Interviewed	10,290	
BY TIME PERIOD:		
1988-1997		17.9
1998-2007		11.9
2008-2015		10.7
Workers on OSHA Log	583	
# Companies Inspected	792	
# Companies w/Ee on Log	135	17.0
BY TIME PERIOD:		
1988-1997		17.4
1998-2007		19.5
2008-2015		7.9
Total Workers w/Symptoms ^a	2,173	

^aTen individuals were identified both on the co-worker questionnaire and the OSHA Log.



Michigan Workforce Exposed to Select Causes of WRA

The United States Environmental Protection Agency (EPA) requires reporting by manufacturers, mines or electrical utilities that have at least 10 employees and use any one of 650 different chemicals in amounts greater than 10,000 pounds per year. Queries of reportable chemicals can be generated to identify state-level statistics.

We identified Michigan's isocyanate-using companies in the EPA Toxic Release Inventory (TRI) to estimate the number of workers employed by manufacturers potentially exposed to isocyanates, one of the most commonly reported causes of WRA in Michigan (Table 22). Our estimate under-counts non-manufacturing-exposed employees such as at auto body paint shops because the EPA does not include non-manufacturing establishments. Conversely, our estimate over-counts manufacturing employees because we included the total number of employees at each facility that reported isocyanates, even though not all workers at these facilities would have worked with or around isocyanates.

Another source to identify chemical exposures associ-

ated with WRA comes from the Michigan Department of Environmental Quality (DEQ). The chemicals listed in the Michigan Facilities' Guide to SARA Title III, Emergency Planning and Release Reporting (December 2007, 6th edition) are subject to reporting under the Emergency Planning and Community Right-to-Know Act (EPCRA) Section 313, triggered by threshold amounts of 25,000 pounds manufactured or processed or 10,000 pounds otherwise used at Michigan facilities.

Unlike the EPA TRI data, all companies must report if they meet the threshold amount of chemical used; there are no limitations to reporting based on the type of facility or the number of individuals employed.

Between the two reporting sources, there were 112 companies that reported using isocyanates in 2015, which is up from 107 companies in 2014. The number of workers employed in companies that use isocyanates, the total number of workers in these counties, and the percentage of workers by county who work in facilities where isocyanates are used is listed in Table 22. The 39,587 workers potentially exposed to isocyanates in 2015 is up from the 36,371 potentially exposed in 2014.

TABLE 22

Michigan Workers Employed in Manufacturing Facilities Where Isocyanates are Used, by County

County	Company Name ^{c,d}	# Workers Employed ^a by Isocyanate-Using Facilities	Total # Workers in the County ^b	% Workers Potentially Exposed to Isocyanates
ALLEGAN	HAWORTH INC VAN FENG AUTOMOTIVE INTERIORS PMSC MOTUS INTEGRATED TECHNOLOGIES—MAPLEWOOD	2890	58512	4.9
BARRY	BRADFORD WHITE CORP	1100	29390	3.7
BAY	QUANTUM COMPOSITES INC RENOSOL-BAY CITY PLANT	45	49668	0.1
BERRIEN	LECO CORP NILES STEEL TANK VAIL RUBBER WORKS INC	875	70456	1.2
CALHOUN	COMCAST URETHANE CONVERIS FLEXIBLES US	173	61523	0.3
CHARLEVOIX	EAST JORDAN FOUNDRY	504	12453	4.0
CLARE	LEAR FARWELL PLANT	300	11016	2.7
CLINTON	INNOVATIVE POLYMERS INC	10	38607	<0.1
CRAWFORD	WEYERHAEUSER	125	4858	2.6

Table 22, continued...

County	Company Name ^{c,d}	# Workers Employed ^a by Isocyanate-Using Facilities	Total # Workers in the County ^b	% Workers Potentially Exposed to Isocyanates
DICKINSON	GREDE, LLC IRON MOUNTAIN LOUISIANA-PACIFIC-SAGOLA OSB	580	12114	4.8
EATON	ALLIANCE INTERIORS AXSON N AMERICA GM LANSING DELTA TWP	1210	53934	2.2
GENESEE	ASI PACKAGING COMPANY LANDAAL PACKAGING SYSTEMS	78	172233	<0.1
HILLSDALE	DOW CHEMICAL	45	19857	0.2
HURON	VALLEY ENTERPRISES	265	15748	1.7
INGHAM	HUNTSMAN ADVANCED MATERIALS S GROUP AUTOMOTIVE WILLIAMSTON PRODUCTS INC	290	139986	0.2
ISABELLA	MANITOWOC FOODSERVICE UNIFIED BRANDS	900	34028	2.6
JACKSON	MILSCO MICHIGAN SEAT TAC MFG WOLVERINE SIDING SYSTEMS	852	69324	1.2
KALAMAZOO	AZON USA PARKER HANNIFIN CORP-HYDRAULIC SYS STRYKER INSTRUMENTS	3200	124614	2.6
KENT	CLIPPER BELT LACING CO GRAND RAPIDS FOAM TECHNOLOGIES HB FULLER LACKS WHEEL TRIM SYSTEMS LEON INTERIORS NA FUELS SYSTEM REMFG PURFORMS INC RICHWOOD INDUSTRIES INC UNIVAR USA	1093	331429	0.3
LENAWEE	ANDERSON DEVELOPMENT HI-LEX CONTROLS INSULSPAN INTEVA PRODUCTS	645	45643	1.4
LIVINGSTON	ANTOLIN-HOWELL	400	90101	0.4
LUCE	LOUISIANA-PACIFIC CORP-NEWBERRY SIDING	111	2345	4.7
MACOMB	AXALTA COATING SYSTEMS CHRYSLER STERLING HTS ASSY FAURECIA INTERIOR SYSTEMS INTERNATIONAL CASTING CORP NJT ENTERPRISES ROMEO RIM INC SHELBY FOAM SYSTEM WOLVERINE BRONZE	4522	390572	1.2
MARQUETTE	ARGONICS—MI PLANT	60	31667	0.2
MASON	GREAT LAKES CASTING	240	13759	1.7
MECOSTA	WOLVERINE WORLD WIDE	540	18173	3.0
MIDLAND	CENTRAL WAREHOUSE –MIDLAND DOW CHEMICAL CO– 1790 BLDG & 1100 BLDG	2005	39761	5.0
MISSAUKEE	TJ'S WAREHOUSE	4	6635	0.1
MONTCALM	AGA MARVEL KENT FOUNDRY	274	26513	1.0

Table 22, continued...

County	Company Name ^{c,d}	# Workers Employed ^a by Isocyanate-Using Facilities	Total # Workers in the County ^b	% Workers Potentially Exposed to Isocyanates
MUSKEGON	DIVERSIFIED MACHINE-MONTAGUE	400	73444	0.5
OAKLAND	ARMALY SPONGE AXSON TECH USA BEHR AMERICA, MAHLE EAGLE INDUSTRIES EXOTIC RUBBER & PLASTICS CORP FANUC ROBOTICS—CORP HDQTRS ITW FUTURA COATING, ITW POLYMERS LYMTAL INTERNATIONAL INC RECTICEL UREPP N AMERICA	1544	593961	0.3
OCEANA	BARBER STEEL FOUNDRY CORP	50	11675	0.4
OTTAWA	EAGLE PACKAGING MAGNA MIRRORS ROYAL TECH	1240	147386	0.8
SAGINAW	ESSENTRA POROUS TECHNOLOGIES GLASTENDER NEXTTEER AUTOMOTIVE CORP SAGINAW METAL CASTING OPERATIONS STC	4080	84159	4.8
SANILAC	GRUPO ANTOLIN MIDWEST RUBBER CO NUMATICS SANDUSKY MAIN TRELLEBORG YSH INC	784	18404	4.3
ST CLAIR	IAC PORT HURON IAC ST CLAIR	470	67169	0.7
ST JOSEPH	IAC MENDON	800	28053	2.9
VAN BUREN	BASF CORP SPECIAL-LITE INC	182	33538	0.5
WASHTENAW	EXTANG CORP FAURECIA INTERIOR SYSTEMS THETFORD CORP	1975	183151	1.1
WAYNE	ALPHA RESINS BASF CORP—LIVONIA PLANT BASF CORP—WYANDOTTE PLANT CHRYSLER JNAP CYGNET AUTOMATED CLEANING EFTEC EQ DETROIT NORTHFIELD MFG INC PLASTOMER CORP U.S. ECOLOGY, MICHIGAN DBA DYNECOL UNIVAR USA—ROMULUS WINDSOR MACHINE & STAMPING (US) LTD WOODBIDGE CORP	4690	696033	0.7
WEXFORD	REC BOAT HOLDINGS-CRUISER PLANT	36	13636	0.3
TOTAL		39,587	4,493,000	0.9

^aSource: 2015 Michigan Manufacturers' Directory.

^bSource: Michigan Labor Market Information, Data Explorer, www.milmi.org accessed October 14, 2016.

^cSource: U.S. Environmental Protection Agency, Toxics Release Inventory, Michigan Companies Using Isocyanates in 2015, data accessed October 11, 2016.

^dSource: MI Dept of Environmental Quality, FOIA Request for SARA Title III Emergency Planning & Release Reporting of isocyanates, for calendar year 2015, received September 15, 2016.

Michigan Workforce Exposed to Select Causes of WRA, continued

Table 23 summarizes the companies, by county, using other chemicals that are known to cause asthma and those that are irritants and capable of causing Reactive Airways Dysfunction Syndrome. Those that can cause asthma are: Bisphenol A, Cobalt, Epichlorohydrin, Formaldehyde, Methyl Acrylate, Phthalic and Maleic Anhydride and Styrene. Ammonia and Chlorine are classified as irritants. These companies were identified through the MI DEQ SARA Title III Emergency Planning and Release Reporting for calendar year 2015.

Additional chemical exposures associated with WRA in Michigan can be found at: http://www.oem.msu.edu/userfiles/file/Resources/2015_MIWorkforceExposedSelectAsthmaCausingAgents.pdf

TABLE 23

Michigan Facilities by County, Reporting Toxic Chemicals to the Michigan Dept. of Environmental Quality (DEQ) Under Section 313 of the Emergency Planning and Community Right-to-Know Act (EPCRA)^a

SUBSTANCES CAPABLE OF CAUSING ASTHMA:

Acrylates, Anhydrides, Bisphenol A, Cobalt, Epichlorohydrin, Formaldehyde & Styrene

SUBSTANCES CAPABLE OF CAUSING REACTIVE AIRWAYS DYSFUNCTION SYNDROME: Ammonia & Chlorine

A=Ammonia, B=Bisphenol A, CH=Chlorine, CO=Cobalt, E=Epichlorohydrin, F=Formaldehyde, MA=Maleic Anhydride, M=Methyl Acrylate, MMA=Methyl Methacrylate, P=Phthalic Anhydride, S=Styrene

COUNTY	COMPANY NAME	EXPOSURE	COUNTY	COMPANY NAME	EXPOSURE
ALGER	NEENAH PAPER - MICHIGAN INC	A	BAY	QUANTUM COMPOSITES, INC.	S
ALLEGAN	BIRDS EYE FOODS LLC	A, CH		WEST BAY COUNTY REGIONAL WASTEWATER	CH
	CHS INC-HAMILTON FARM BUREAU	A	BENZIE	GRACELAND FRUIT, INC.	A
	CSD	A		PLATTE RIVER ST FISH HATCHERY	F
	DOUGLAS MARINE CORP	S		SMELTZER ORCHARD COMPANY	A
	HUDSONVILLE CREAMERY & ICE CREAM	A	BERRIEN	ADVANCE PRODUCTS CORP	A
	JBS PLAINWELL, INC.	A		BENTON HARBOR	A
	OTSEGO, CITY WELLS #3, #4, #5 & WWTP	CH		BUCHANAN AGRONOMY & PETROLEUM	A
	SHERMAN WILLIAMS CO- HOLLAND	A		BUCHANAN WATER & WWTP	CH
	TIARA YACHTS INC	S		COLOMA FROZEN FOODS INC	A
	WATER RENEWAL	CH		FREEZER/REPACK CTR	A
ALPENA	AMERICAN PROCESS—ENERGY RECOVERY	A		GREG ORCHARDS & PRODUCE INC	A
ANTRIM	JORDAN RIVER NAT FISH HATCHERY	F		HANSON COLD STORAGE	A
ARENAC	WHITESTONE PUMPING STATION	CH		NCP COATINGS	A, P
BARRY	CALEDONIA FARMERS ELEVATOR	A		NEW BUFFALO WATER PLANT	CH
	WATER TREATMENT FACILITY	CH		NILES, CITY - DECKER, FORT & FRONT WELLS & IRON REMOVAL	CH
BAY	BAY CITY MUNICIPAL WATER TREATMENT PLANTS	CH		OLD EUROPE CHEESE, INC.	A
	BAY CARBON INC	CH		SAINT JOSEPH WATER PLANT	CH
	MERSEN USA BN. CORP.	CH		SANDVIK MATERIALS TECHNOLOGY	A

Table 23, continued...

COUNTY	COMPANY NAME	EXPOSURE	COUNTY	COMPANY NAME	EXPOSURE
BRANCH	PRIDGEON FARMS	A	GD TRAV- ERSE	CENTREICE	A
	QUINCY	CH		CENTURY SUN METAL TREATING	A
	REAL ALLOY RECYCLING	CH		CHERRY GROWERS INC	A
	REAL ALLOY SPECIFICATIONS	CH		HILLSHIRE BRANDS, TRAVERSE CITY	A
	WATER TREATMENT PLT/COLDWATER	CH		MICHIGAN PLANT	A
CALHOUN	ALBION PLANT	A		TCS TRAVERSE COLD STORAGE LLC	A
	ANATECH, LTD.	F		TRAVERSE CITY	CH
	BATTLE CREEK WATER & WWTP	A, CH	GENESEE	A RAGNONE TREATMENT PLANT	CH
	BLEISTAHL CO	A		AIRGAS-FLINT	A
	MARSHALL CITY WATER	CH		FLINT WATER PLANT	CH
	MUSASHI AUTO PARTS-MICHIGAN INC	A		HENDERSON ROAD PUMP STATION	CH
	POST FOODS - BATTLE CREEK	CH		KOEGEL MEATS INC.	A
	PRAIRIE FARMS DAIRY, INC.	A		STOKES STEEL TREATING CO	A
	RBT J SWALWELL WWTP	CH		WATER POLLUTION CONTROL FAC	CH
CASS	THE MENNEL MILLING CO. OF MI	CH		WOODWORTH INC. FLINT	A
CHEBOYGAN	CHEBOYGAN WELLHOUSE #4 & #7 & WWTP	CH	GRATIOT	ALMA WASTEWATER PLANT	CH
CHIPPEWA	PENDILLS CREEK NFH	F		CITY OF ST. LOUIS WWTP	CH
	SULLIVAN CREEK NFH	F		NH3 TANK	CH
CLINTON	CROP PRODUCTION SERVICES 622	A	HILLSDALE	BEF FOODS INC.	A
	MAHLE ENGINE COMPONENTS USA, INC.	A		CONAGRA FOODS INC	A
	MARTIN BROWER	A		HILLSDALE WWTP	CH
	MICHIGAN MILK PRODUCERS ASSOC	A		PRATTVILLE FERTILIZER & GRAIN	A
	SAVE-A-LOT LTD	A		THE ANDERSONS LITCHFIELD FARM	A
	SCCMUA	CH	HOUGHTON	MICHIGAN-AMERICAN WATER CO	CH
	WASTEWATER TREATMENT FACILITY	CH		KOPPERS PERFORMANCE CHEM- ICALS	A
CRAWFORD	ARCTIC GLACIER INC	A	HURON	BAD AXE WWTP	CH
DELTA	ESCANABA PAPER COMPANY	A, CH		COOPERATIVE ELEVATOR	A
EATON	AXSON NORTH AMERICA INC.	S		DOW AGROSCIENCES LLC	A
	CROP PRODUCTION SERVICES	A		FARMERS CO-OP GRAIN CO.	A
	ETM ENTERPRISES INC.	S		HARBOR BEACH WATER WORKS & WWTP	CH
	LANSING PLANT	A, CH		THUMB TOOL & ENGINEERING	A
EATON	MEIJER LANSING DISTRIBUTION	A	INGHAM	ALDI INC - WEBBERVILLE	A
EMMET	ODEN STATE FISH HATCHERY	F			

Table 23, continued...

COUNTY	COMPANY NAME	EXPOSURE	COUNTY	COMPANY NAME	EXPOSURE	
INGHAM	ALEXANDER CHEMICAL CORPORATION	A, CH	JACKSON	WESTCHESTER PUMP STATION	CH	
	ARCTIC GLACIER—LANSING	A		KALAMA-ZOO	BELL'S BREWERY	A
	AURORA SPECIALTY CHEMISTRIES	E		CITY OF KALAMAZOO- STATIONS #28,#39	CH	
	CREMER FARM CENTER, INC.	A		HAVILAND PRODUCTS COMPANY	F	
	DYE WATER CONDITIONING PLANT	A		KALAMAZOO WATER DIV/STA #1-#5, #8, #9, #11, #12, #14, #17, #18, #22, #24, #25, #31	CH	
	E LANSING-MERIDIAN WATER & SEWER	A		KLC-2	A	
	JORGENSEN FARM ELEVATOR	A		KNAPPEN MILLING CO	CH	
	HAMLIN FARMS	A		PHARMACIA & UPJOHN LLC	A, CH, E, F	
	LANSING MINT RD.	A		PRECISION HEAT TREATING COMPANY	A	
	MASON P.O.T.W. PLANT	CH		THERMO FISHER SCIENTIFIC	F	
	MICHIGAN STATE UNIVERSITY	A		KENT	29th STREET WAREHOUSE	P
	NITREX INC - MICHIGAN OPERATION	A			ARKEMA INC.	B,P,S
	QUALITY DAIRY CO	A			BODYCOTE- GRAND RAPIDS	A
	SYMMETRY MEDICAL INC-LANSING	CO			BRENN'TAG GREAT LAKES LLC	A,F
THE ANDERSONS WEBBERVILLE –AG PRODUCTS	A	BRETON INDUSTRIAL PARK WAREHOUSE	B,S			
WATER TREATMENT PLANT	CH	CHASE STORAGE & CHASE ORCHARDS	A			
IONIA	BELDING TANK TECHNOLOGIES, INC	S	COCA-COLA GRAND RAPIDS	A		
	CARGILL KITCHEN SOLUTIONS	A	COUNTRY FRESH LLC	A		
	FARM DEPOT 3 LTD	S	EAGLES ICE CENTER	A		
	GALLAGHERS	A	FINISHMASTER INC #990 DIST CR	S		
	HERBRUCKS POULTRY RANCH	A	FORTY-FOURTH STREET FACILITY	A		
	PORTLAND WWTP	CH	FRUIT RIDGE APPLE CO	A		
	STAHLIN ENCLOSURES	S	GM COMPONENTS HOLDINGS, LLC	A		
	THK RHYTHM AUTOMOTIVE	A	GORDON FOOD SERVICE	A		
TWIN CITY FOODS	A, CH	GRANDVILLE	A, CH			
IOSCO	HURON SHORE REGIONAL UTILITY A	CH	HEEREN BROS	A		
	ROSE ICE COMPANY	A	JACK BROWN PRODUCE INC	A		
	TAWAS UTILITY AUTHORITY WWTP	CH	KENT QUALITY FOODS INC	A		
	TIP-TOP SCREW MFG IN	A	KING MILLING COMPANY	CH		
JACKSON	CITY OF JACKSON WATER TREATMENT	CH	LACKS TRIM SYSTEM - AIRLANE PLANT	F		
	COVENTRY PARK	CH	LACKS WHEEL SYSTEMS	F		
	INDUSTRIAL STEEL TREATING	A	LOWELL WWTP & WATER TREATMENT	CH		
	JCC WELL HOUSE	CH	MICHIGAN NATURAL STORAGE CO	A		
	KIMMEL ROAD WELL HOUSE	CH	MICHIGAN TURKEY PRODUCERS	A		
	MEADOW HEIGHTS WELL	CH	NBHX TRIM USA	S		
SOUTHVIEW PUMP STATION	CH	PATTERSON ICE CENTER	A			

Table 23, continued...

COUNTY	COMPANY NAME	EXPOSURE	COUNTY	COMPANY NAME	EXPOSURE
KENT	PLASTIC PLATE INC (KRAFT)	F	MACOMB	CARBIDE TECHNOLOGIES	A
	REMICO STREET FACILITY	CH, F		EVERFRESH / LA CROIX BEVERAGES	A
	RIVERIDGE PACKING	A		FORMSPRAG LLC	A
	S1	A		GM WARREN LLC TECHNICAL CENTER	A
	SPARTA FACILITY	A		METALLURGICAL PROCESSING CO	A
	SPARTAN NASH DISTRIBUTION	A		NITRO-VAC HEAT TREATING	A
	SUPERIOR SEAFOOD INC.	A		NORBROOK PLATING	A
	SUPERIOR STONE PRODUCTS INC	MMA, S		REINHART FOODSERVICE LLC	A
	SYSCO GRAND RAPIDS, LLC	A		RIVIERA BUILDING 2	A
	THE HOME CITY ICE CO	A		SPECIALTY STEEL TREATING, INC.	A
	UNIVAR USA	B		TURRI'S ITALIAN FOODS, INC	A
	VI-CHEM CORPORATION	S		MAR-QUETTE KI SAWYER WWTP	CH
VILLAGE OF SPARTA WATER DEPT	CH	MASON HOUSE OF FLAVORS INC	A		
WYOMING CLEAN WATER PLANT	CH	JOS. SANDERS INC	A		
KEWEENAW	SUSANS FARM	A	LUDINGTON WASTEWATER PLANT	CH	
LAPEER	LAPEER PLATING & PLASTICS	F	MICHIGAN FOOD PROCESSORS	A	
LEELANAU	CHERRY GROWERS-PLT 2	A	NORON COMPOSITE TECHNOLOGIES	MMA,S	
LENAWEE	ADC MAIN PLANT	MA,MMA,S	MECOSTA	LEPRINO FOODS COMPANY REMUS	A
	AIRGAS CARBONIC, INC	A		UNITED STATES MARBLE INC.	S
	CROP PRODUCTION SVCS 634 & 641	A	MENOMINEE	L.E. JONES COMPANY	CO
	DAIRY FARMERS OF AMERICA	A		MENOMINEE WATER & WWTP	CH
	WAR-AG FARMS SERVICES LLC	A		RULEAU BROS INC	A
	WELLHOUSE #3 #8—#12 & #14	CH		MIDLAND	CITY OF MIDLAND - WATER & WWTP
WILBUR-ELLIS COMPANY - MUNSON	A	DOW- MICHIGAN OPERATIONS	A, B, CH, MMA, S		
LIVING-STON	AMERICAN COMPOUNDING SPECIALTIES	MA	MIDLAND STORE	A	
	ASAHI KASEI PLASTICS NA	MA	TRINSEO, LLC MICHIGAN OPERATIONS	MMA,S	
	CHEMCO PRODUCTS, INC.	F	MONROE	ADVANCED HEAT TREAT CORP	A
	GORDON FOOD SERVICE	A		DETROIT EDISON - MONROE POWER PLT	A
	GREEN OAK DC	A		GUARDIAN INDUSTRIES CORP	A
	PEPSI HOWELL	A		HOME CITY ICE COMPANY- Toledo	A
	WATER PLANT & WWTP	CH		INDEPENDENT DAIRY INC	A
MACKINAC	WATER TREATMENT PLANT & WWTP	CH	MAYBEE FARMERS INC	A	
MACOMB	AXALTA COATING SYSTEMS	B,M,MMA,S	MEIJER NEWPORT DISTRIBUTION	A	
	BOSCOS PIZZA	A	OTTAWA LAKE CO-OP ELEVATOR	A	

Table 23, continued...

COUNTY	COMPANY NAME	EXPOSURE	COUNTY	COMPANY NAME	EXPOSURE
MONTCALM	WILBUR-ELLIS CO	A	OAKLAND	US FOODS INC.	A
MUSKEGON	ALLOY RESOURCE CORPORATION	CH		VILLAGE OF HOLLY WWTP	CH
	BAYER CROPS SCIENCE USA	A		VILLAGE OF MILFORD-IRON REMOVAL PLANT	CH
	COLE'S QUALITY FOODS, INC.	A		WATERFORD IRON REMOVAL 5-1, 12-1, 14-1, 16-1 & 2, MS-1, 19-1, 24-1, 25-1 & 2, 28-1, 31-1	CH
	ESCO COMPANY, LLC	P		WOODWORTH INC PONTIAC	A
	GMI COMPOSITES, INC	S	OCEANA	2ND STREET STORAGE	A
	HOWMET CORP - PLT 5	B		ARBRE FARMS CORPORATION	A
	L-3 COMBAT PROPULSION SYSTEMS	A		HART DIVISION	A
	PARAMELT (M. ARGUESO)	B		MICHIGAN FREEZE PACK	A
	SNAPPY APPLE FARMS INC	A		OCEANA CTY FREEZER STORAGE	A
	SUN CHEMICAL CORPORATION	A		PETERSON FARMS MAIN CAMPUS	A
	WEBB CHEMICAL SERVICE CORP	F	OGEMAW	SANDVIK HARD MATERIALS	CO
NEWAYGO	GERBER PRODUCTS COMPANY	A	OSCEOLA	ADVANCED FIBERMOLDING	S
	WILBUR-ELLIS CO	A		VENTRA EVART, LLC	F
OAKLAND	BEHR AMERICA INC (MAHLE)	A		YOPLAIT REED CITY	A
	CHEMICAL BLENDING	F	OTSEGO	GAYLORD	CH
	CHOR INDUSTRIES	A	OTTAWA	ALLENDALE PLANT	A
	COMMERCIAL STEEL TREATING	A		BOAR'S HEAD PROVISIONS CO INC	A
	DEPOR INDUSTRIES	F		BODYCOTE-HOLLAND	A
	DETROIT SKATING CLUB	A		CREME CURLS BAKERY, INC.	A
	DETROIT STEEL TREATING CO.	A		DIETRICH ORCHARDS	A
	ENGINEERED HEAT TREAT INC	A		GEORGETOWN ICE CENTER	A
	FARMINGTON HILLS ICE ARENA	A		J.B.SIMS GENERATING STATION	CH
	GENERAL MOTORS - PROVING GD	CH		JOHN F. DONNELLY PLANT	A
	HAZEL PARK VIKING ARENA	A		LEO DIETRICH & SONS	A
	JOHN LINDELL ICE ARENA	A		MEAD JOHNSON AND CO LLC	CH
	LAKELAND ARENA	A		MICHIGAN CELERY PROMOTION	A
	MACDERMID INCORPORATED	F		POLYPLY COMPOSITES LLC.	S
	MATHESON VALLEY	A		QUINCY STREET, INC	A
	NOVI ICE ARENA	A		RYDER HOLLAND LOGISTIC CTR	A
	ONYX-ROCHESTER ICE ARENA	A		SUPERIOR SALES INC	A
	RMT WOODWORTH, SOUTHFIELD	A		TRUE BLUE PACKAGING—NORTH	A
	SPECIALTY STEEL TREATING INC	A		VERTELLUS HEALTH SPEC PRODUCTS	A,MA
	STONE SOAP COMPANY INC	F		ZEELAND FACILITY	A
	SUBURBAN ICE TRAINING CENTER	A		ZEELAND FARM SERVICES, INC	A
	SULZER METCO (US) INC	CO	SAGINAW	ADVANCED MICRONUTRIENT PRODUCTS INC	A
	SUN STEEL TREATING INC	A		AGRIUM ADVANCED TECH (US)	A

Table 23, continued...

COUNTY	COMPANY NAME	EXPOSURE	COUNTY	COMPANY NAME	EXPOSURE
SAGINAW	BRIDGEPORT WWTP	CH	VAN BU- REN	FRUIT BELT CANNING COMPANY INC	A
	BUENA VISTA WWTP	CH		GRAND JUNCTION FACILITY	A
	DOW CORNING CORPORATION - HEALTHCARE IND MFG	A		HARTFORD WAREHOUSE	A
	FRANKENMUTH CITY OF WATER & WWTP	CH		IQF FACILITY	A
	HI-TECH STEEL TREATING, INC.	A		LAWRENCE FREEZER CORP.	A
	NEXTEER AUTOMOTIVE	A		PAW PAW RIVER PRODUCE	A
	OAKLEY CORN	A		PAW-PAW PLANT	A
	SAGINAW STOKER DRIVE	CH		RYDER PAW PAW LOGISTIC CTR	A
	THOMSON AEROSPACE & DEFENSE	A		SHAFFER LAKE FRUIT, INC	A
	WATER & WWTP, SAGINAW CHARTER TWP	CH		SILL FARMS MARKET, INC	A
SANILAC	WINFIELD SOLUTIONS LLC	A	WASHTE NAW	ST. JULIAN WINE COMPANY INC	A
	CROP PRODUCTION SERVICES - BROWN CITY, DECKERVILLE & SANDUSKY	A		WELCH FOODS, INC.	A
	CROSWELL WATER PLANT	CH		ANN ARBOR	A, CH
	DGP INCORPORATED	S		ANN ARBOR, CITY OF WPP	A
SHIAWAS- SEE	WILBUR-ELLIS CO-MARLETTE	A	WAYNE	ANN ARBOR ICE CUBE	A
	AIRGAS SPECIALTY PRODUCTS - OWOSSO	A		ARBOR HILLS ENERGY LLC	A
	FROMM FARMS	A		ARCTIC GLACIER INC	A
	HARVEST MILLS	A		CHELSEA MILLING CO	CH
ST CLAIR	MACHINE TOOL & GEAR, INC.	A	WAYNE	CROP PRODUCTION SERVICES	A
	DUNN PAPER, INC.	CH		DAPCO INDUSTRIES	A
	LK HURON WATER TREATMENT	CH		ELECTRO ARC MFG. COMPANY	A
ST JOSEPH	Z F MARYSVILLE AXLE DRIVES	A	WAYNE	UNIVERSITY OF MICHIGAN	A
	ABBOTT NUTRITION - STURGIS	A		3M DETROIT ABRASIVES	F
	AQUATIC CO.	S		A&R PACKING CO INC	A
	MENDON UNIT 635	A		ARCTIC COLD STORAGE	A
	MICHIGAN MILK PRODUCERS	A		ARCTIC EDGE ICE ARENA	A
	STURGIS WWTP	CH		BASF CORPORATION	A, MMA, S
TUSCOLA	THREE RIVERS WWTP	CH	WAYNE	BODYCOTE THERMAL PROCESSING	A
	CARO WWTP	CH		BOTTLING GROUP LLC, PEPSI BOTT	A
	CASS CITY WWTP	CH		BRENNTAG GREAT LAKES LLC	A
	COOPERATIVE ELEVATOR CO	A		C. F. BURGER CO	A
VAN BU- REN	FARM DEPOT	S	WAYNE	CANTON	A
	ALLOY STEEL TREATING CO INC	A		CANTON RENEWABLES	A
	CITY OF SOUTH HAVEN, WWTP	CH		CARDINAL HEALTH	F
	COCA COLA REFRESHMENTS	A		CHRYSLER-JEFFERSON NORTH ASSY	E, F
	DECATUR	A		CLASSIC PLATING	A

Table 23, continued...

COUNTY	COMPANY NAME	EXPOSURE	COUNTY	COMPANY NAME	EXPOSURE
WAYNE	COOPER HEAT TREATING LLC	A	WAYNE	MELVINDALE CIVIC ARENA	A
	COSTCO WHOLESALE	A		MICHIGAN DAIRY	A
	COUNTRY FRESH, LLC - LIVONIA	A		NORTHEAST WATER PLANT	CH
	CREST INDUSTRIES INC	S		PEPSI BOTTLING GROUP	A
	DAIRY FRESH FOODS INC	A		POLYCHEMIE INC	F
	DBA ALDOA COMPANY	E		PRAXAIR DISTRIBUTION INC	A,CH
	DEARBORN ICE SKATING CENTER	A		PVS TECHNOLOGIES, INC.	CH
	DETROIT PRODUCTION CENTER	A		S & F FOODS	A
	DETROIT WWTP	CH		SANTEMP	A
	DRDC	M		SOUTHWEST WATER PLANT	CH
	DYNAMIC SURFACE TECHNOLOGIES INTERNATIONAL	A		SPRINGWELLS WATER TREATMENT PLT	CH
	EDDIE EDGAR ARENA	A		SYSCO DETROIT, LLC	A
	FAYGO BEVERAGES INC.	A		TRENTON CHANNEL POWER PLANT	A
	FREEZER & DRY STORAGE LLC	A		TRENTON, CITY OF WWTP	CH
	FREEZER SERVICES OF MI LLC	A		UNISTRUT-WAYNE MANUFACTURING	A
	FRITZ PRODUCTS	CH		UNIVAR USA—ROMULUS	MA
	HOME CITY ICE COMPANY - DETROIT	A		WATER WORKS PARK PLANT	CH
	INLAND WATERS POLLUTION CONTROL, INC.	S		WOLVERINE PACKING COMPANY DIST PLT & LAMB & VEAL PLANT	A
	JCI JONES CHEMICALS INC.	CH		USA HOCKEY ARENA	A
	KENNEDY RECREATION CENTER	A		YACK ARENA	A
LINCOLN DISTRIBUTING	S	WEXFORD AAR MOBILITY SYSTEMS	F		
MASTRONARDI PRODUCE	A	CADILLAC	CH		
MCLANE FOOD SERVICE - PLYMOUTH	A	CRUISER DIVISION	S		

^aSource: Michigan Department of Environmental Quality (DEQ). Michigan Facilities' Guide to SARA Title III, Emergency Planning and Release Reporting, December 2007, 6th edition. The chemicals listed in this table are subject to reporting under the Emergency Planning and Community Right-to-Know Act (EPCRA) section 313, which is triggered by threshold amounts of 25,000 pounds manufactured or processed or 10,000 pounds otherwise used at facilities in Michigan. The companies listed in this table were current as of calendar year 2015 from a report generated by the Michigan DEQ on 9-15-16.

Discussion

The consensus in the medical literature is that the true number of WRA cases is much greater than what is actually reported in public health surveillance systems, including Michigan's. The American Thoracic Society (ATS) released a consensus statement in 2003 that estimates in 15% of adults with asthma, the asthma is caused by work exposures.⁶ In 2011, a second ATS consensus statement estimated 21.5% of adults with asthma have work-aggravated asthma.⁷ The combined estimates from these consensus statements would indicate that 36.5% of all adult asthma is work-related.

For the years 2008-2010, 52.5% (95% CI 48.2-56.8%) of Michigan adults who were ever employed and currently have asthma reported that a health care provider told them or they told a health provider their asthma was caused or made worse by exposures at work.¹ Table 24 shows how this percentage varied by age, gender, race, annual income and education. Among those individuals who responded their asthma was caused or made worse by work, only 22% had a discussion about work's effect on their asthma with their health care provider.¹ At minimum, the data suggest that providers are not addressing concerns of their patients and probably missing the identification of WRA triggers.

National data showed that individuals with work-related asthma had higher mean numbers of days with asthma symptoms. Individuals with more days of symptoms were more likely to not be able to work or perform usual activities.⁸

On average, from 1989-2013, 130 cases each year are reported to the Michigan Department of Licensing and Regulatory Affairs (LARA) with confirmed WRA. In recent years, the number of reports has decreased. Eighty-five reports were confirmed in 2013, the most recent year with complete data. The number of individuals with exposure to a known occupational sensitizer (disease category OA) shows a downward trend since the 1990s. The reason for this trend is unknown and may be related to changes in reporting sources or to the success of workplaces in better controlling their employees' exposures to known sensitizers.

Based on responses from the 2005 BRFSS random sample of Michigan residents, we estimate that up to 62,000 (95% CI 42,000—83,000) Michigan adults have

their asthma caused or aggravated by work.¹ Based on the medical literature we would estimate that there are 97,500 Michigan adults with WRA.⁶ Using capture-recapture analysis, we estimate 228—801 adults in Michigan develop WRA each year.⁹ Table 24 shows the characteristics of Michigan adults with asthma attributable to work, based on a telephone survey. These characteristics are similar to that found in the cases of WRA identified through our surveillance system.

Workers who are reported are generally young to middle-age Caucasian men and women, with the greatest number being reported from the Detroit metropolitan area. However, the rate of WRA in African Americans is 1.7 times greater than among Caucasians. Based on an analysis conducted for previous annual reports, factors from the WRA surveillance data that would contribute to greater morbidity among African Americans include: a greater likelihood to continue to be exposed to the workplace agent, having a longer time of exposure before leaving work, and being less likely to receive Workers' Compensation.

As companies trim costs, more temporary workers are being hired on an as-needed basis. The transient nature of temporary work underscores the potential for under-counting of cases of WRA when employees move from job to job, especially those jobs that have a high potential for exposure to sensitizing agents.

Individuals in the Michigan workforce develop their asthma from exposure to agents in the manufacturing sector, particularly automobiles, machinery, metals, chemicals, and rubber and plastics. The predominant causes of WRA are cleaning products (12.3%), isocyanates (12.2%) and metal working fluids (9.4%). Until recently, metal working fluids were the second most frequently reported exposure, and until this year isocyanates were the most frequently reported exposure.

The trend of fewer individuals with the known causes of WRA such as isocyanates, metal-working fluids and high molecular weight compounds would suggest improvements in controls when these agents are used since the number of facilities using isocyanates has increased. The increase in cases secondary to office settings and in services, and the increase in WRA secondary to cleaning agents suggests that exposures in these situations have proven more difficult to control (Figure 3) as well as increased workers in service industries.

We updated the table first presented in the 2002 Work-Related Asthma Annual Report (Table 22) on the number of manufacturing workers in companies that use isocyanates. In Allegan, Dickinson, Luce, Midland and Saginaw counties, approximately 5% of the work force is employed in facilities where isocyanates are used. Health care providers can use this information to heighten their awareness of potential exposures to isocyanates among their patients with asthma.

Table 23 shows selected agents by county and company that have been associated with WRA. Health care providers can use this table as an initial step in evaluating possible exposure for their patients if they work at one of the facilities listed.

Asthma symptoms may persist despite removal from the precipitating work exposures (Tables 15 & 16). Studies show that the sooner an individual is removed from the exposure after symptoms develop, the more likely the individual’s symptoms will resolve.¹⁰ On the average, among the 2,201 individuals who are no longer exposed to the causal agent, almost three years elapse from 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.

Data from the United Kingdom estimated that when medical care and lost time are factored in, the work-related asthma costs were 100 million dollars per year with 49% of the cost borne by the patient, 48% by the State and only 3% by the employer.¹¹ We do not have cost estimates for Michigan, but given the fact that only 49% of individuals applied for Workers’ Compensation benefits and we do not have universal health insurance as in the United Kingdom, we suspect that the individual patients in Michigan bear a high percentage of the costs associated with work-related asthma.

TABLE 24

Proportion of Asthma Attributable to Work Among Michigan Adults Who Were Ever Employed and Who Currently Have Asthma, Michigan Asthma Call Back Survey, 2008-2010 Combined

AGE in years	Proportion, %	95% Confidence Interval
18-34	39.9	29.6-51.1
35-64	61.8	57.5-65.9
>=65	43.8	38.3-49.5
GENDER		
Male	54.7	46.3-62.8
Female	51.4	46.5-56.2
RACE		
White	50.5	45.7-55.2
Black	58.9	46.7-70.1
ANNUAL INCOME		
<\$20,000	60.6	51.1-69.3
\$20,000-\$34,999	60.3	50.6-69.1
\$35,000-\$49,999	51.4	41.2-61.5
\$50,000-\$74,999	54.7	42.2-66.7
>=\$75,000	44.8	37.8-52.0
EDUCATION		
< High School	62.6	46.7-76.3
High School Graduate	57.4	49.1-65.3
Some College	51.1	43.4-58.7
College Graduate	48.7	41.7-55.8



Personal habits like cigarette smoking and individual susceptibility measured through personal or family history of allergies do not predict who develops WRA. About 50% of the WRA patients identified through the Michigan Tracking System have no personal or family history of allergies and 80% are not smoking cigarettes at the time their asthma symptoms develop (Tables 11,13).

Although most facilities where the patient developed asthma were in compliance with exposure standards, there were high percentages of symptomatic co-workers identified in those facilities. It is possible that either air sampling was not conducted under similar enough conditions as the exposures associated with the development of the index cases' asthma, such as spills or leaks, or that the current standards are not protective enough.

We identified 1,590 fellow workers with symptoms compatible with WRA (Table 21). Five hundred eighty-three individuals were listed on the MIOSHA Injury and Illness Log (Form 300) as having WRA or symptoms compatible with WRA. There was only an overlap of 10 individuals of co-workers reporting symptoms on co-worker interviews and those being reported on the MIOSHA 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.

Medical monitoring is particularly relevant to reducing the burden of work-related causes of asthma. The longer a person with asthma remains exposed, the more likely their asthma will become a chronic problem.¹⁰ A review of companies using isocyanates showed that only 32% were providing periodic medical surveillance.¹²

The percentages of individuals reported with work-related asthma that this surveillance system documented with breathing tests performed in relation to work was less than 10%. This reflects the standard of medical care in the United States where the diagnosis of WRA is made from the patient's history. More frequent use of objective pulmonary function testing performed in relation to work would allow health care providers to feel more confident when they should advise their patients to leave their work exposure.

Cessation of exposure is the most important aspect of treatment; patients who are removed from exposure the

soonest have the best prognosis.¹⁰ Effective asthma treatment requires that the health care providers consider a patient's asthma triggers. Many times the health care provider reacts to concerns that their patient raises about workplace exposures, rather than proactively inquiring whether their patient has triggers at work that contribute to their respiratory symptoms. One of the factors related to a 2005 death caused by isocyanate exposure was that the primary care physician waited until the patient requested a medical restriction, rather than instructing the patient at an earlier time that he needed to be removed from any further exposure to isocyanates at work.

The report of a patient with known or suspected WRA 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 WRA 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 the current permissible exposure limits, document the need for the development of new standards, identify new occupational allergens, and prevent co-workers from developing disease.

The potential that 54% of Michigan adults with asthma report work causes or aggravates their work-related asthma emphasizes the importance that health care providers and all asthma initiatives planned on surveillance and education, both for health care providers and the public address the importance of work exposures in diagnosing and managing asthma in adults.

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APPENDIX

2015 PATIENT NARRATIVES BY TYPE OF INDUSTRY & EXPOSURE

Abbreviations:

- OA = Occupational Asthma with Exposure to a Known Sensitizer
- POA = Possible Occupational Asthma, Work-related Symptoms, but Exposure is not a Known Sensitizer
- AA = Aggravated Asthma (Pre-Existing Asthma Exacerbated at Work)
- RADS = Reactive Airways Dysfunction Syndrome

The patient narratives that follow are based on information collected from interviews and medical records of patients reported with work-related asthma.

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MANUFACTURING

EXPOSURE TO ISOCYANATES

OA3828. A male in his 40s died from exposure to isocyanates. He worked at a urethane foam parts manufacturing facility. He had developed wheezing and shortness of breath approximately four years before his death. He was prescribed a bronchodilator and Qvar. He formerly smoked a pack of cigarettes a day for 20 years, but quit smoking about three years before he died.

OA3595. A male in his 40s developed work-related asthma from exposure to isocyanates used in the manufacture of automotive seat cushions. He experienced wheezing, a cough, shortness of breath and chest tightness, and was treated in an emergency department where he was prescribed Albuterol, Qvar and an EpiPen. He was a lifelong non-smoker.

OA3585. A male in his 50s developed work-related asthma from exposure to isocyanates. He worked as a mold machine operator at a company that made automotive seat cushions. He experienced wheezing, a cough and shortness of breath and was prescribed Advair and Albuterol. His asthma developed within a year of starting to work for the company. Upon his diagnosis, he was reassigned to a new job; since then, his symptoms improved and he required less asthma medication. He smoked a pack of cigarettes a day for approximately 30 years, but quit smoking when he was diagnosed with asthma.

OA3587. A female in her 40s developed work-related asthma from exposure to isocyanates. She worked at a company that made foam seats for automobiles. Her job was to trim and pack the foam. She developed a cough and shortness of breath and was prescribed Symbicort, Albuterol and an Albuterol nebulizer at the emergency department where she sought treatment. After she developed asthma, she was reassigned to a different area of the plant, away from isocyanates. Since then her symptoms improved and she discontinued her asthma medication. She was a lifelong non-smoker.

OA3572. A female in her 50s developed work-related asthma from exposure to isocyanates. She worked at an automotive parts manufacturing company that used isocyanate-based glue. She had worked at the company for approximately three years before she developed a cough and shortness of breath. She was prescribed Pulmicort, Advair, ProAir and a nebulizer. She continued to work at the facility. She was a lifelong non-smoker.

OA3757. A male in his 40s developed work-related asthma after working with isocyanate-based paint for 15 years at an automotive manufacturing facility. His job was to repair scratches in the paint finish of cars before they left the plant. He developed wheezing, a cough, shortness of breath and chest tightness, and was prescribed an Albuterol inhaler, Symbicort and Advair. He was placed on medical disability after his diagnosis. Since that time his symptoms worsened and he required more asthma medication. He was a lifelong non-smoker.

OA3782. A male in his 30s developed work-related asthma from exposure to isocyanates. He had worked for about a year at an aluminum automotive parts manufacturer as a molder when he developed wheezing, a cough, chest tightness and shortness of breath. He was treated in an emergency department and prescribed Spiriva, Albuterol, Qvar and Prednisone. He continued to work at the factory, and six years after his diagnosis, his symptoms worsened and he required a greater amount of asthma medication. He formerly smoked a half a pack of cigarettes a day from his mid-20s to his late-30s.

EXPOSURE TO METAL WORKING FLUIDS

POA3708. A male in his 20s developed work-related asthma after working for three years at a manufacturing facility. He was exposed to coolant mist in his job as a machinist, grinding, drilling and sawing metal parts. He developed wheezing, chest tightness and shortness of breath and was prescribed Prednisone, and an EpiPen. He quit this job upon his doctor's advice, and found new employment. Since then, his symptoms improved and he no longer required medication. He smoked a half a pack of cigarettes a day since his late-teens.

OA3778. A male in his 30s developed work-related asthma from exposure to coolants used at the automotive manufacturing plant where he was a CNC operator. He wore a paper mask. He was on the job for less than a year when he developed a cough, chest tightness, shortness of breath and wheezing. He sought treatment at an emergency department and was prescribed Advair and an Albuterol nebulizer. Upon his doctor's advice, he quit his job and found new employment at another automotive manufacturing plant. Since then his symptoms improved and he no longer required asthma medication. He was a lifelong non-smoker.

EXPOSURE TO COBALT

OA3734. A male in his 20s developed work-related asthma shortly after beginning to work at an airplane parts manufacturing company. He was exposed to cobalt while grinding small airplane parts. He developed wheezing, a cough, shortness of breath and chest tightness and was prescribed Advair during his visit to an emergency department. He was fired shortly after this for seeking treatment for his asthma, and had not found new employment at the time of interview. Since that time, his symptoms have remained unchanged, although he was able to discontinue his asthma medication. He smoked almost a pack of cigarettes a day since his mid-teens.

EXPOSURE TO WELDING FUME

OA3736. A male in his 40s developed work-related asthma while welding at his job at a company that made train parts. He was exposed to welding fumes including zinc oxide while welding on galvanized metal. He developed wheezing, chest tightness and shortness of breath, and was prescribed an inhaler and steroids. He was fired from his job and had not found new employment at the time of interview. Since being off work, his symptoms improved and he no longer took asthma medication, because he could not afford the cost. He smoked less than half a pack of cigarettes a day for 20 years, but quit after he was diagnosed with asthma.

EXPOSURE TO MISCELLANEOUS CHEMICALS AND DUSTS

OA3711. A female in her 30s developed work-related asthma shortly after beginning to work at a chrome parts finishing factory. She was exposed to chromium and other chemicals used in the process to dip and coat automotive parts. She developed a cough, wheezing, shortness of breath and chest tightness and was treated at an emergency department, where she was prescribed Albuterol. Since the development of her asthma, she quit her

job on her doctor's advice. Her symptoms improved and she required less asthma medication. She had not found a new job at the time of interview, approximately five months after stopping work at the chrome plating plant. Since her early teens, she has smoked approximately one pack of cigarettes per week.

AA3719. A female in her 40s experienced an exacerbation of her pre-existing asthma when she was exposed to a fire in the automotive parts manufacturing facility where she worked. The company doctor gave her an Albuterol treatment. She was a lifelong non-smoker.

OA3750. A male in his 60s developed work-related asthma from exposure to particulates at a company that made cleaning products. He experienced a cough and shortness of breath when exposed to particulates from the cleaning agents, and was prescribed Albuterol. He continued to work at the company. He was a lifelong non-smoker.

POA3739. A male in his 20s developed work-related asthma while working at a steel fabricating shop. He was exposed to a silicon spray and epoxy fumes. He developed a cough and shortness of breath and was prescribed ProAir. He smoked a pack of cigarettes a day since his early teens.

OA3569. A male in his 60s developed work-related asthma from multiple exposures in his job at an airplane parts manufacturing facility. He was exposed to primers, lube oil and silicone. He worked at the company for over five years before he developed shortness of breath, received treatment at an emergency department and was prescribed Advair and Albuterol. He went on medical disability and since that time his symptoms improved and he required less asthma medication. He formerly smoked a pack of cigarettes a day for approximately 10 years, but quit when he was diagnosed with asthma.

AA3721. A female in her 20s experienced an exacerbation of her pre-existing asthma from exposure to fumes in the auto parts manufacturing company where she worked. Her job was in the assembly area. She was a lifelong non-smoker.

AA3727. A male in his 50s experienced an exacerbation of his pre-existing asthma from exposure to lime dust in his job at a food manufacturing facility. The exacerbation of his asthma resulted in lost work time, and he was fired for this. He was a lifelong non-smoker.

AA3733. A male in his 60s experienced an exacerbation of his pre-existing asthma at the factory where he worked while he was helping move some dusty shelves. He was a lifelong non-smoker.

POA3601. A female in her 30s developed work-related asthma after working for almost five years at a pharmaceutical manufacturing facility. She was exposed to dust while cleaning the machines used to make various types of medicine. She developed chest tightness and shortness of breath, and was prescribed Albuterol and Symbicort by her primary care physician. Shortly after her diagnosis, she was placed on medical leave; since that time her symptoms improved, although she still requires the same amount of asthma medication. She formerly smoked approximately one pack of cigarettes per week for 15 years, but quit in her late 20s.

RADS3712. A female in her 50s developed RADS from an acute exposure to acrolein that was improperly mixed at the chemical manufacturing plant where she worked. She immediately developed a cough and shortness of breath and was treated at an emergency department where she was prescribed Flovent and Flonase. Since the incident, her symptoms improved although she still required the same amount of asthma medication. She formerly smoked a pack of cigarettes a day for 10 years from her late-20s until her late-30s.

POA3751. A male in his 20s developed work-related asthma shortly after being assigned a job at a steel treating facility through a temporary employment agency. He was exposed to dust, paint fumes, truck exhaust and leaks from the ovens where the steel was treated. He described the factory as having poor ventilation. He developed a cough, wheezing, shortness of breath and chest tightness and was prescribed Albuterol, Qvar and Flovent when he sought treatment for his symptoms at an emergency department. He continued to work at the facility, and reported his symptoms had worsened and he required a greater amount of asthma medication. He was a lifelong non-smoker.

AA3744. A female in her 20s experienced an exacerbation of her childhood asthma while working at an auto-

motive manufacturing plant. She was placed at the factory through a temporary employment agency. She was exposed to flux powder in her job assignment, which was to move flux-covered parts from the furnace and put them on a conveyor belt. She continued to do this job and reported her symptoms improved although she required a greater amount of asthma medication. She formerly smoked a half a pack of cigarettes per day for three years, but quit when her asthma symptoms worsened.

POA3586. A female in her 30s developed work-related asthma at a company that manufactured eyeglasses. Exposures included mold, acetone, a chemical used to coat the edges of the eyeglasses, and dust from cutting the lenses. She has worked for about two years when she developed wheezing, cough and shortness of breath. She continued to work at this facility for over 20 years. She was prescribed Advair, Qvar and Albuterol. Over time her symptoms improved although she still required the same amount of asthma medication. She was a lifelong non-smoker.

AA3786. A female in her 40s experienced an exacerbation of her pre-existing asthma as she began a new job at a lumber mill. Her job was to move the wood from the saw to a conveyor belt. She described her exposure to mold, dirt and wood dust. She was fired shortly after she began working at the lumber mill, when she was on medical leave for her asthma exacerbation. She was unable to find a new job at the time of interview. She smoked almost a pack of cigarettes a day from her mid-teens, but quit when her asthma flared up at the lumber mill job.

POA3580. A male in his 40s developed work-related asthma shortly after beginning to work at a chemical manufacturing plant. Within a year of working at the plant, he developed wheezing, chest tightness and shortness of breath. He was prescribed Advair, Pulmicort, Albuterol and Qvar. A couple years later he developed a cough. He continued to work at the facility; his symptoms worsened and he required a greater amount of asthma medication. He was a lifelong non-smoker.

EDUCATIONAL SERVICES

EXPOSURE TO CLEANING PRODUCTS

AA3737. A female in her 30s with childhood asthma worked in a lab. She experienced an exacerbation of her asthma from exposure to a new cleaning product that contained quaternary ammonium compounds. When first introduced, the product was being improperly mixed. Corrections were made, but the cleaning product continued to exacerbate her asthma. A new cleaning product was substituted and her symptoms subsequently improved. On spirometry, her FVC was 92% of predicted and her FEV₁ was 65% of predicted. She was a lifelong non-smoker.

POA3578. A female in her 50s developed work-related asthma after working as a teacher at a school for approximately five years. She was exposed to mold in the ceiling tiles and carpet dust. She was prescribed Advair, Singulair and Prednisone. She worked an additional four years at the school. After she retired, her symptoms improved although she still required the same amount of asthma medication. She was a lifelong non-smoker.

EXPOSURE TO INDOOR AIR CONTAMINANTS

AA3774. A female in her 50s developed work-related asthma after working at a school for over 10 years. She was exposed to chemicals from the school's auto body shop. She experienced wheezing, cough and shortness of breath. She was prescribed Pulmicort, Nasacort, Singulair, Advair and Albuterol. After she retired, her symptoms improved and she required less asthma medication. She was a lifelong non-smoker.

POA3556. A female office worker in her 40s developed work-related asthma from exposure to indoor air contaminants in the school where she worked. She described mold and mildew throughout the school. She developed wheezing and shortness of breath and was prescribed Albuterol. She continued to work at the school, and reported her symptoms were unchanged although she required less asthma medication. She was a lifelong non-smoker.

EXPOSURE TO ANIMAL DANDER

AA3594. A female in her 20s experienced an exacerbation of her pre-existing asthma from exposure to cat dander at the veterinary school where she worked as a veterinary technician. She was prescribed a greater

amount of asthma medication, and continued to work at the veterinary school. She smoked a half a pack of cigarettes a day since her mid-teens.

HEALTH CARE SERVICES

EXPOSURE TO ANIMAL DANDER

AA3723. A female in her 40s experienced an exacerbation of her pre-existing asthma when she was exposed to a cat at the nursing home where she worked as a nursing assistant. The nursing home would not get rid of the cat, so she had to find a new job. She smoked a pack of cigarettes a day since her early teens.

EXPOSURE TO CLEANING PRODUCTS

AA3748. A female in her 50s experienced an exacerbation of her pre-existing asthma from exposure to floor stripper. She worked at a hospital as a medical technician. She was treated in the hospital emergency department and prescribed additional asthma medication, Asmanex and ProAir. She was a lifelong non-smoker.

AA3593. A female in her 50s experienced an exacerbation of her pre-existing asthma from exposure to chemicals used to flush a catheter. She worked at a hospital as a medical technician.

EXPOSURE TO INDOOR AIR CONTAMINANTS AND MISCELLANEOUS CHEMICALS AND DUSTS

AA3732. A female in her 60s experienced an exacerbation of her pre-existing asthma when she was exposed to air contaminants from roof construction being done at the hospital where she worked as a nurse. She was prescribed additional asthma medication after this exposure triggered her asthma. She was a lifelong non-smoker.

RADS3735. A male in his 30s developed RADS from an acute exposure to roofing construction fumes that entered the ventilation system of the hospital where he worked as a surgical technologist. He developed wheezing, a cough and shortness of breath and was prescribed Symbicort, Flovent, Proventil, Prednisone and ProAir. He left this job due to his lung problems and has since found new employment. His symptoms improved and he required less asthma medication. He was a lifelong non-smoker.

RADS3725. A female in her 50s developed RADS from an acute exposure to fumes from a roofing construction project that filtered into the ventilation system of the hospital where she worked as a surgical assistant. She immediately experienced wheezing, a cough, chest tightness and shortness of breath. She was prescribed Symbicort, an Albuterol nebulizer and Albuterol. She was placed on medical leave, after which her symptoms improved although she required a greater amount of asthma medication. She formerly smoked a half a pack of cigarettes a day from her mid-teens, but quit when she was diagnosed with asthma.

AA3574. A male in his 40s experienced an exacerbation of his pre-existing asthma at the hospital where he worked as a medical technologist. He was exposed to a leak of refrigerant. The hospital subsequently fixed the leak. He was a lifelong non-smoker.

RADS3766. A male surgeon in his 40s developed RADS from an acute exposure to polyurethane fumes that came through the ventilation system at the hospital where he worked. The fumes were from a construction roofing project. He immediately experienced cough, shortness of breath, chest tightness and wheezing. He was treated at the hospital and prescribed Albuterol, Prednisone, Combivent, Spiriva, Qvar, Xopenex and Singulair. Since the acute exposure, his symptoms improved and he required less asthma medication. He was a lifelong non-smoker.

WHOLESALE & RETAIL SERVICES

EXPOSURE TO CLEANING AGENTS

AA3741. A female in her 20s experienced an exacerbation of her pre-existing asthma from exposure to cleaning chemicals used on the floors at the retail store where she worked as a sales associate. The store ended up going out of business and since that time her symptoms improved and she required less asthma medication. She was a lifelong non-smoker.

RADS3728. A male in his 40s developed RADS from an acute exposure to cleaning chemicals at the retail store where he worked. Within 24 hours, he developed wheezing, a cough, shortness of breath and chest tightness.

He sought treatment at an emergency department and was prescribed Albuterol. He was fired due to his lung problems, and had not found new employment at the time of interview. Since being away from the cleaning chemicals, his symptoms improved although he still required the same amount of asthma medication. He was a lifelong non-smoker.

EXPOSURE TO WEATHER CHANGES

AA3792. A male in his 20s experienced an exacerbation of his childhood asthma while working outside in the winter. He was helping load merchandise in the car of a customer at the store where he worked. After this occurred, he was transferred to an indoor position for the fall and winter seasons. Since that time, his symptoms improved. He was a lifelong non-smoker.

OFFICE/INDOOR AIR

EXPOSURE TO INDOOR AIR CONTAMINANTS

POA3726. A female in her 50s developed work-related asthma after working in an office building for 15 years. She was exposed to paint and carpet fumes. She sought treatment for her wheezing, cough, chest tightness and shortness of breath, and was prescribed Albuterol, Prednisone and Symbicort. She was reassigned to a new office location after her asthma diagnosis, and since that time her symptoms improved and she required less asthma medication. She was a lifelong non-smoker.

AA3797. A female in her 40s experienced multiple exacerbations of her pre-existing asthma from exposure to mold from a water leak into the basement of the building where she worked. In addition to the basement, mold was found under the wallpaper in the upper floor of the building, including her office. The mold was remediated, and since that time her symptoms improved while she was at work. She smoked a cigarette a day for about a year in her late teenage years.

CONSTRUCTION

EXPOSURE TO ISOCYANATES

OA3776. A male in his 20s developed work-related asthma shortly after beginning to work for a foam insulation company. His job was to spray isocyanate-based foam insulation in residential attics and other areas. He wore a full-face respirator, suit and gloves. Within months of working at this job, he developed a cough, wheezing, shortness of breath and chest tightness. He was treated at an emergency department and prescribed Albuterol and Prednisone. After his asthma diagnosis, he was able to continue to work at the company, but away from the spray foam applications. Since then, his symptoms improved and he no longer required asthma medication. He smoked almost a pack of cigarettes a day since his late-teens.

EXPOSURE TO MISCELLANEOUS CHEMICALS AND DUSTS

AA3767. A female in her 50s experienced an exacerbation of her pre-existing asthma at her office job for a construction company. She was exposed to hazardous waste fumes that leaked into her office area. She was a current cigarette smoker.

AA3756. A male in his 30s experienced an exacerbation of his pre-existing asthma at his construction job. He was exposed to concrete dust from cutting, prepping and laying stone. He formerly smoked approximately a pack of cigarettes a day for 15 years till his early 30s.

RADS3563. A male in his 50s developed RADS from an acute exposure to an engineered cement product in his construction job as a carpenter. He immediately experienced a cough and shortness of breath from the product, which contained calcium carbonate, calcium aluminate and vinyl acetate co-polymer. The MSDS labeled the product as "very toxic." He was hospitalized due to this exposure, and was prescribed Albuterol, Dulera and Singulair. He quit his job due to his asthma. He was a lifelong non-smoker.

FOOD SERVICE

EXPOSURE TO MISCELLANEOUS SUBSTANCES

POA3588. A male in his 30s developed work-related asthma after working at a restaurant for over 10 years. He was exposed to fumes in the kitchen from shellfish. He developed wheezing, chest tightness and shortness of breath and was prescribed Albuterol and Symbicort. He was treated in the emergency department twice and was hospitalized once for his asthma from exposures at work. Shortly after his diagnosis, he went on medical disability. Since no longer being exposed to seafood fumes, his symptoms improved although he still required the same amount of asthma medication. He was a lifelong non-smoker.

OA3573. A female in her 20s developed work-related asthma from exposure to flour shortly after beginning to work at a restaurant. She developed a cough, chest tightness, wheezing and shortness of breath. She sought treatment from an allergist who prescribed Albuterol. Shortly after her diagnosis, she quit this job because of her asthma. Since that time her symptoms improved and she required less asthma medication. She was a lifelong non-smoker.

POA3598. A male in his 30s developed work-related asthma after working at a restaurant for several years. He was exposed to fumes from the heated oil used in the deep fryer, noting that there was poor ventilation in the building. He developed a cough, chest tightness, shortness of breath and wheezing and was prescribed asthma medication. He continued to work at the restaurant, his symptoms worsened and he required more asthma medication. He was a lifelong non-smoker.

AA3758. A female in her 30s experienced an exacerbation of her pre-existing asthma at her job at a restaurant. She was exposed to fumes from glue used when tile was being installed at the restaurant. The exposure triggered an asthma attack that required treatment in an emergency department. After this incident, she continued to work at the restaurant and her symptoms improved, although she required a greater amount of asthma medication. She was a lifelong non-smoker.

PUBLIC SERVICES

EXPOSURE TO CLEANING AGENTS

RADS3713. A female in her 60s developed RADS from exposure to floor stripper in her job as a custodian at a jail. She had worked over 10 years in this job before she developed wheezing, a cough and shortness of breath, and was treated at a hospital emergency department. She eventually quit her job on her doctor's advice, and had not found new employment. Since that time, her symptoms remained unchanged and she requires the same amount of asthma medication. She smoked a pack of cigarettes a week, since her mid-teens.

EXPOSURE TO MISCELLANEOUS SUBSTANCES

RADS3589. A male firefighter in his 50s developed RADS while fighting a fire at a factory. He was exposed to unknown chemicals and fumes during this incident. He developed a cough, chest tightness, wheezing and shortness of breath. He was treated at an emergency department and prescribed asthma medication including Ventolin, Spiriva, Singulair and Dulera. He continued to work as a firefighter; since the incident that caused his asthma, his symptoms worsened and he required a greater amount of asthma medication. He was a lifelong non-smoker.

RADS3722. A male police officer in his 30s developed RADS when he was exposed to smoke from an old building that was on fire. He developed wheezing, a cough and shortness of breath, and was treated in an emergency department where he was prescribed Symbicort and Albuterol. Since the fire, his symptoms improved and he required less asthma medication. He was a lifelong non-smoker.

AA3745. A female in her 20s experienced an exacerbation of her pre-existing childhood asthma at her job in county government.

POA3793. A female in her 40s developed work-related asthma at the prison where she worked. She was exposed to pepper spray. She developed a cough, wheezing, shortness of breath and chest tightness almost immediately when she began working at the prison. A couple years later she was prescribed Albuterol, Qvar, Azmacort and Prednisone. Approximately 10 years later she was assigned to a location with no pepper spray expo-

sure; her symptoms remained unchanged although she required less asthma medication. She formerly smoked less than half a pack of cigarettes a day in her mid 20s for approximately six years.

TRANSPORTATION SERVICES

EXPOSURE TO MISCELLANEOUS SUBSTANCES

AA3582. A male truck driver in his 30s experienced an exacerbation of his pre-existing asthma when he was exposed to multiple chemicals that spilled when he was unloading a delivery at a paper mill. After that incident, which resulted in treatment at an emergency department, he minimized his potential exposure to chemicals by not standing close to the truck when his deliveries were unloaded. He was a lifelong non-smoker.

AA3714. A male in his 40s experienced an exacerbation of his pre-existing asthma when he was exposed to coal dust as he was helping to unload coal from a transportation ship. He smoked a half a pack of cigarettes a day for over 20 years.

POA3581. A male truck driver in his 60s developed work-related asthma from exposure to diesel fumes. He drove a truck with a leaking exhaust system that was eventually repaired. He developed a cough, wheezing and chest tightness and was treated in an emergency department where he was prescribed Flovent and Singulair. After the truck was repaired, his symptoms improved although he did require a greater amount of asthma medication. He was a lifelong non-smoker.

MISCELLANEOUS SERVICES & INDUSTRIES

EXPOSURE TO ISOCYANATES

OA3781. A male in his 20s developed asthma from exposure to isocyanate-based paint while doing automotive body repair work. He developed shortness of breath and chest tightness and was treated in a hospital emergency department. After being diagnosed with asthma, he quit his job. He was a lifelong non-smoker.

EXPOSURE TO CLEANING PRODUCTS

AA3773. A female in her 30s experienced an exacerbation of her childhood asthma from exposure to bleach that was being used to clean the bathroom at the daycare where she worked. She was a lifelong non-smoker.

RADS3724. A female in her 50s developed RADS from an acute exposure to a cleaning agent that contained quaternary ammonium compounds. She was a housekeeper at a hotel. She had not used this particular cleaning agent prior to this exposure; when she did, she immediately experienced a cough, shortness of breath and chest tightness, and was treated at an emergency department where she was prescribed Prednisone and Albuterol. After this incident, the hotel stopped using this cleaning agent. Since her exposure, she has continued to have symptoms and required a greater amount of asthma medication. She smoked about a pack of cigarettes a week since her late-30s.

RADS3706. A female in her 30s developed RADS from an acute exposure to sulfuric acid when she was cleaning out a storage closet. She was a janitor at a company for two years prior to this exposure. She immediately experienced chest tightness and shortness of breath from this exposure, and was treated in an emergency department where she was prescribed Symbicort and Albuterol. After this acute exposure she was fired, and had not found new employment at the time of interview. Since that time, her symptoms improved although she still required the same amount of asthma medication. She was a lifelong non-smoker.

AA3592. A male in his 50s experienced an exacerbation of his pre-existing asthma from cleaning with chlorine-based cleaning agents. He worked at an automotive maintenance shop. He was treated at an emergency department for this asthma attack. He was a lifelong non-smoker.

EXPOSURE TO MISCELLANEOUS SUBSTANCES

POA3809. A male in his 50s developed asthma from exposure to pool chemicals and pollen while doing pool maintenance work. He had done this job for about 10 years before he developed wheezing, a cough and shortness of breath. He was prescribed a Symbicort inhaler, an Albuterol nebulizer and an Albuterol inhaler. He con-

tinued to work doing swimming pool maintenance, his symptoms improved, and he required less asthma medication. He was a lifelong non-smoker.

AA3709. A female in her 70s experienced an exacerbation of her pre-existing asthma from exposure to fumes at work, which resulted in treatment at an emergency department, followed by admission to the hospital for several days. She formerly smoked a half a pack of cigarettes a day for 40 years from her mid-30s to her mid-70s.

POA3718. A maintenance man in his 30s who worked for a hotel developed work-related asthma from exposure to fumes from bed bug chemicals that were applied in the rooms where he was assigned to perform maintenance work. He also described mold in some of the wood and drywall of the hotel rooms. He developed wheezing, a cough and shortness of breath and was prescribed Ventolin. He was subsequently reassigned to a different job/area, but his symptoms and medication remained unchanged. He was a lifelong non-smoker.

POA3752. A female in her 20s developed work-related asthma about two years after she began working at a daycare facility. She developed chest tightness and shortness of breath after new carpet was laid at the facility. She was exposed to formaldehyde off-gassing from the new carpet, as well as dust and mold that was stirred up when the old carpet was removed. She was treated in an emergency department and prescribed Prednisone and ProAir. Shortly after this, she quit her job upon the advice of her doctor. Since that time, her symptoms improved although she required a greater amount of asthma medication. She had not found new employment at the time of interview. She was a lifelong non-smoker.