

NOVEMBER 14, 2019

2017 ANNUAL REPORT

TRACKING WORK-RELATED ASTHMA IN MICHIGAN



2017 ANNUAL REPORT

Work-Related Asthma Surveillance Program

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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: 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

LEO MI Department of Labor & Economic Opportunity

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



This report was funded by the National Institute for Occupational Safety & Health, under cooperative agreement U60-OH008466.

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 27th 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 at: aoec.org

Summary, continued...

- ◆ Since 2007, the number of cases identified each year has been less than the overall yearly average of 126.
- ◆ From 1988-2017, 3,592 WRA cases have been identified with MI's tracking system.
- ◆ We estimate there are 62,000-97,000 adults in MI with WRA.
- ◆ 80% of the MI WRA patients have new-onset asthma; 20% have pre-existing asthma aggravated by an exposure at work.
- ◆ MIOSHA enforcement inspections at the facilities where individuals worked who were reported with WRA revealed that, on average, almost one out of every six of the fellow workers have asthma or respiratory symptoms compatible with asthma.
- ◆ Cleaning agents (12.6%) and isocyanates (12.0%), are the most commonly reported exposures causing WRA in MI.
- ◆ Approximately 44,739 individuals in the MI workforce are employed in manufacturing where isocyanates are used.
- ◆ The average incidence rate of WRA among African Americans is 2 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-10 J45 and 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**

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.*

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.

*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

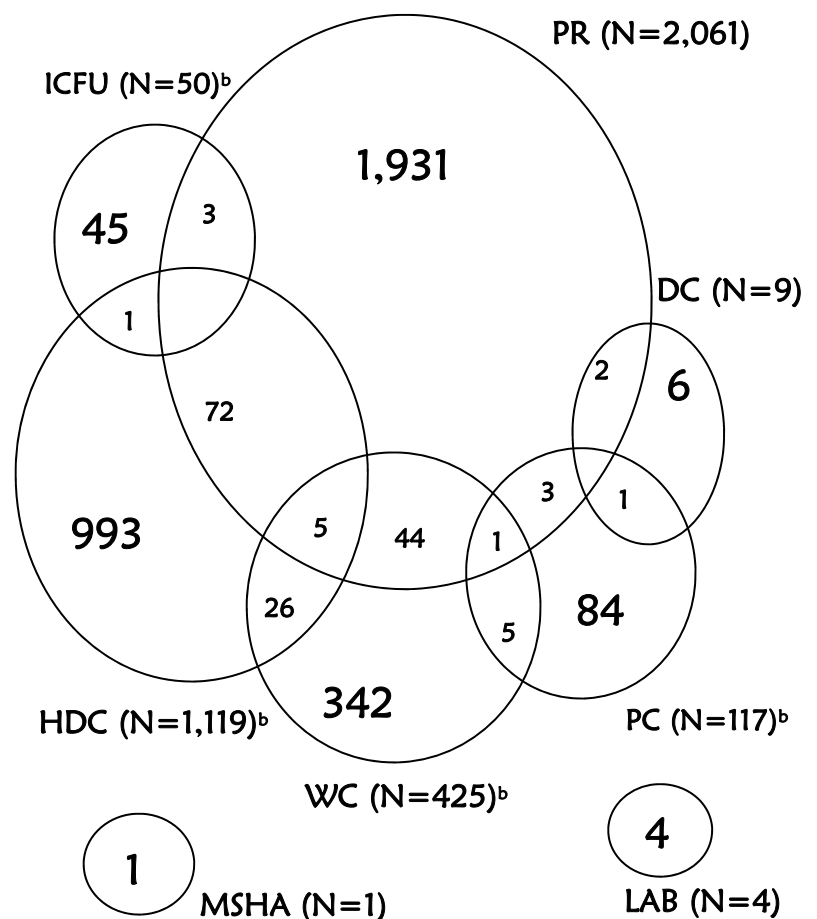
Table 1 shows that 3,592 people were confirmed with WRA between 1988—2017. The reports are divided into: occupational asthma (OA), possible occupational asthma (POA), aggravated asthma (AA) and Reactive Airways Dysfunction Syndrome (RADS). Eighty-three additional patients have been confirmed since last year's report (one for 2016, and 82 for 2017). Figure 1 shows the overlap of the patients by reporting sources for 1988—2017.

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

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	27	2	67
2015	16	21	33	13	83
2016	21	14	38	6	79 ^a
2017	10	24	43	5	82 ^a
Total	1,165	1,312	710	405	3,592

^aReports are still being processed for calendar years 2016 and 2017; an increase in these totals will be reflected in next year's annual report.

FIGURE 1
Overlap of Reporting Sources for 3,592 Confirmed Work-Related Asthma Patients: 1988-2017^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=Poison Control Center; LAB= Laboratory IgE.

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

Demographics-Trends

The analyses conducted for the annual report were divided into 1988-1997, 1998-2007 and 2008-2017 to examine trends over time. There were 1,274 individuals reported with work-related asthma from 1988-1997, 1,461 individuals reported from 1998-2007 and 857 reported from 2008 to 2017. The trend analyses can be found along with the tables that present the overall statistics. The CHANGE IN PERCENTAGE column on select tables indicates the percentage of increase or decrease in the percentages from the 1988-1997 to the 2008-2017 time periods.

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 2.61 per 100,000 Michigan African American workers compared to 1.27 per 100,000 for Michigan Caucasian workers; this was a 2 times greater incidence (95% CI 1.165, 3.609).

TABLE 2
Gender of Work-Related Asthma Patients by Time Period

	Time Period				
	All years	1988-1997	1998-2007	2008-2017	Change in Percentage
Gender	# (%)	# (%)	# (%)	# (%)	
Female	1,945 (54)	626 (49)	800 (55)	519 (61)	+ 24%
Male	1,647 (46)	648 (51)	661 (45)	338 (39)	- 24%

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.

TABLE 3
Race of Work-Related Asthma Patients by Time Period

	Time Period				
	All years	1988-1997	1998-2007	2008-2017	Change in Percentage
Race	# (%)	# (%)	# (%)	# (%)	
Caucasian	2,626 (73)	973 (76)	1,074 (74)	579 (68)	-11%
African American	672 (19)	239 (19)	271 (19)	162 (19)	None
Hispanic	79 (2)	24 (2)	27 (2)	28 (3)	+ 50%
Alaskan/Am Indian	30 (1)	10 (1)	13 (1)	7 (0.8)	- 20%
Asian	15 (<1)	4 (0.3)	7 (0.5)	4 (0.5)	+ 67%
Other	39 (1)	11 (1)	20 (1)	8 (0.9)	-10%
Unknown	131 (4)	13 (1)	49 (3)	69 (8)	N/A

Location in State-Trends

Table 4 and Figure 2 show the average annual incidence rates of WRA among the working population, by county. The highest rates were in Luce (11.1 cases per 100,000), Clare (8.2 cases per 100,000), Genesee (4.9 cases per 100,000), Huron (4.8 cases per 100,000) and Osceola and Saginaw (4.7 cases per 100,000 each).

TABLE 4
Average Annual Incidence Rates of Work-Related Asthma
Among Michigan Workers by County of Exposure: 1989-2015^a

<u>County</u>	<u>Avg Annual</u>		<u>Cases</u> <u>1989-2015</u>	<u>County</u>	<u>Avg Annual</u>		<u>Cases</u> <u>1989-2015</u>
	<u># EE's^b</u>	<u>Inc Rate^c</u>			<u># EE's^b</u>	<u>Inc Rate^c</u>	
Alcona	3,701	1.0	1	Keweenaw	934	4.0	1
Alger	4,082	1.8	2	Lake	4,078	1.8	2
Allegan	51,890	3.5	49	Lapeer	41,930	2.9	33
Alpena	13,883	2.9	11	Leelanau	10,451	1.8	5
Antrim	10,773	1.0	3	Lenawee	47,409	2.5	32
Arenac	6,827	2.2	4	Livingston	86,477	1.6	37
Baraga	3,466	4.3	4	Luce	2,678	11.1	8
Barry	28,195	0.7	5	Mackinac	5,996	1.9	3
Bay	51,280	1.8	25	Macomb	396,836	2.8	298
Benzie	7,828	1.4	3	Manistee	11,000	1.3	4
Berrien	73,886	1.5	29	Marquette	31,306	2.5	21
Branch	21,410	4.0	23	Mason	13,628	1.1	4
Calhoun	65,736	2.5	44	Mecosta	17,904	1.7	8
Cass	24,866	0.7	5	Menominee	12,260	0.3	1
Charlevoix	12,704	2.6	9	Midland	39,455	2.7	29
Cheboygan	11,260	4.3	13	Missaukee	6,220	2.4	4
Chippewa	15,632	1.2	5	Monroe	72,714	1.6	31
Clare	11,718	8.2	26	Montcalm	27,030	2.3	17
Clinton	34,384	0.9	8	Montmorency	3,781	3.9	4
Crawford	6,164	3.6	6	Muskegon	78,772	1.3	27
Delta	18,237	2.4	12	Newaygo	20,992	2.8	16
Dickinson	13,230	3.4	12	Oakland	613,059	2.6	429
Eaton	55,075	0.9	13	Oceana	12,255	1.2	4
Emmet	17,085	1.1	5	Ogemaw	8,852	3.3	8
Genesee	194,623	4.9	257	Ontonagon	3,234	1.1	1
Gladwin	10,067	1.1	3	Osceola	10,174	4.7	13
Gogebic	7,230	1.0	2	Otsego	11,317	3.6	11
Grand Traverse	42,943	1.6	19	Ottawa	123,438	0.8	25
Gratiot	18,133	2.5	12	Roscommon	9,630	2.7	7
Hillsdale	21,637	2.2	13	Saginaw	90,666	4.7	114
Houghton	15,701	1.7	7	Sanilac	19,843	3.7	20
Huron	15,387	4.8	20	Schoolcraft	3,448	2.1	2
Ingham	144,855	3.4	132	Shiawassee	33,207	0.7	6
Ionia	27,764	1.5	11	St. Clair	78,702	2.7	57
Iosco	9,639	1.9	5	St. Joseph	28,518	1.4	11
Iron	5,278	2.8	4	Tuscola	26,543	3.1	22
Isabella	33,403	2.6	23	Van Buren	36,707	0.9	9
Jackson	72,768	2.4	48	Washtenaw	178,274	3.6	174
Kalamazoo	123,404	1.5	49	Wayne	851,213	3.5	797
Kalkaska	7,816	3.8	8	Wexford	13,447	1.7	6
Kent	294,931	1.1	90	All Michigan Counties^d	4,702,000	2.6	3,321

^a 1989 through 2015 represent complete years of reporting. Reporting in 1988 was begun mid-year and is incomplete. Reporting for 2016 and 2017 is not yet complete. Therefore, 1988, 2016 and 2017 reports are not included in this table.

^b EE's = employees. 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 1989-2015 (27 years), per 100,000 Michigan workers.

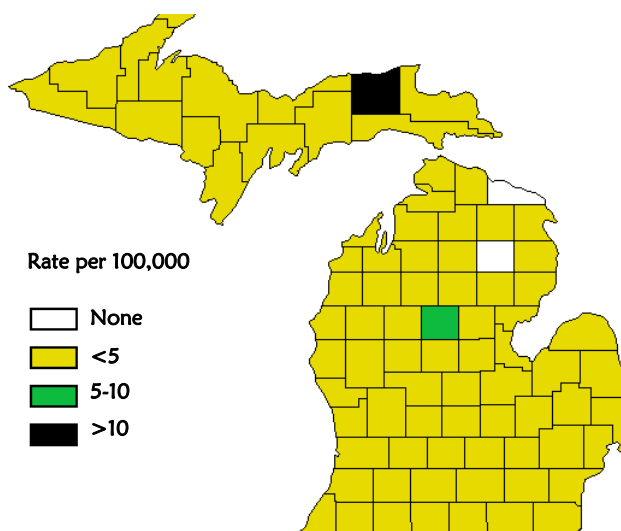
^d Fifty-seven cases had an out-of-state exposure and 22 had an unknown county of exposure, for the 1989-2015 reporting period.

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 1989-2015 time period. All of the top 10 counties with the highest overall rates of WRA had a decrease greater than 10% in the rate of WRA over time. Many of the rates increased during the 1998-2007 time period but then decreased during the 2008-2017 time period.

FIGURE 2
Average Annual Incidence Rate of WRA by County of Exposure: 1989-2015^a



^a 1989 through 2015 represent complete years of reporting. Reporting in 1988 was begun mid-year and is incomplete. Reporting for 2016 and 2017 is not yet complete. Therefore, 1988, 2016 and 2017 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			2008-2017			
County	Rate	# Cases	# EE's ^a	Rate	# Cases	# EE's	Rate	# Cases	# EE's	Rate	Change in Percentage
Branch	3.7	7	17,699	4.0	12	21,340	5.6	5	17,032	2.9	- 28%
Cheboygan	3.8	8	9,658	8.3	2	11,422	1.8	3	9,277	3.2	- 61%
Clare	7.7	8	9,100	8.8	11	11,761	9.4	8	10,570	7.6	-14%
Genesee	4.6	83	179,394	4.6	132	191,377	6.9	50	163,453	3.1	- 33%
Huron	4.3	7	14,941	4.7	8	15,499	5.2	5	15,104	3.3	- 30%
Kalkaska	3.4	4	6,188	6.5	4	7,932	5.0	0	6,604	—	- 23%
Luce	10.0	4	2,021	19.8	2	2,660	7.5	2	2,112	9.5	- 52%
Osceola	4.4	2	9,343	2.1	10	9,938	10.1	1	8,996	1.1	- 48%
Saginaw	4.3	31	91,307	3.4	67	90,388	7.4	19	80,771	2.4	- 29%
Sanilac	3.4	5	17,992	2.8	12	19,452	6.2	3	17,315	1.7	- 39%
All MI Counties	2.5	1,274	4,258,000	3.0	1,461	4,702,000	3.1	857	4,198,000	2.0	-33%

^a EE's = employees. Source: MI Dept of Tech, Mgt, & Budget, Labor Market Information, Annual Unemployment Statistics (LAUS) by County, 2002.

Type of Industry-Trends

Table 6 shows the Michigan industries by NAICS codes, with cases of work-related asthma from 1988 to 2017. The main industries were in manufacturing (57%) 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 9.5 cases per 100,000 in manufacturing. Industries with the next highest average annual incidence rates were: mining with 5.6 cases per 100,000 workers and health care and social assistance with 3.0 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, which dropped from 71.6% of cases in 1988-1997 to 36.5% in 2008-2017. 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, 1988-2017 by Primary Industrial Exposure and Average Annual Incidence Rate per 100,000 Workers, 1989-2015 (Years of Complete Reporting)

2002 North American Industry Classification System		WRA Cases 1988-2017		Number of Employees ^a	Average Ann. Incidence Rate ^b	
		#	%		Rate	# Cases
11	Agriculture, Forestry, Fishing, & Hunting	24	0.7	81,664	1.0	23
21	Mining	13	0.4	8,600	5.6	13
22	Utilities	19	0.5	35,300	2.0	19
23	Construction	99	2.8	199,800	1.7	91
31-33	Manufacturing	2,032	56.6	761,400	9.5	1,948
42	Wholesale Trade	39	1.1	175,400	0.8	38
44-45	Retail Trade	116	3.2	530,700	0.7	102
48-49	Transportation & Warehousing	70	1.9	92,900	2.7	68
51	Information	24	0.7	70,400	1.3	24
52	Finance & Insurance	34	0.9	157,700	0.7	29
53	Real Estate & Rental & Leasing	19	0.5	55,700	1.1	16
54	Professional, Scientific & Technical Services	31	0.9	258,700	0.4	28
55	Management of Companies & Enterprises	2	0.1	73,600	0.1	1
56	Administrative & Support & Waste Management	77	2.1	267,000	1.0	73
61	Educational Services	163	4.5	332,000	1.7	156
62	Health Care & Social Assistance	444	12.4	499,300	3.0	410
71	Arts, Entertainment & Recreation	31	0.9	53,500	2.1	30
72	Accommodation & Food Services	111	3.1	345,200	1.1	103
81	Other Services (except Public Administration)	82	2.3	256,100	1.1	78
92	Public Administration	141	3.9	390,400	1.3	133
00	Unknown	21	0.6	--	--	17
Total		3,592	100.1^c	4,568,564	2.8	3,400

^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 2016 and 2017 is not yet complete. Therefore, 1988, 2016 and 2017 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 1989-2015 (27 years), per 100,000 Michigan workers.

^cPercentage does not add to 100 due to rounding.

Type of Industry-Trends

TABLE 7
1,948 Work-Related Asthma Patients from Manufacturing Industries:
1989-2015^a

	2002 North American Industry Classification System	WRA Cases #	Avg Ann Rate ^a	# Employees ^b
311	Food Mfg	65	7.5	31,900
323	Printing & Related Support Activities	19	3.5	20,200
325	Chemical Mfg	104	11.4	33,800
326	Plastics & Rubber Products Mfg	104	8.8	43,700
327	Nonmetallic Mineral Product Mfg	18	3.8	17,600
331	Primary Metal Mfg	68	8.9	28,300
332	Fabricated Metal Product Mfg	113	5.0	84,500
333	Machinery Mfg	149	6.9	79,700
334	Computer & Electronic Product Mfg	14	2.5	21,100
336	Transportation Equipment Mfg	1,139	14.2	296,900
337	Furniture & Related Product Mfg	14	1.7	31,000
	Miscellaneous Mfg (*includes NAICS: 312-16,321-322,324,335,339)	141	7.2	72,700

^aAverage annual incidence rate, based on cases from 1989-2015 (27 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 2016 and 2017 is not yet complete. Therefore, 1988, 2016 and 2017 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.

Workers can
be exposed to
sensitizing
agents in any
type of



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

		Time Period						
		1988-1997		1998-2007		2008-2017		
NAICS	Industry	#	%	#	%	#	%	Change in Percentage
11	Agriculture, Forestry, Fishing, & Hunting	4	0.3	12	0.8	8	0.9	+ 200%
21	Mining	5	0.4	6	0.4	2	0.2	- 50%
22	Utilities	3	0.2	5	0.3	11	1.3	+ 550%
23	Construction	32	2.5	37	2.5	30	3.5	+ 40%
31-33	Manufacturing	912	71.6	809	55.4	313	36.5	- 49%
42	Wholesale Trade	23	1.8	14	1.0	3	0.4	- 78%
44-45	Retail Trade	15	1.2	48	3.3	51	6.0	+ 400%
48-49	Transportation & Warehousing	14	1.1	35	2.4	21	2.5	+ 127%
51	Information	6	0.5	11	0.8	7	0.8	+ 60%
52	Finance & Insurance	2	0.2	17	1.2	15	1.8	+ 800%
53	Real Estate & Rental & Leasing	2	0.2	11	0.8	6	0.7	+ 250%
54	Professional, Scientific & Technical Services	9	0.7	16	1.1	6	0.7	N/A
55	Management of Companies & Enterprises	0	—	1	0.1	1	0.1	N/A
56	Administrative & Support & Waste Management	10	0.8	27	1.8	40	4.7	+ 488%
61	Educational Services	40	3.1	73	5.0	50	5.8	+ 87%
62	Health Care & Social Assistance	105	8.2	194	13.3	145	16.9	+ 106%
71	Arts, Entertainment & Recreation	5	0.4	11	0.8	15	1.8	+ 350%
72	Accommodation & Food Services	19	1.5	49	3.4	42	4.9	+ 227%
81	Other Services (except Public Administration)	22	1.7	31	2.1	29	3.4	+100%
92	Public Administration	44	3.5	46	3.1	51	6.0	+ 71%
00	Unknown	2	0.2	8	0.5	11	1.3	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 automotive 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 453 (12.6%) of Michigan's WRA patients, and isocyanates (MDI, TDI, HDI and others) accounting for 432 (12.0%) of the WRA case exposures. Metal working fluids (coolants) accounted for 329 (9.2%) 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, such as services and manufacturing, 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 WRA 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 7.0% in 2008-2017. Cleaning agents increased from 4.6% of all the WRA exposures in 1988-1997 to 21.1% in 2008-2017. Metalworking fluids, solvents, latex rubber, welding fume, epoxy, formaldehyde and acids also decreased over time, while there was an increase in cases reported from exposure to fungus and paint fumes 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 (years of most complete data). 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 metal-working 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. The manufacturing industry and associated exposures have been decreasing over time.



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 9

Top Workplace Exposures Associated with Confirmed WRA Patients: 1988-2017

Exposure Agent	#	%
Cleaning Solutions	453	12.6
Isocyanates	432	12.0
Metal Working Fluids	329	9.2
Unknown (Mfg.)	264	7.3
Unknown (Office)	207	5.8
Exhaust/Smoke/Fumes	168	4.7
Welding Fume-Stainless & Other	156	4.3
Solvents	113	3.1
Paint Fumes	88	2.4
Epoxy	80	2.2
Fungus	79	2.2
Formaldehyde	67	1.9
Acids	66	1.8
Latex/Rubber	62	1.7
Fire	60	1.7
Chlorine	52	1.4
Plastic Fumes	52	1.4
Chemicals Used in Construction	51	1.4
Animal Dander	41	1.1
Acrylates	39	1.1
Cobalt	33	0.9
Fragrances	31	0.9
Flour	29	0.8
Wood Dust	27	0.8
Ammonia	24	0.7
Styrene	23	0.6
Cigarette Smoke	22	0.6
Herbicide/Pesticide	21	0.6
Fiberglass	19	0.5
Aldehydes	19	0.5
Chromium	16	0.4
Amines	16	0.4
Cement Dust	15	0.4
Medication	15	0.4
Cosmetology Chemicals	14	0.4
Plants/Organic Matter	14	0.4
Asphalt	13	0.4
Caustics	13	0.4
Rust Inhibitor	13	0.4
Fire Extinguisher Powder	12	0.3
Grain Dust	12	0.3
Printing Inks	12	0.3
Anhydrides	11	0.3
Insecticides	9	0.3
Meat Wrapper's Asthma	9	0.3
Freon	8	0.2
Heat	8	0.2
Other ^a	275	7.7
Total	3,592	99.7^b

^aThere were 7 cases with exposure to: Enzymes, Paper Dust, Polyurethane, Sewage.

There were 6 cases each with exposure to: Azodicarbonamide, Nitrogen, Pickling Ingredients, Solder Fume, Sulfur Dioxide, Textile Lint.

There were 5 cases each with exposure to: 1,1,1 Trichloroethane, Coal Dust, Mold Release Spray, Photo Developing Fluids.

There were 4 cases each with exposure to: Asbestos, Cold Air, Cooking Oil, Drywall Dust, Exercise, Lime Dust, Rose Hips, Sand, Sulfonate, Trichloroethylene, X-Ray Developing Fluids.

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

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

There was 1 case each with exposure to: 1,3-Dichloro-2-Propanol, 1,3-Dichloro 1-bromo-3-chloro-5 5-Dimethyl Hydantoin, Agent Orange, Ammonium Bifluoride, Barbeque Smoker, Benzoate Esters, Bitrex, Blood, Blue Prints, Calcium Carbonate, Calcium Chloride (used in Cherry Brine), Capsaicin, Car Window Sealant, Carbon Dioxide, Carbon Monoxide, 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, Metal Dust, 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, Propane, Soda Ash, Sodium Acetate, Sodium Chlorite, Soot, Stress, Swimming Pool Shock, Tetrahydrofuran, Titanium Tetrachloride, Tuberculosis Vaccine, Vinegar, White Lithium, Wood Smoke, World Trade Center Exposure, Zinc Borate.

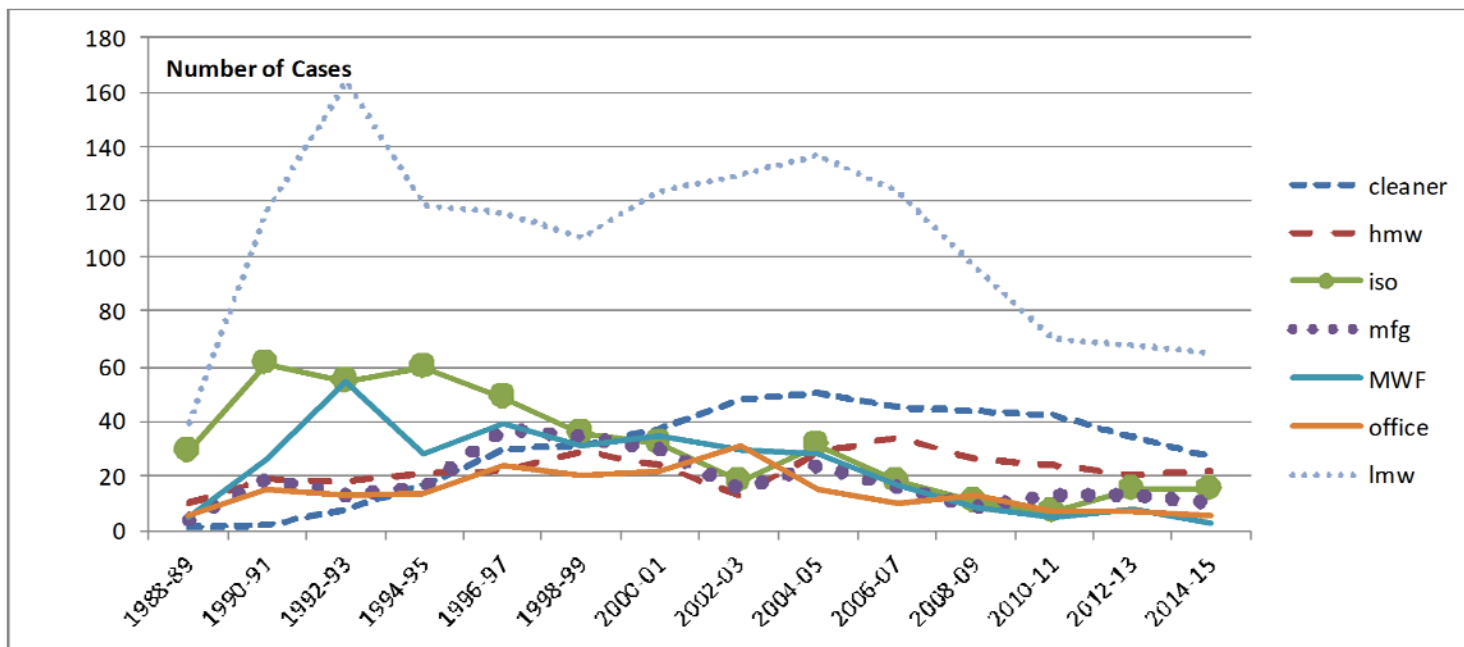
^bPercentage does not add to 100 due to rounding.

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

	Time Period				
	All Years	1988-1997	1998-2007	2008-2017	Change in Percentage
Exposure Type	# (%)	# (%)	# (%)	# (%)	
Cleaning Agents	453 (12.6)	59 (4.6)	213 (14.6)	181 (21.1)	+ 359%
Isocyanates	432 (12.0)	246 (19.3)	126 (8.6)	60 (7.0)	- 64%
Metalworking Fluids	329 (9.2)	153 (12.0)	144 (9.9)	32 (3.7)	- 69%
Welding Fume	156 (4.3)	63 (4.9)	62 (4.2)	31 (3.6)	- 27%
Solvents	113 (3.1)	51 (4.0)	52 (3.6)	10 (1.2)	- 70%
Paint	88 (2.4)	18 (1.4)	49 (3.4)	21 (2.5)	+ 79%
Epoxy	80 (2.2)	33 (2.6)	28 (1.9)	19 (2.2)	- 15%
Fungus	79 (2.2)	0	41 (2.8)	38 (4.4)	+ 57%
Formaldehyde	67 (1.9)	33 (2.6)	19 (1.3)	15 (1.8)	- 31%
Acids	66 (1.8)	27 (2.1)	24 (1.6)	15 (1.8)	- 14%
Latex/Rubber	62 (1.7)	25 (2.0)	33 (2.3)	4 (0.5)	- 75%

FIGURE 3

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



^aCleaner=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 higher than the state average for 2017 (19.3%) (source, CDC BRFSS results, www.cdc.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). Sixteen percent of the asthma patients had a personal history of allergies and asthma (Table 13). Forty-six percent had no history of allergies or asthma.

HEALTH CARE USAGE Sixty-six percent of the WRA patients had at least one visit to the Emergency Department (ED) in their lifetime for their WRA, and 35% had at least one hospitalization for their WRA (Table 14). The average number of ED visits was 5.5 and the average number of hospitalizations was 3.7.

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 and in 2016 or 2017. There was one work-related asthma death in 2015. Case ID OA3828 in the Case Narratives Section (page 33 of the 2015 Annual Report, Tracking WRA in Michigan www.oem.msu.edu) 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 3,458^a
Confirmed WRA Patients: 1988-2017

	Smoking Status						TOTAL
	Current		Ex-Smoker		Non-Smoker		
	#	% ^b	#	%	#	%	
OA	244	21.1	444	38.4	469	40.5	1,157
POA	190	15.0	515	40.8	558	44.2	1,263
AA	139	21.4	172	26.5	338	52.1	649
RADS	105	27.0	146	37.5	138	35.5	389
All	678	19.6	1,277	36.9	1,503	43.5	3,458

^aMissing data on 134 patients.

^bPercents may not add to 100 due to rounding.

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 19.3% in 2017.

Source: www.cdc.gov

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

	Time Period				
	All Years	1988-1997	1998-2007	2008-2017	Change in Percentage
Smoking Status	# (%)	# (%)	# (%)	# (%)	
Current	678 (20)	243 (20)	295 (21)	140 (17)	- 15%
Ex-Smoker	1,277 (37)	540 (43)	479 (34)	258 (32)	- 26%
Non-Smoker	1,503 (43)	463 (37)	632 (45)	408 (51)	+ 38%
Total	3,458	1,246	1,406	806	

Medical Results-Trends

TABLE 13
Personal History of Allergies or Asthma Among 3,274^a Confirmed WRA Patients: 1988-2017

		Personal History of...							
		Allergies & Asthma		Asthma Only		Allergies Only		No Allergies or Asthma	
		#	%	#	%	#	%	#	%
OA	60	5.5		54	4.9	327	29.9	652	59.7
POA	86	7.3		55	4.7	407	34.5	632	53.6
AA	347	52.2		285	42.9	14	2.1	19	2.9
RADS	17	5.1		35	10.4	82	24.4	202	60.1
All	510	15.6		429	13.1	830	25.4	1,505	46.0

^aMissing data on 318 patients.

TABLE 14
Health Care Usage Among Confirmed WRA Patients: 1988-2017

Lifetime History of Health Care Usage			
ED Visit ^a		Hospitalized ^b	
Yes	No	Yes	No
# (%)	# (%)	# (%)	# (%)
2,212 (66)	1,159 (34)	1,115 (35)	2,082 (65)
Range		Range	
1-300 visits		1-200 hospitalizations	
AVG 5.5 ±15.0		AVG 3.7±10.0	
^a Missing data on 221 patients.			
^b Missing data on 395 patients.			

SYMPTOMS

Two thousand eight hundred twenty-six (2,826) 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: Approximately 70% of the cases were no longer exposed to the agent associated with their WRA and this did not change 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 2008-2017, 24% of those still exposed reported an improvement in symptoms, compared to 46% among those no longer exposed. Also among those still exposed, there was a decrease among those reporting the need for less asthma medication, with 21% reporting the need for less asthma medication during 1988-1997 compared to 30% among those no longer exposed, and 14% reporting the need for less asthma medication during 2008-2017, compared to 32% among those no longer exposed.

TABLE 15
Persistence of Symptoms and Medication Use in 3,240 Confirmed WRA Patients: 1988-2017

		Breathing Problems Still Present?				Still Taking Asthma Medications?			
		Yes		Less		Yes		Less	
		#	%	#	%	#	%	#	%
Still Exposed?	Total								
Yes	938	896	95.5	276	29.4	817	87.1	166	17.7
No	2,302	1,930	83.8	1,095	47.6	1,803	78.3	666	28.9
Total	3,240 ^a	2,826		1,371		2,620		832	

^aInformation missing on 352 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	
2008-2017	Yes	210	194	92.4	51	24.3	193	91.9	30	14.3
	No	527	397	75.3	241	45.7	410	77.8	169	32.1
	Total	737	591		292		603		199	
Change in Percentage	Yes			-4%		-29%		+8%		-33%
	No			-9%		-8%		+5%		+9%

PULMONARY FUNCTION 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 pre-post bronchodilatation and a methacholine challenge test over time. Too few individuals had peak flow monitoring at work and home, pre-post work-shift testing or specific antigen challenge testing to calculate changes over time.

TABLE 17
Pulmonary Function Testing of Work-Related Asthma Patients by Time Period

	Time Period				
	All Years	1988-1997	1998-2007	2008-2017	Change in Percentage
Test Type	(%)	(%)	(%)	(%)	
Pre-post Bronchodilatation	51	54	54	44	- 19%
Methacholine Challenge	18	25	16	10	- 60%
Peak Flow at Work & Home	4	3	3	5	a
Pre-post Work-shift	3	2	4	3	a
Specific Antigen Challenge	<1	0.9	0.3	—	a

^aNot calculated because the number of individuals with testing was too small.

Workplace Investigations-Trends

WORKERS' COMPENSATION

Over all the years of reports, 49% of individuals with work-related asthma applied for workers' compensation benefits; among those, 38% were awarded, 17% were denied and 45% were pending approval.

WORKERS' COMPENSATION OVER TIME: The percentage of WRA patients who applied for workers' compensation benefits did not change across the time periods: 1988-1997, 1998-2007 and 2008-2017. The first two time periods showed 49% of patients applying for workers' compensation benefits, and the third period had 50% apply. However, there were differences in the outcomes of applying for benefits, with an increase in the percentage awarded benefits over the three time periods from 37% to 33% to 47% 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 32% in the most recent time period.

INDUSTRIAL HYGIENE

A total of 809 workplace inspections have been conducted since 1988 (Table 18); 123 of those facilities had been inspected more than once. Thirteen completed inspection reports have been received since last year's report.

Air sampling was conducted during 580 inspections (Table 19); 30 (5.2%) of the 573 facilities with a MIOSHA standard for the presumed causal agent were above the enforceable permissible exposure limit.

TABLE 18
Status of Facilities Where Confirmed WRA Patients Were Exposed to the Suspected Causal Agent: 1988-2017

<u>Inspection Status</u>	<u># Patients</u>	<u>Companies</u>	
	<u>Represented</u>	<u>#</u>	<u>%</u>
Inspected	1,267	809 ^a	31.5
No Follow-up Planned	2,116	1,563	60.9
Scheduled for Inspection	1	1	<0.1
Out of Business	78	70	2.7
No Longer Use Occupational Allergen	27	26 ^b	1.0
<u>Sent Company Letter to Check Exposures^d</u>	<u>103</u>	<u>96</u>	<u>3.7</u>
Total	3,592	2,565 ^c	99.8

^a809 inspections were conducted in 686 different workplaces.

^bEight companies that no longer use the suspected causal agent were previously inspected.

^cRepresents 2,442 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 809
Workplace Inspections: 1988-2017

<u>Air Sampling – NIOSH Standard</u>	<u>#</u>	<u>%</u>
Above NIOSH Standard	69	8.5
Below NIOSH Standard	482	59.6
No NIOSH Standard	31	3.8
Unknown (no report yet)	5	0.6
Did Not Sample for an Allergen	29	3.6
<u>Did Not Sample</u>	<u>193</u>	<u>23.9</u>
Total	809	100.0
<u>Air Sampling – MIOSHA Standard</u>	<u>#</u>	<u>%</u>
Above MIOSHA Standard	30	3.7
Below MIOSHA Standard	543	67.1
No MIOSHA Standard	7	0.9
Unknown (no report yet)	5	0.6
Did Not Sample for an Allergen	31	3.8
<u>Did Not Sample</u>	<u>193</u>	<u>23.9</u>
Total	809	100.0

AIR MONITORING

Table 20 shows the suspected causal agents 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 suspected causal agents found to be above the MIOSHA enforceable PEL were:

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

TABLE 20
Suspected Causal Agents Above the MIOSHA Permissible Exposure Limit (PEL)
and/or NIOSH Recommended Exposure Limit (REL): Michigan 1988-2017

	Above NIOSH REL		Above MIOSHA PEL	
<u>Asthma-Causing Agents</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 618 of the 809 inspections. Workers had daily or weekly breathing symptoms associated with work or new onset asthma since beginning to work at 399 of the 618 (65%) companies. The average percentage of co-workers with symptoms in these 399 companies was 20.4%. All 1,692 co-workers from the remaining 219 companies reported no daily or weekly breathing symptoms associated with work. One thousand six hundred twenty-six (1,626) of the 10,472 (15.5%) co-workers interviewed had symptoms consistent with work-related asthma (Table 21). Over time, the percentage of co-workers with breathing problems decreased between the first two periods, but then increased during the third period.

The MIOSHA Injury and Illness Logs (Form 300) kept by employers listed 585 workers from 136 companies with asthma or asthma-like symptoms. Only 10 workers identified in the interviews with daily or weekly chest tightness, shortness of breath (SOB) or wheezing were also listed on the MIOSHA Log. Combining the information from the interviews and Injury and Illness Logs, a total of 2,211 symptomatic workers were identified during the 809 MIOSHA enforcement inspections.

TABLE 21
Breathing Symptoms Among Co-Workers of the 3,592
Confirmed WRA Patients:
1988-2017 and by Time Period

<u>Symptoms</u>	<u>ALL</u>		
	<u># Workers</u>	<u>Daily or Weekly SOB, Wheezing or Chest Tightness</u>	<u>%</u>
	10,472	1,626	15.5
BY TIME PERIOD:			
1988-1997	6,293	1,125	17.9
1998-2007	3,200	380	11.9
2008-2017	979	121	12.4
Workers on OSHA		585	
	<u># Companies Inspected</u>	<u># Companies w/Employee on Log</u>	<u>%</u>
	809	136	16.8
BY TIME PERIOD:			
1988-1997	437	76	17.4
1998-2007	266	52	19.5
2008-2017	106	8	7.5
Total Workers with Symptoms ^a		2,211	

^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 associated 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 2017, which is similar to the 111 companies in 2016 and the 112 companies in 2015. 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 44,739 workers potentially exposed to isocyanates in 2017 is up from 40,490 in 2016 and 39,587 potentially exposed in 2015.

TABLE 22
Michigan Workers Employed in Manufacturing Facilities in 2017
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 MOTUS INTEGRATED TECHNOLOGIES—MAPLEWOOD YAN FENG AUTOMOTIVE INTERIORS PMSC	2,890	58,958	4.9
ARENAC	GLOBE FIRE SPRINKLER	200	5,593	3.6
BARRY	BRADFORD WHITE CORP	1,100	29,866	3.7
BAY	QUANTUM COMPOSITES INC	25	48,120	0.1
BERRIEN	LECO CORP NILES STEEL TANK VAIL RUBBER WORKS INC	879	70,122	1.3
CALHOUN	BREMBO HOMER FOUNDRY COMCAST URETHANE CONVERIS FLEXIBLES US	298	60,560	0.5
CHARLEVOIX	EAST JORDAN FOUNDRY	504	12,324	4.1
CLARE	LEAR CORP. FARWELL PLANT	300	11,240	2.7

Table 22.				
County	Company Name^{c,d}	# Workers Employed^a by Isocyanate-Using Facilities	Total # Workers in the County^b	% Workers Potentially Exposed to Isocyanates
CRAWFORD	WEYERHAEUSER	125	5,068	2.5
DICKINSON	GREDE, LLC IRON MOUNTAIN LOUISIANA-PACIFIC-SAGOLA OSB	561	11,940	4.7
EATON	ALLIANCE INTERIORS GM LANSING DELTA TWP SIKAAXON US	4,031	55,093	7.3
GENESEE	ASI PACKAGING COMPANY LANDAAL PACKAGING SYSTEMS	98	172,577	0.1
HILLSDALE	DOW CHEMICAL	58	20,040	0.3
HURON	VALLEY ENTERPRISES	265	14,906	1.8
INGHAM	HUNTSMAN ADVANCED MATERIALS SA AUTOMOTIVE WILLIAMSTON PRODUCTS INC	290	143,970	0.2
ISABELLA	DELFIELD CO. UNIFIED BRANDS	900	33,858	2.7
JACKSON	MILSCO MICHIGAN SEAT TAC MFG	900	70,799	1.3
KALAMAZOO	AZON USA PARKER HANNIFIN CORP-HYDRAULIC SYS STRYKER INSTRUMENTS	3,260	126,982	2.6
KENT	CLIPPER BELT LACING CO, DBA FLEXCO INC GALE INSULATION GRAND RAPIDS FOAM TECHNOLOGIES HB FULLER LACKS WHEEL TRIM SYSTEMS, BARDEN PLATER NA FUELS SYSTEM REMFG PLASAN CARBON COMPOSITES PURFORMS INC RICHWOOD INDUSTRIES INC	1,981	342,568	0.6
LENAWEE	ANDERSON DEVELOPMENT INSULSPAN INTEVA PRODUCTS	500	45,089	1.1
LIVINGSTON	ANTOLIN-HOWELL PACKAGE DESIGN MFG INC	430	98,038	0.4
LUCE	LOUISIANA-PACIFIC CORP-NEWBERRY SIDING	111	2,263	4.9
MACOMB	AXALTA COATING SYSTEMS INTERNATIONAL CASTING CORP MOON ROOF CORP OF MI NEXEO SOLUTIONS NJT ENTERPRISES ROMEO RIM INC SHELBY FOAM SYSTEM WOLVERINE BRONZE	1,647	422,560	0.4
MARQUETTE	ARGONICS—MI PLANT	60	30,931	0.2
MASON	GREAT LAKES CASTING	225	13,340	1.7
MECOSTA	ORIGINAL FOOTWEAR INC	540	17,808	3.0
MIDLAND	CENTRAL WAREHOUSE –MIDLAND DOW CHEMICAL CO– 1790 BLDG	2,005	38,565	5.2
MONTCALM	AGA MARVEL KENT FOUNDRY	267	26,753	1.0

Table 22. County	Company Name^{c,d}	# Workers Employed^a by Isocyanate-Using Facili- ties	Total # Workers in the County^b	% Workers Potentially Exposed to Isocyanates
MUSKEGON	DIVERSIFIED MACHINE-MONTAGUE MUSKEGON COMPOSITES, INC	700	73,961	0.9
OAKLAND	ARMALY SPONGE EAGLE INDUSTRIES EXOTIC RUBBER & PLASTICS CORP FANUC ROBOTICS—CORP HDQTRS ITW ENGINEERED POLYMERS LYMTAL INTERNATIONAL INC MAHLE BEHR USA INC RECTICEL UREPP N AMERICA SIKAAXSON US	1,559	639,968	0.2
OCEANA	BARBER STEEL FOUNDRY CORP	88	11,510	0.8
OTTAWA	EAGLE PACKAGING MAGNA ENGINEERED GLASS ROYAL TECH	1,190	152,022	0.8
SAGINAW	GLASTENDER NEXTEER AUTOMOTIVE CORP POREX TECHNOLOGIES SAGINAW METAL CASTING OPERATIONS STC	7,040	82,820	8.5
SANILAC	GRUPO ANTOLIN MIDWEST RUBBER CO NUMATICS SANDUSKY MAIN TRELLEBORG YSH INC (VIBRACOUSTIC)	990	18,287	5.4
ST CLAIR	AURIA SOLUTIONS ST CLAIR (IAC) IAC PORT HURON	470	71,672	0.7
ST JOSEPH	IAC MENDON	600	27,615	2.2
VAN BUREN	BASF CORP SPECIAL-LITE INC	182	33,395	0.5
WASHTENAW	EXTANG CORP FAURECIA INTERIOR SYSTEMS	1,800	186,598	1.0
WAYNE	ALPHA RESINS BASF CORP—LIVONIA PLANT BASF CORP—WYANDOTTE PLANT BAY LOGISTICS CYGNET AUTOMATED CLEANING DRDC EFTEC EQ DETROIT FCA US JEFFERSON NORTH ASSEMBLY PLANT NORTHFIELD MFG INC PLASTOMER CORP US ECOLOGY MICHIGAN DBA DYNECOL WAYNE DISPOSAL INCE WINDSOR MACHINE & STAMPING (US) LTD WOODBIDGE CORP	5,216	746,415	0.7
WEXFORD	REC BOAT HOLDINGS-CRUISER PLANT TJS WAREHOUSE	454	13,936	3.3
TOTAL		44,739	4,657,000	1.0

^aSource: 2017 Michigan Manufacturers' Directory.

^bSource: Michigan Labor Market Information, Data Explorer, www.milmi.org accessed October 29, 2018.

^cSource: U.S. Environmental Protection Agency, Toxics Release Inventory, Michigan Companies Using Isocyanates in 2017, data accessed October 29, 2018.

^dSource: MI Dept of Environmental Quality, FOIA Request for SARA Title III Emergency Planning & Release Reporting of isocyanates, for calendar year 2017, received November 26, 2018.

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, Methyl Methacrylate, 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 2017.

Additional chemical exposures associated with WRA in Michigan can be found in a 2017 report at: https://oem.msu.edu/images/resources/WR_Asthma/2017_MI_Workforce_Exposed_to_Select_Asthma-Causing_Agents.pdf

TABLE 23

Michigan Facilities by County, Reporting Toxic Chemicals to the MI Dept. of Environmental Quality (DEQ) in 2017, 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	MERSEN USA BN. CORP.	CH
ALLEGAN	ADVANCED ARCHITECTURAL PRODUCTS	S		MICHIGAN SUGAR CO	A
	BIRDS EYE FOODS LLC	A, CH		QUANTUM COMPOSITES, INC.	S, MA
	CHS INC-HAMILTON FARM BUREAU	A		WEST BAY CTY REGIONAL WW	CH
	CSD	A	BENZIE	GRACELAND FRUIT, INC.	A
	DOUGLAS MARINE CORP	S		PLATTE RIVER ST FISH HATCHERY	F
	HUDSONVILLE CREAMERY & ICE CREAM	A		SMELTZER ORCHARD COMPANY	A
	JBS PLAINWELL, INC.	A	BERRIEN	ADVANCE PRODUCTS CORP	A
	OTSEGO, CITY WELLS #3, #4, #5 & WWTP	CH		BENTON HARBOR	A
	SEKISUI POLYMER INNOVATIONS	S		BLUEWATER THERMAL SOLUTIONS	A
	SHERWIN WILLIAMS CO- HOLLAND	A		BUCHANAN AGRON. & PETRO.	A
	TIARA YACHTS INC	S		BUCHANAN WATER & WWTP	CH
	UNIFORM COLOR CO	S		CHAMPLAIN SPECIALTY METALS	A
	WATER RENEWAL	CH		COLOMA FROZEN FOODS INC	A
ALPENA	DECORATIVE PANELS INTERNATIONAL	F		FREEZER/REPACK CTR	A
	LAFARGE MIDWEST INC	A		GREG ORCHARD	A
ANTRIM	BFI ELK RAPIDS	A		HANSON COLD STORAGE	A
	JORDAN RIVER NAT FISH HATCHERY	F		LETIZ FARMS	A
ARENAC	WHITESTONE PUMPING STATION	CH		NCP COATINGS	A, P
BARRY	CALEDONIA FARMERS ELEVATOR	A		NEW BUFFALO WATER PLT	CH
	CARBON GREEN BIOENERGY	F		NILES, CITY - DECKER, FRONT WELLS & IRON REMOVAL	CH
BAY	BAY CARBON INC	CH		OLD EUROPE CHEESE, INC.	A
	BAY CITY MUNICIPAL WATER TREAT.	CH		SAINT JOSEPH WATER PLT	CH
	DEKARN JC WEADLOCK GEN. PLT.	A		SANDVIK MATERIALS TECH.	A

Table 23, continued...

COUNTY	COMPANY NAME	EXPOSURE	COUNTY	COMPANY NAME	EXPOSURE
BRANCH	CLEMENS FOOD GROUP	A	DICKINSON	LOUISIANA PACIFIC, SAGOLA OSB	F
	DARLING INGREDIENTS INC.	A		VERSO QUINNESEC	A, CH
	HC STARCK, INC	A, CO	EATON	ETM ENTERPRISES INC.	S
	QUINCY	CH		LANSING PLANT	A, CH
	REAL ALLOY RECYCLING INC	CH		MEIJER LANSING DISTRIBUTION	A
	REAL ALLOY SPECIFICATIONS INC	CH		SIKAAXSON US	S
CALHOUN	STAR OF THE WEST MILLING	CH	EMMET	SP KISCH IND	A
	WATER TREATMENT PLT/COLDWATER	CH		INTERTOWN	CH
	ALBION PLANT	A		LIMEKILN	CH
	ANATECH, LTD.	F		NORTHMAN WELLHOUSE	CH
	BATTLE CREEK WATER & WWTP	CH		ODEN STATE FISH HATCHERY	F
	BLEISTAHL	CO		PRESERVE WELLHOUSE	CH
	HOMER	A	GD TRAVERSE	CENTRE ICE	A
	KNAUF INSULATION, INC	A		CENTURY SUN METAL TREATING	A
	MARSHALL CITY WATER	CH		CHERRY GROWERS INC	A
	MUSASHI AUTO PARTS-MICHIGAN INC	A		HILLSHIRE BRANDS	A
	POST FOODS - BATTLE CREEK	CH		MICHIGAN PLANT	A
	PRAIRIE FARMS DAIRY, INC.	A		TCS TRAVERSE COLD STORAGE LLC	A
	RBT J SWALWELL WWTP	CH	GENESEE	TRAVERSE CITY	CH
	ROSLER METAL FINISHING USA LLC	S		A RAGNONE TREATMENT PLANT	CH
	WOODWORTH INC	A		CENTER ROAD, N PUMP STATION	CH
	THE MENNEL MILLING CO. OF MI	CH		HENDERSON ROAD PUMP STATION	CH
CASS	UNION HIGH SCHOOL	F		KOEGEL MEATS INC.	A
	ST MARYS CEMENT US LLC	A		STOKES STEEL TREATING CO	A
CHEBOYGAN	CHEBOYGAN WELLHOUSE #4,#7 & WWTP	CH	GRATIOT	WATER POLLUTION CONTROL FAC	CH
CHIPPEWA	PENDILLS CREEK NFH	F		WOODWORTH INC. FLINT	A
	PULLAR COMMUNITY BUILDING	A		AGROLIQUID-ASHLEY SITE	A
	SAULT STE MARIE WATER & WWTP	CH		ALMA WASTEWATER PLANT	CH
	SULLIVAN CREEK NFH	F		NH3 TANK	A
CLINTON	CROP PRODUCTION SERVICES 622	A		BEF FOODS INC.	A
	MAHLE ENGINE COMPONENTS USA, INC.	A	HILLSDALE	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 LITCHFLD FARM	A
	SCCMUA	CH	HOUGHTON	CALUMET ELECTRONICS CORP	A, F
CRAWFORD	ST JOHNS WWTP	CH		KOPPERS PERFORMANCE CHEM	A
	ARCTIC GLACIER INC	A		MICHIGAN-AMERICAN WATER CO	CH
DELTA	GEORGIA PACIFIC CHEMICALS LLC	A, F		WARM RAIN CORP	MMA, S
	ESCANABA WATER & WWTP	CH	HURON	BAD AXE WWTP	CH
	VERSO ESCANABA LLC	A, CH, F		COOPERATIVE ELEVATOR	A

Table 23, continued...

COUNTY	COMPANY NAME	EXPOSURE	COUNTY	COMPANY NAME	EXPOSURE
HURON	DOW AGROSCIENCES LLC	A	JACKSON	JCC WELL HOUSE	CH
	FARMERS CO-OP GRAIN CO.	A		KIMMEL ROAD WELL HOUSE	CH
	HARBOR BEACH WATER & WWTP	CH		MEADOW HEIGHTS WELL	CH
	MICHIGAN SUGAR CO-SEBEWAING	A		SOUTHVIEW PUMP STATION	CH
	THUMB TOOL & ENGINEERING	A		WESTCHESTER PUMP STATION	CH
INGHAM	ALDI INC - WEBBERVILLE	A	KALAMAZOO	ALLNEX USA INC	F
	ARCTIC GLACIER—LANSING	A		BELL'S BREWERY INC	A
	ATMOSPHERE ANNEALING LLC	A		CITY OF KALAMAZOO- STATIONS #28,#39	CH
	AURORA SPECIALTY CHEMISTRIES	E		KALAMAZOO	A, CH
	CREMER FARM CENTER, INC.	A		KALAMAZOO WATER DIV/STA #1-#5, #8, #9, #11, #12, #14, #17, #18, #22, #24, #25, #31	CH
	DYE WATER CONDITIONING PLANT	A		KLC-2	A
	E LANSING-MERIDIAN WATER & SEWER	A		KNAPPEN MILLING CO	CH
	JORGENSEN FARM ELEVATOR	A		PHARMACIA & UPJOHN LLC	A, CH, E, F
	MASON P.O.T.W. PLANT	CH		PRECISION HEAT TREATING COMPANY	A
	MICHIGAN STATE UNIVERSITY	A, CH		RICHARD-ALLAN SCIENTIFIC	F
	MOLDED PLASTIC INDUSTRIES INC	S	KENT	WESTERN MICHIGAN UNIVERSITY	A
	NITREX INC - MICHIGAN OPERATION	A		29th STREET WAREHOUSE	S
	SYMMETRY MEDICAL INC-LANSING	CO		ARKEMA INC.	B,P,S
	TECOMET-LANSING	CO		BODYCOTE- GRAND RAPIDS	A
	THE ANDERSONS WEBBERVILLE	A		BRENNTAG GREAT LAKES LLC	F
	WATER TREATMENT PLANT	CH		BRETON INDUSTRIAL PARK WAREHOUSE	B,S
	WISE WATER CONDITIONING PLANT	A		CHASE STORAGE & CHASE ORCHARDS	A
	COCA-COLA GRAND RAPIDS	A		COUNTRY FRESH LLC	A
IONIA	BELDING TANK TECHNOLOGIES, INC	S		FINISHMASTER INC #990 DIST CR	S
	CARGILL KITCHEN SOLUTIONS	A		FORTY-FOURTH STREET FACILITY	A
	FARM DEPOT 3 LTD	S		FRUIT RIDGE APPLE CO	A
	GALLAGHERS	A		GM COMPONENTS HOLDINGS, LLC	A
	HERBRUCKS POULTRY & HENNERY	A		GORDON FOOD SERVICE	A
	ROBROY ENCLOSURES	S		GRANDVILLE	A, CH
	STAHLIN ENCLOSURES	S		HB FULLER	P
	THK RHYTHM AUTOMOTIVE	A		HEEREN BROS	A
	TWIN CITY FOODS	A, CH		JACK BROWN PRODUCE INC	A
	WILBUR-ELLIS CO	A		KENT QUALITY FOODS INC	A
IOSCO	HURON SHORE REGIONAL UTILITY A	CH		KING MILLING COMPANY	CH
	ROSE ICE COMPANY	A		LACKS TRIM SYSTEM - AIRLANE PLANT	F
	TAWAS UTILITY AUTHORITY WWTP	CH		LACKS WHEEL SYSTEMS	F
	TIP-TOP SCREW MFG IN	A		LOWELL WWTP & WATER TREATMENT	CH
JACKSON	CHEMETALL US INC	MA		MICHIGAN NATURAL STORAGE CO	A
	CITY OF JACKSON WATER TREATMENT	CH		MICHIGAN TURKEY PRODUCERS	A
	COVENTRY PARK	CH			
	INDUSTRIAL STEEL TREATING	A			

Table 23, continued...

COUNTY	COMPANY NAME	EXPOSURE	COUNTY	COMPANY NAME	EXPOSURE
KENT	MONROE, LLC	MMA	LIVINGSTON	PROGRESSIVE METAL FORMING INC	CO
	NBHX TRIM USA	S		THIRD STREET PUMP STATION	CH
	NORTH RIDGE ORCHARD	A		WYMAN-GORDON CO	CO
	PATTERSON ICE CENTER	A	LUCE	LOUISIANA-PACIF-NEWBERRY SIDING	F
	PLAINFIELD TWP WATER DEPT	CH		NEWBERRY WWTP	CH
	PLASTIC PLATE INC (KRAFT)	F	MACKINAC	MACKINAW ISL. WATER & WWTP	CH
	REMICO STREET FACILITY	CH, F		ST IGNACE WATER PLANT	CH
	RIVERIDGE PACKING	A	MACOMB	AXALTA COATING SYSTEMS	B,M,MMA,S
	ROSKAM BAKING CO-S1 & S2	A		BOSCOS PIZZA	A
	SPARTA FACILITY	A		CARBIDE TECHNOLOGIES	A
	SPARTAN NASH DISTRIBUTION	A		CERATIZIT USA INC	CO
	SUPERIOR SEAFOOD INC.	A		EVERFRESH / LA CROIX BEVERAGES	A
	SUPERIOR STONE PRODUCTS INC	MMA, S		EXCO EXTRUSION DIES INC	A
	SYSCO GRAND RAPIDS, LLC	A		FORMSPRAG LLC	A
	THE HOME CITY ICE CO	A		GM WARREN LLC TECHNICAL CENTER	A
	UNIVAR USA	B		INVECAST CORP	CO
	VI-CHEM CORPORATION	S		METALLURGICAL PROCESSING CO	A
	VILLAGE OF SPARTA WATER & WWTP	CH		MITSUBISHI CHEM PERF POLYMERS	B
	WYOMING CLEAN WATER PLANT	CH		NITRO-VAC HEAT TREATING	A
KEWEENAW	YOUNG'S FARMS	A		NORBROOK PLATING	A
LAPEER	GENESEE COUNTY WATER	CH		REINHART FOODSERVICE LLC	A
	LAPEER PLATING & PLASTICS	F		RIVIERA BUILDING 2	A
LEELANAU	CHERRY GROWERS-PLT 2	A		SPECIALTY STEEL TREATING, INC.	A
	LEELANAU FRUIT CO	A		TURRI'S ITALIAN FOODS, INC	A
LENAWEE	ADC MAIN PLANT	MA,MMA,S	MANISTEE	PACKAGING CORP OF AMERICA	F
	ADRIAN STEEL CO	CO		DYNO NOBEL INC	A
	AIRGAS USA LLC	A	MARQUETTE	KI SAWYER WWTP	CH
	CROP PRODUCTION SVCS 634 & 641	A		HOUSE OF FLAVORS INC	A
	DAIRY FARMERS OF AMERICA	A	MASON	JOS. SANDERS INC	A
	GREEN PLAINS HOLDINGS LLC	A, F		LUDINGTON WASTEWATER PLANT	CH
	WACKER CHEMICAL CORP	A		MICHIGAN FOOD PROCESSORS	A
	WAR-AG FARMS HOME	A		NORON COMPOSITE TECHNOLOGIES	MMA,S
	WELLHOUSE #3 #8—#12 & #14	CH	MECOSTA	OCCIDENTAL CHEMICAL CORP	A
	WILBUR-ELLIS COMPANY - MUNSON	A		ICE MTN NATURAL SPRING WATER	A
LIVINGSTON	AMERICAN COMPOUNDING SPEC	MA		LEPRINO FOODS COMPANY REMUS	A
	ASAHI KASEI PLASTICS NA	MA		USM ACQUISITION LLC	S
	CHEMCO PRODUCTS, INC.	F		L.E. JONES COMPANY	CO
	GORDON FOOD SERVICE	A	MENOMINEE	MENOMINEE WATER & WWTP	CH
	GREEN OAK DC	A		RULEAU BROTHERS INC	A
	HOWELL WATER PLANT & WWTP	CH	MIDLAND	CABOT FORMED SILICA, MIDLAND PLT	A
	PEPSI HOWELL	A		CITY OF MIDLAND - WATER & WWTP	CH

Table 23, continued...

COUNTY	COMPANY NAME	EXPOSURE	COUNTY	COMPANY NAME	EXPOSURE
MIDLAND	DOW- MICHIGAN OPERATIONS	A, CH, S	OAKLAND	GENERAL MOTORS - PROVING GD	CH
	DOW CORNING-MIDLAND PLT	A, CH		HAZEL PARK VIKING ARENA	A
	MIDLAND STORE	A		KC JONES PLATING CO	A
	SK SARAN	A, M		LAKELAND ARENA	A
	THE DOW CHEMICAL CO	A, B, CH, F, M, S		MACDERMID INCORPORATED	A, F
MONROE	TRINSEO, LLC MICHIGAN OPERATIONS	MMA,S		MAHLE BEHR AMERICA INC	A
	ADVANCED HEAT TREAT CORP	A		MARATHON PET –REFINING DIV	A
	DTE ELECTRIC - MONROE POWER	A		MARBELITE CORP	S
	GUARDIAN INDUSTRIES CORP	A, CO		MATHESON WIXOM	A
	HOME CITY ICE COMPANY- Toledo	A		OERLIKON	A
	INDEPENDENT DAIRY INC	A		ONYX-ROCHESTER ICE ARENA	A
	MAYBEE FARMERS INC	A		RMT WOODWORTH, SOUTHFIELD	A
	MEIJER NEWPORT DISTRIBUTION	A		SPECIALTY STEEL TREATING INC	A
MUSKEGON	OTTAWA LAKE CO-OP ELEVATOR	A		STONE SOAP COMPANY INC	F
	BAYER CROPSOURCE USA	A		SUBURBAN ICE TRAINING CENTER	A
	CANNON MUSKEGON	CO		SULZER METCO (US) INC	CO
	COLE'S QUALITY FOODS, INC.	A		SUN STEEL TREATING INC	A
	ESCO CO LLC	P		UNITED PAINT & CHEMICAL	E
	GMI COMPOSITES, INC	S		US FOODS INC.	A
	HOWMET CORP– PLT 1, 3 & 10	CO		VILLAGE OF HOLLY WWTP	CH
	HOWMET CORP - PLT 5 & 10	B		VILLAGE OF MILFORD-IRON REMOVAL PLANT	CH
	L-3 COMBAT PROPULSION SYSTEMS	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
	MUSKEGON COMPOSITES INC	S		WOODWORTH INC PONTIAC	A
NEWAYGO	PARAMELT (M. ARGUESO)	B	OCEANA	2ND STREET STORAGE	A
	SNAPPY APPLE FARMS INC	A		ARBRE FARMS CORPORATION	A
	SUN CHEMICAL CORPORATION	A		HART DIVISION	A
	TECHLINE PRODUCTS	S		MICHIGAN FREEZE PACK	A
	WEBB CHEMICAL SERVICE CORP	F		OCEANA CTY FREEZER STORAGE	A
	CEDAR VALLEY PACKAGING	A		PETERSON FARMS MAIN CAMPUS	A
	GERBER PRODUCTS COMPANY	A	OGEMAW	SANDVIK HARD MATERIALS	CO
OAKLAND	RICE LAKE FARMS PACKAGING LLC	A		ADVANCED FIBERMOLDING	S
	CHEMICAL BLENDING	F, MMA	OSCEOLA	VENTRA EVART, LLC	F
	CHOR INDUSTRIES	A		YOPLAIT REED CITY	A
	COMMERCIAL STEEL TREATING	A	OTSEGO	ALBIE'S FOODS	A
	DEPOR INDUSTRIES	B,F		GAYLORD	CH
	DETROIT SKATING CLUB	A	OTTAWA	ALLENDAL PLANT	A
	DETROIT STEEL TREATING CO.	A		BOAR'S HEAD PROVISIONS CO INC	A
	ENGINEERED HEAT TREAT INC	A		BODYCOTE-HOLLAND	A
	FARMINGTON HILLS ICE ARENA	A		COUNTRYSIDE GREENHOUSES	CH

Table 23, continued...

COUNTY	COMPANY NAME	EXPOSURE	COUNTY	COMPANY NAME	EXPOSURE
OTTAWA	CREME CURLS BAKERY, INC.	A	ST CLAIR	DUNN PAPER, INC.	CH
	DIETRICH ORCHARDS	A		LK HURON WATER TREATMENT	CH
	GOOD FRUIT STORAGE	A		MICHIGAN METAL COATINGS	CO
	J.B.SIMS GENERATING STATION	CH		PORT HURON	A
	J.H.CAMPBELL GENERATING PLT	A	ST JOSEPH	SUNSATON PRODUCTS INC	MMA, S
	JOHN F. DONNELLY PLANT	A		Z F MARYSVILLE AXLE DRIVES LLC	A
	LEO DIETRICH & SONS	A		ABBOTT NUTRITION - STURGIS	A
	MEAD JOHNSON AND CO LLC	CH		AQUATIC CO.	S
	MICHIGAN CELERY PROMOTION	A		MENDON UNIT 635	A
	MICHIGAN NATURAL STORAGE	A		MICHIGAN MILK PRODUCERS ASSOC	A
	MIEDEMA PRODUCE INC.	A		STURGIS WWTP	CH
	POLYPLY COMPOSITES LLC.	S		THREE RIVERS WWTP	CH
	QUINCY STREET, INC	A	TUSCOLA	CARO WWTP	CH
	REQUEST FOODS INC	A		CASS CITY WWTP	CH
	SPECIALTY HEAT TREAT	A		FARM DEPOT	S
	SUPERIOR SALES INC	A	VAN BUREN	MICHIGAN SUGAR-CARO FACTORY	A
	VERTELLUS ZEELAND LLC	A,MA		ALBERMARLE CORP-SOUTH HAVEN	A
	ZEELAND FACILITY	A		ALLOY STEEL TREATING CO INC	A
	ZEELAND FARM SERVICES, INC	A		CITY OF SOUTH HAVEN, WWTP	CH
SAGINAW	ADVANCED MICRONUTRIENT PRODUCTS	A		COCA COLA NORTH AMERICA	A
	BRIDGEPORT WWTP	CH	VAN BUREN	DECATUR	A
	BUENA VISTA WWTP	CH		FRUIT BELT CANNING COMPANY INC	A
	DOW CORNING CORPORATION - HEALTHCARE IND MFG	A		GRAND JUNCTION FACILITY	A
	FRANKENMUTH CITY OF WATER & WWTP	CH		HARTFORD WAREHOUSE	A
	HI-TECH STEEL TREATING, INC.	A		IQF FACILITY	A
	NEXTEER AUTOMOTIVE	A		KNOUSE FOODS COOP-PAW-PAW PLT	A
	SAGINAW TWP RETENTION BASIN	CH		LAWRENCE FREEZER CORP.	A
	STAR OF THE WEST MILLING CO	CH		PAW PAW RIVER PRODUCE	A
	THOMSON AEROSPACE & DEFENSE	A		RYDER PAW PAW LOGISTIC CTR	A
	WATER & WWTP, SAGINAW CHARTER TWP	CH		SHAFFER LAKE FRUIT, INC	A
	WINFIELD UNITED-OAKLEY	A		SILL FARMS MARKET, INC	A
SANILAC	CROSWELL WATER PLANT	CH	WASHTENAW	ST. JULIAN WINE COMPANY INC	A
	DGP INCORPORATED	S		WELCH FOODS, INC.	A
	MIDWEST RUBBER CO.	CH		ANN ARBOR, CITY OF WTP	A
	MICHIGAN SUGAR-CROSWELL FACTORY	A		ANN ARBOR ICE CUBE	A
SHIAWASSEE	AIRGAS SPECIALTY PRODUCTS - OWOSSO	A	WASHTENAW	ARBOR HILLS ENERGY LLC	A
	CIE NEWCOR MFG-PLANT 1	A		ARCTIC COLISEUM	A
	HARVEST MILLS	A		CHELSEA MILLING CO	CH
	MRM INDUSTRIES INC	S		CROP PRODUCTION SERVICES	A
	OWOSSO COMPOSITES-STATE&DELANEY	S		DAPCO INDUSTRIES	A

Table 23, continued...

COUNTY	COMPANY NAME	EXPOSURE	COUNTY	COMPANY NAME	EXPOSURE
WASHTENAW	ELECTRO ARC MFG. COMPANY	A	WAYNE	JCI JONES CHEMICALS INC.	CH
	THETFORD CORP	F		KENNEDY RECREATION CENTER	A
	UNIVERSITY OF MICHIGAN	A		LINCOLN DISTRIBUTING	S
WAYNE	3M DETROIT ABRASIVES	F		MASTRONARDI PRODUCE	A
	A&R PACKING CO INC	A		MCGEAN-ROHCO, INC.	F
	AK STEEL-DEARBORN WORKS	F		MCLANE FOOD SERVICE - PLYMOUTH	A
	ALPHA RESINS LLC	F		MICHIGAN DAIRY	A
	AMERICAN JETWAY CORP	A		NEW BOSTON RTM INC	S
	ARCTIC EDGE ICE ARENA	A		NORTHEAST WATER PLANT	CH
	ARCTIC LOGISTICS LLC	A		PEPSI BOTTLING GROUP	A
	BASF CORPORATION	A,M,MMA, S		PLYMOUTH	MMA
	BODYCOTE THERMAL PROCESSING	A		POLYCHEMIE INC	F
	BRENNTAG GREAT LAKES LLC	S		PRAXAIR DISTRIBUTION INC	A,CH
	C. F. BURGER CO	A		PROGRESSIVE DISTRIBUTION CENTERS INC	F
	CANTON	A		PVS TECHNOLOGIES, INC.	CH, F
	CANTON RENEWABLES	A		SANTEMP	A
	CARDINAL HEALTH	F		SATURN ELECTRONICS CORP	A
	CHAMPION FOODS	A		SMX MANUFACTURING	A
	CLASSIC PLATING	A		SOUTHWEST WATER PLANT	CH
	COOPER HEAT TREATING LLC	A		SPRINGWELLS WATER TREATMENT PLT	CH
	COSTCO WHOLESALE	A		SYSCO DETROIT, LLC	A
	COUNTRY FRESH, LLC - LIVONIA	A		TRENTON CHANNEL POWER PLANT	A
	CREST INDUSTRIES INC	S		TRENTON, CITY OF WWTP	CH
	DEARBORN ICE SKATING CENTER	A		UNIVAR USA—ROMULUS	MA
	DETROIT PRODUCTION CENTER	A		US ECOLOGY DBA DYNECOL	A
	DBA ALDOA COMPANY	E		US STEEL CORP-GREAT LAKES WORKS	A
	DRDC	M		USA HOCKEY ARENA	A
	DYNAMIC SURFACE TECH INT'L	A		WATER RESOURCE RECOVERY FACILITY	CH
	EDDIE EDGAR ARENA	A		WATER WORKS PARK PLANT	CH
	EES COKE BATTERY LLC	A		WAYNE DISPOSAL INC	S
	EQ DETROIT INC	CH,CO, F,S		WESTLAND MANUFACTURING	MMA, S
	FAYGO BEVERAGES INC.	A		WOLVERINE PACKING CO DIST/LAMB/VEAL	A
	FCA US LLC-JEFFERSON PLANT	E, F		YACK ARENA	A
	FREEZER & DRY STORAGE LLC	A		Z TECHNOLOGIES CORP	A
	FREEZER SERVICES OF MI LLC	A	WEXFORD	AAR MOBILITY SYSTEMS	F
	FRITZ PRODUCTS	CH		FOUR WINNS-CRUISER DIVISION	MMA, S
	HOME CITY ICE CO - DETROIT	A		FOUR WINNS-SPORT DIVISION	S
	INLAND WATERS POLL'N CTRL, INC.	S		HARING TOWNSHIP WATER SUPPLY	CH

^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 2017 from a report generated by the Michigan DEQ on 11/26/18.

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. Because of the frequency in which work exposures are a factor in adults with asthma, the American College of Chest Physicians Consensus Statement concluded that: "The substantial prevalence of WRA supports consideration of the diagnosis in all who present with new-onset or worsening asthma, followed by appropriate investigations and intervention including consideration of other exposed workers."⁸

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.⁹

On average, from 1989-2015, 126 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. More recently, 70-80 reports have been confirmed each year. 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 Behavioral Risk Factor Surveillance System (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.¹⁰ 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 2 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 undercounting 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 (12.6%), isocyanates (12.0%) and metal working fluids (9.2%). Until recently, metal working fluids were the second most frequently reported exposure, and until 2014, isocya-

nates 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.

Cleaning agents are one of the major exposures associated with work-related asthma. Because of concern about the hazards of cleaning agents, not just concern about their potential to cause or aggravate asthma, individual companies have begun to list the ingredients of their products (Unilever, Procter & Gamble and SC Johnson). In a move that will provide even greater information about the ingredients of cleaning agents, New York State has promulgated a rule that covers all soaps and detergents sold in New York that contain a surfactant as a wetting or dirt emulsifying agent and are used primarily for domestic or commercial cleaning purposes, including but not limited to the cleansing of fabrics, dishes, food utensils and household and commercial premises. The rule required manufacturers to list ingredients intentionally added to cleaning products on their web page, that are present above trace quantities, by July 1, 2019. Fragrance and nonfunctional ingredients, such as byproducts and contaminants, must be disclosed by July 1, 2020.

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 Saginaw county 8.5% of the workforce is potentially exposed to isocyanates, and in Eaton county approximately 7% of the workforce is exposed. In Allegan, Dickinson, Luce, Midland and Sanilac counties, approximately 5% of the workforce is employed in facili-

ties 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

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

exposure after symptoms develop, the more likely the individual's symptoms will resolve.⁸ On the average, among the 2,302 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.

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 1,626 fellow workers with symptoms compatible with WRA (Table 21). Five hundred eighty-five 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 reporting symptoms on co-worker interviews who were also 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.⁸ 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.⁸ 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.

Reporting can be done online at oem.msu.edu, via email at ODREPORT@msu.edu, via fax at 517-432-3606, via telephone at 1-800-446-7805, or mailed to

MIOSHA, Technical Services Division, PO Box 30649, Lansing, MI 48909-8149. Reporting forms can be found online at oem.msu.edu or by calling the toll free number, 1-800-446-7805.

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.

References

1. Lutzker LA, Rafferty AP, Brunner WM et al. Prevalence of Work-Related Asthma in Michigan, Minnesota, and Oregon. *J Asthma* 2010; 47:156-161.
2. Brooks SM, Weiss MA, Bernstein IL. Reactive Airways Dysfunction Syndrome (RADS)*: Persistent Asthma Syndrome After High Level Irritant Exposures. *Chest* 1985; 83:376-384.
3. Banga A, Reilly MJ, Rosenman KD. A Study of Characteristics of Michigan Workers with Work-Related Asthma Exposed to Welding. *J Occup Environ Med* 2011; 53(4):415-419.
4. Stanbury M, Chester D, Hanna EA, Rosenman KD. How Many Deaths Will it Take? A Death from Asthma Associated with Work-Related Environmental Tobacco Smoke. *Am J Ind Med* 2008; 51(2):111-116.
5. Chester DA, Hanna EA, Pickelman BG, Rosenman KD. Asthma Death after Spraying Polyurethane Truck Bedliner. *Am J Ind Med* 2005; 48:78-84.
6. American Thoracic Society. Occupational Contribution to the Burden of Airway Disease. *Am J Resp Crit Care Med* 2003; 167:787-797.
7. Henneberger PK, Redlich CA, Callahan DB, Harber P, Lemiere C, Martin J, Tarlo SM, Vandenplas O. An Official American Thoracic Society Statement: Work-Exacerbated Asthma. *Am J Resp Crit Care Med* 2011; 184:368-378.
8. Tarlo SM et al. Diagnosis and Management of Work-Related Asthma. ACCP Consensus Statement. *Chest* 2008; 134:1S-41S.
9. Knoeller GE, Mazurek JM, Moorman JE. Asthma Symptoms among Adults with Work-Related Asthma. *J Asthma* 2012; 1532-4303 online DOI:10.3109/02770903.2012.754029.
10. Henneberger PK, Kreiss K, Rosenman KD, Reilly MJ, Chang YF, Geidenberger CA. An Evaluation of the Incidence of Work-Related Asthma in the United States. *Int J Occup Environ Health* 1999; 5:1-8.
11. Ayres JG, Boyd R, Cowie H, Hurley JF. Costs of Occupational Asthma in the UK. *Thorax* 2011; 66:128-133.
12. Rosenman KD, Reilly MJ. Are U.S. Companies that Use Isocyanates Providing Medical Surveillance? Presentation and poster at Isocyanates and Health Conference April 3-4, 2013, Bethesda Maryland.

APPENDIX

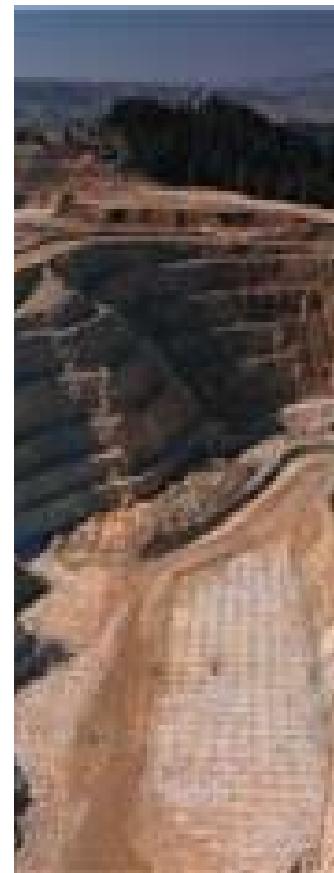
2017 PATIENT NARRATIVES BY TYPE OF INDUSTRY & EXPOSURE

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

OA3983. A male in his 60s developed work-related asthma from exposure to isocyanates while working for an automobile manufacturing company. He developed shortness of breath and sought medical treatment. On spirometry, his FVC was 78% of predicted, FEV1 was 100% of predicted, and FEV1/FVC was 128% of predicted.

OA3981. A male in his 30s developed work-related asthma after being exposed to Methylene diphenyl isocyanate (MDI) and sawdust while working as a chemist for a chemical manufacturing company. He developed a cough, wheezing, and shortness of breath and sought medical treatment in the emergency department. He was prescribed Proventil. When he was reassigned to a new work area his asthma improved and he required less asthma medication. He was a lifelong non-smoker.

OA3988. A female in her 50s developed work-related asthma from exposure to MDI after working 21 years at an automotive manufacturing facility. She developed a cough and shortness of breath and sought medical treatment in the emergency department. She was prescribed Advair, Combivent, Spiriva, and Ventolin. On spirometry, her FVC was 94% of predicted, FEV1 was 65% of predicted, and FEV1/FVC was 69% of predicted. She continued to work this job. She smoked a half of a pack of cigarettes per day for 40 years.

OA4034. A male in his 40s developed work-related asthma after exposure to MDI at a manufacturing company that makes commercial kitchen appliances. He developed shortness of breath and sought medical treatment from his primary care physician. He was prescribed ProAir. On spirometry, his FVC was 105% of predicted, FEV1 was 85% of predicted, and FEV1/FVC was 81% of predicted. He was a lifelong non-smoker.

Exposure to Metal Working Fluids

AA3950. A female in her 20s experienced an exacerbation of her pre-existing asthma after exposure to metal working fluids at an automobile parts supply company. She developed shortness of breath and chest tightness and sought medical treatment in the emergency department. She was prescribed Prednisone. She smoked cigarettes.

OA4010. A female in her 40s developed work-related asthma after the metal stamping plant where she worked for five years increased the use of metal working fluids. She developed a cough, chest tightness, and shortness of breath and sought medical treatment in the emergency department. On spirometry, her FVC was 70% of predicted, FEV1 was 76% of predicted, and FEV1/FVC was 107% of predicted. After she quit this job her asthma improved. She was a lifelong non-smoker.

AA3935. A male in his 40s experienced an exacerbation of his pre-existing asthma after working in an automotive powertrain manufacturing plant. His symptoms began within the same month of starting employment when he was exposed to metal working fluids. He developed chest tightness and shortness of breath. On spirometry, his FVC was 92% of predicted, FEV1 was 76% of predicted, and FEV1/FVC was 82% of predicted. He continued to work at this job but was reassigned and no longer exposed.

OA3869. A male in his 30s developed occupational asthma after working as a machinist for an auto parts manufacturer. His symptoms began within the same month of starting employment from exposure to metal working fluids. He developed wheezing, chest tightness and shortness of breath. He was prescribed Symbicort and Ventolin. He left this job six months later. His asthma improved and he required less asthma medication. He was a lifelong non-smoker.

Exposure to Welding Fume

POA4035. A male in his 50s developed work-related asthma from welding fume after working 15 years as a welder for a storage shelving company. He developed a cough and shortness of breath and sought medical treatment in the emergency department. He was prescribed Albuterol and DuoNeb. He formerly smoked cigarettes.

Exposure to Pharmaceutical Agents

POA4031. A male in his 40s developed work-related asthma from exposure to cleaning agents at an animal health and pharmaceutical company where he worked for six months as a formulator/cleaner. He developed a cough, wheezing, chest tightness, and shortness of breath and sought medical treatment from his primary care physician. He was prescribed Albuterol. He started a new job and was no longer exposed to the cleaning agents. He formerly smoked about 2 cigarettes per day for one year in his late teens.

AA3969. A male in his 20s experienced an exacerbation of his pre-existing asthma from exposure to a powdered medication while working for a prescription drug manufacturer. He developed a cough and shortness of breath and sought treatment in the emergency department. He was prescribed Prednisone. He smoked an average of four cigarettes per day.

Exposure to Miscellaneous Chemicals and Dusts

POA4111. A male in his 30s developed work-related asthma after being exposed to galvanized steel fume and zinc selenide while working as a laser operator for a steel fabrication company. He developed a cough, wheezing, chest tightness, and shortness of breath and sought medical treatment from an urgent care center. He was prescribed Albuterol. After he quit this job he required less asthma medication. He was a lifelong non-smoker.

POA4110. A male in his 40s developed work-related asthma after working five years at an auto manufacturing plant. He developed a cough, chest tightness and shortness of breath. He was treated at an occupational medicine clinic. He formerly smoked for 13 years.

POA4038. A male in his 20s developed work-related asthma after working as an operator for an injection mold manufacturer for five years. He developed a cough, wheezing, chest tightness, and shortness of breath from exposure to mold release spray. He sought treatment in the emergency department. He was reassigned to a new job and his asthma improved. He was a lifelong non-smoker.

AA4015. A male in his 20s experienced an exacerbation of his pre-existing asthma after working as a machine operator for a plastic car parts company. He developed a cough from plastic fume exposure and sought medical treatment in the emergency department. He was prescribed Albuterol. He continued to work at the facility. He smoked an average of five cigarettes per day for five years.

AA3994. A female in her 50s experienced an exacerbation of her pre-existing asthma after being exposed to a new adhesive while working for an electronics manufacturer. She developed wheezing, chest tightness, and shortness of breath and sought medical treatment from her primary care physician who sent her to the emergency department. Shortly after this incident she was fired from her job. She was a lifelong non-smoker.

AA4019. A female in her 40s experienced an exacerbation of her pre-existing asthma from exposure to an adhesive while working as a parts handler for an automobile company where she worked for four years. She developed a cough, chest tightness, wheezing, and shortness of breath and sought medical treatment from her primary care physician. She began using her Albuterol inhaler again. She was placed on medical leave. She was a lifelong non-smoker.

OA4021. A male in his 40s developed work-related asthma from exposure to glue at an automotive interior manufacturing facility. He developed a cough, wheezing, chest tightness, and shortness of breath. He sought medical treatment in the emergency department and was prescribed Qvar, Ventolin, and Prednisone. He continued to work at this job. He smoked an average of eight cigarettes per day for 27 years.

AA4011. A male in his 40s experienced an exacerbation of his pre-existing asthma after exposure to smoke from cutting plastic in a dental lab. He worked at the dental lab for three years. He developed a cough and

shortness of breath and sought medical treatment in the emergency department. He continued to work at the dental lab and required more asthma medication. He formerly smoked a half a pack of cigarettes per day for 5 years in his late teens.

OA4018. A male in his 50s developed work-related asthma from exposure to glue after working four years at an automobile parts factory. He developed a cough, wheezing, and shortness of breath and sought treatment in the emergency department. He was prescribed Symbicort and Albuterol. On spirometry, his FVC was 49% of predicted and FEV1 was 46% of predicted. He was placed on disability leave. He was a lifelong non-smoker.

AA3943. A female in her 60s experienced an exacerbation of her pre-existing asthma after working at an automotive manufacturer. She was exposed to tar fumes and developed wheezing and shortness of breath. She was prescribed Albuterol. She continued to work this job.

POA3936. A female in her 50s developed work-related asthma from cleaning coke ovens at a steel manufacturer. She had been working this job for 11 years. She developed wheezing, cough, chest tightness and shortness of breath. She was prescribed Pro-Air, Advair, Singulair, Albuterol and Spiriva. On spirometry, her FVC was 88% of predicted, FEV1 was 75% of predicted, and FEV1/FVC was 87% of predicted. She had been treated in an emergency department 30 times for asthma. She continued to work cleaning coke ovens. She previously smoked a half pack of cigarettes per day for 41 years.

POA4036. A female in her 50s developed work-related asthma from exposure to mohair and leather after working four years at a furniture manufacturing facility. She experienced wheezing, cough, chest tightness, and shortness of breath. She sought medical treatment in the emergency department. She was reassigned to a new job at the factory. She formerly smoked one pack of cigarettes a week for 4 years in her late teens and early 20s.

AA3979. A female in her 50s experienced an exacerbation of her pre-existing asthma from exposure to propane fumes after working two years at an automobile parts manufacturing facility. She developed a cough, wheezing, chest tightness, and shortness of breath and sought treatment in the emergency department. On spirometry, her FVC was 74% of predicted, FEV1 was 60% of predicted, and FEV1/FVC was 80% of predicted. She required increased asthma medication despite being off work. She smoked a half a pack of cigarettes a day for 44 years.

POA4073. A female in her 20s developed work-related asthma after working at a foundry for three months. She developed a cough, wheezing, and shortness of breath and sought medical treatment at an urgent care facility. She was prescribed Albuterol and Prednisone.

OA3917. A male in his 30s developed occupational asthma after working as a chrome plater. He had worked at this job for one year. He was exposed to fumes from various chemicals after there was a malfunction with the air scrubbers. He developed wheezing, cough, chest tightness and shortness of breath. He was prescribed Prednisone, Singulair, a nebulizer and Symbicort. He sought treatment twice from the emergency department and was admitted once for inpatient care. Five months later he was awarded workers' compen-

sation and no longer exposed. His asthma improved but he still required the same amount of medication. He previously smoked one and a half packs of cigarettes a day for 18 years.

Exposure to Indoor Air Contaminants

POA3996. A female in her 30s developed work-related asthma from exposure to secondhand cigarette smoke from co-workers after working for 11 years at an automobile assembly plant. She developed a cough, shortness of breath, chest tightness and wheezing and sought treatment in the emergency department. She was prescribed Prednisone. She continued to work this job. She was a lifelong non-smoker.

EDUCATIONAL SERVICES

Exposure to Cleaning Products

AA4007. A female in her 30s experienced an exacerbation of her pre-existing asthma from exposure to cleaning chemicals while working as a custodian at a university. She developed shortness of breath and wheezing and sought medical treatment in the emergency department. She smoked cigarettes.

Exposure to Indoor Air Contaminants

POA3980. A male in his 50s developed work-related asthma from exposure to chemical additives for a boiler after working four years doing maintenance at a high school. He developed a cough, wheezing, and shortness of breath and sought medical treatment. He was prescribed ProAir and Symbicort. He was reassigned. He formerly smoked for two years in his late teens.

AA4033. A female in her 50s experienced an exacerbation of her pre-existing asthma when she was exposed to chlorine dust at the school where she worked. The chlorine dust was from tablets used to treat the swimming pool at the school. She required increased Albuterol and steroids.

HEALTH CARE SERVICES

Exposure to Disinfectants

AA3913. A female in her 20s experienced an exacerbation of her pre-existing asthma from exposure to a disinfectant while working as an environmental aide in a hospital. She developed wheezing and shortness of breath and sought treatment in the hospital in which she worked. She was prescribed Pulmicort. On spirometry, her FVC was 97% of predicted, FEV1 was 83% of predicted, and FEV1/FVC was 85% of predicted. She was a lifelong non-smoker.

AA4004. A female in her 30s experienced an exacerbation of her pre-existing asthma from exposure to a spill of disinfectants while working at a hospital. She developed chest tightness and sought medical treatment in the emergency department. The hospital adopted new engineering controls to prevent further exposures. She was a lifelong non-smoker.

AA3944. A female in her 20s experienced an exacerbation of her pre-existing asthma after exposure to bleach while cleaning. She had worked as an environmental technician at a hospital for eight years. She developed wheezing, a cough, chest tightness and shortness of breath. On spirometry, her FEV1 was 94% of

predicted, FVC was 96% of predicted, and FEV1/FVC was 100% of predicted. She was treated in the emergency department and prescribed Xopenex, Spiriva and Medrol. She continued to work this job but was re-assigned and no longer exposed. Her asthma improved and she required less asthma medication. She was a lifelong non-smoker.

AA3941. A male in his 50s experienced an exacerbation of his pre-existing asthma after working as a custodian in a skilled nursing facility. He had been working this job for two years. He was exposed to bleach and other cleaners. He developed wheezing, chest tightness and shortness of breath. He was treated in the emergency department and prescribed Singulair, Albuterol and Nasonex. He left this job two years later. His symptoms improved and he required less asthma medication. He was a lifelong non-smoker.

AA3885. A female nurse in her 40s experienced an exacerbation of her pre-existing asthma after cleaning with a disinfectant at a hospital. She had worked as a nurse for 22 years. She developed wheezing, cough, chest tightness and shortness of breath. She was prescribed Prednisone, Dulera and Pro-air. On spirometry, her FEV1 was 98% of predicted, FVC was 102% of predicted, and FEV1/FVC was 80% of predicted. Four months later a new disinfectant was substituted and she was no longer exposed. Her symptoms improved and she required no asthma medication. She was a lifelong non-smoker.

AA3903. A female in her 50s experienced an exacerbation of her pre-existing asthma after working as an environmental service technician at a hospital. She had been working this job for 21 years. A new disinfectant was introduced. She developed a cough and shortness of breath. She was prescribed Prednisone and Advair. She continued to work this job but was no longer exposed because the disinfectant was replaced with another. She smoked cigarettes.

POA3904. A female in her 60s developed work-related asthma after exposure to a new disinfectant. She worked as an environmental services technician at a hospital. She developed wheezing, cough, chest tightness and shortness of breath. She continued to work this job. She smoked cigarettes for over 20 years.

Exposure to Other Cleaning Products

POA4000. A female in her 30s developed work-related asthma from exposure to laundry cleaning agents after working for a year at a nursing home. She developed a cough, wheezing, chest tightness, and shortness of breath and sought treatment in the emergency department. On spirometry, her FVC was 97% of predicted, FEV1 was 91% of predicted, and FEV1/FVC was 92% of predicted. She was prescribed Breo, Albuterol, and Prednisone. She was placed on disability leave. She was a lifelong non-smoker.

POA4020. A female in her 40s developed work-related asthma from exposure to cleaning products after working four years at a hospital as a patient care technician. She was prescribed Proair, Qvar, Albuterol and Prednisone. She continued to work at the hospital. Her asthma worsened and she required a greater amount of asthma medication. She formerly smoked three cigarettes a day for 26 years.

Exposure to Indoor Air Contaminants and Miscellaneous Chemicals and Dusts

AA3984. A female in her 30s experienced an exacerbation of her pre-existing asthma after being exposed to an unknown chemical while working as a research assistant at a hospital. She developed a cough, wheezing,

and shortness of breath and sought medical treatment in the emergency department. She was prescribed ProAir and Albuterol. On spirometry, her FVC was 96% of predicted, FEV1 was 103% of predicted, and FEV1/FVC was 106% of predicted. She formerly smoked an average of seven cigarettes per day for four years.

AA4042. A female in her 50s experienced an exacerbation of her pre-existing asthma from exposure to dust while working as a pharmacy technician at a drugstore. She developed wheezing and shortness of breath and sought medical treatment in the emergency department. She formerly smoked cigarettes.

OA4083. A female in her 50s developed work-related asthma from exposure to latex and fragrances at a hospital where she worked as an ultrasound technician for 24 years. She developed a cough, wheezing, chest tightness, and shortness of breath. She sought medical treatment in the emergency department and was prescribed Prednisone and a rescue inhaler. She quit working at this hospital. She was a lifelong non-smoker.

POA3995. A female in her 60s developed work-related asthma from exposure to mold, working as a group home manager for special needs adults. She developed a cough, wheezing, chest tightness, and shortness of breath and sought medical treatment in the emergency department. She was prescribed ProAir, Prednisone, Montelukast, Qvar, Azelastine, and Dulera. She was no longer exposed to the mold when the home went out of business. Since then, her asthma improved. She smoked two cigarettes per day for 45 years.

AA3933. A female in her 40s experienced an exacerbation of her pre-existing asthma after working as a nurse for a hospital. She was exposed to Denatonium Benzoate for respirator fit testing, and shortly afterwards developed wheezing, cough, and shortness of breath. She was treated in the emergency department and prescribed Prednisone, Pro-Air and DuoNeb. She continued to work this job as the exposure was limited to one-time fit testing. Her asthma improved but she required the same amount of asthma medication. She previously smoked half pack of cigarettes a day for 20 years.

POA3846. A female in her 50s developed work-related asthma after working as a pharmacy technician in a pharmacy for four years. She was exposed to medication dust that contaminated the carpeting in her work area. She developed wheezing, cough, and shortness of breath. She was prescribed Proventil and oral steroids. On spirometry, her FVC was 88% of predicted, FEV1 was 88% of predicted and FEV1/FVC was 98% of predicted. She continued to work this job, and her symptoms worsened. She was a lifelong non-smoker.

AA4040. A female in her 30s experienced an exacerbation of her pre-existing asthma from an unknown exposure at the hospital where she worked. She required increased Prednisone and Albuterol.

POA3937. A female in her 40s developed work-related asthma from exposure to mold at the hospital where she worked as a nurse for 12 years. She was treated in the hospital's emergency department. She was prescribed Prednisone and Albuterol. After the mold was cleaned up, her asthma improved and she required less asthma medication. She was a lifelong non-smoker.

Exposure to Animal Dander

AA4017. A female in her 30s experienced an exacerbation of her pre-existing asthma after being exposed to a service dog in the hospital where she worked for 16 years. She developed a cough, wheezing, and shortness of breath and sought medical treatment in the emergency department. She was prescribed Albuterol and

Prednisone. She quit working at this hospital and was no longer exposed to the service dogs. She was a lifelong non-smoker.

WHOLESALE & RETAIL SERVICES

Exposure to Indoor and Outdoor Air Contaminants and Miscellaneous Chemicals and Dusts

POA4026. A male in his 40s developed work-related asthma after exposure to freon and construction debris working at a grocery store that was being remodeled. He developed a cough, wheezing, chest tightness, and shortness of breath and sought medical treatment in the emergency department. On spirometry, his FVC was 82% of predicted, FEV1 was 92% of predicted, and FEV1/FVC was 110% of predicted. He was a lifelong non-smoker.

AA3953. A female in her 30s experienced an exacerbation of her pre-existing asthma after being exposed to dust from fertilizer while working at a supercenter. She developed a cough, chest tightness, shortness of breath, and wheezing and sought medical treatment in the emergency department. Her asthma improved and she was no longer exposed to the fertilizer dust because her company began using new engineering controls. She formerly smoked one pack of cigarettes per week for 15 years.

AA4002. A female in her 30s experienced an exacerbation of her pre-existing asthma after being exposed to a spill of vinegar at work. She had been working at the supercenter for about a month. She developed shortness of breath and sought medical treatment in the emergency department. She formerly smoked cigarettes.

AA3939. A female in her 50s experienced an exacerbation of her pre-existing asthma after exposure to dust from floor construction while working at a drugstore. She worked at this drugstore for nine years. She developed a cough, wheezing, chest tightness, and shortness of breath. She sought medical treatment from her primary care physician. She was prescribed Prednisone. She continued to work this job and was still exposed to the construction dust. She was a lifelong non-smoker.

POA3942. A female in her 40s developed work-related asthma after exposure to mold while working in a retail video game store. She had been working this job for one year. She developed wheezing, a cough, chest tightness and shortness of breath. On spirometry, her FVC was 70% of predicted, FEV1 was 68% of predicted, and FEV1/FVC was 64% of predicted. She was prescribed Albuterol, Ventolin, Prednisone, ProAir, Singulair, Symbicort, Claritin and Advair. She continued to work this job. She formerly smoked a quarter pack of cigarettes a day for 20 years.

AA3909. A male in his 50s experienced an exacerbation of his pre-existing asthma after exposure to freon while working in a grocery store. He developed shortness of breath and was treated in the emergency department. He was prescribed Albuterol and Prednisone. He continued to work this job. He was a lifelong non-smoker.

OFFICE/INDOOR AIR

Exposure to Indoor Air Contaminants

AA3959. A female in her 50s experienced an exacerbation of her pre-existing asthma from exposure to fragrances while working for an insurance company. She developed shortness of breath and sought treatment in the emergency department. She was a lifelong non-smoker.

AA4089. A female in her 40s experienced an exacerbation of her pre-existing asthma while working for a company whose workplace was undergoing construction. She developed shortness of breath and chest tightness and sought medical treatment in the emergency department. She was prescribed Albuterol. She was a lifelong non-smoker.

AA4077. A female in her 50s experienced an exacerbation of her pre-existing asthma after being exposed to paint in her office while working for an insurance company. She developed a cough, wheezing, and shortness of breath and sought medical treatment at an urgent care facility. She was prescribed Prednisone. She was a lifelong non-smoker.

POA3989. A female in her 50s developed work-related asthma after working 13 years for a vocational rehabilitation organization. She developed a cough, wheezing, chest tightness, and shortness of breath and sought medical treatment in the emergency department. She was prescribed Albuterol. On spirometry, her FVC was 48% of predicted, FEV1 was 53% of predicted and FEV1/FVC was 92% of predicted. Her symptoms improved and she required less asthma medication after she quit this job. She was a lifelong non-smoker.

AA3977. A female in her 50s experienced an exacerbation of her pre-existing asthma from poor indoor air quality while working for an insurance company. She developed a cough and sought care in the emergency department. She was prescribed Albuterol and Symbicort. She was a lifelong non-smoker.

Exposure to Cleaning Agents

AA4005. A female in her 40s experienced an exacerbation of her pre-existing asthma after improperly mixing cleaning agents while working in an office. She developed a cough, shortness of breath, and wheezing and sought medical treatment in the emergency department. She was prescribed Prednisone and Albuterol. She was a current every day smoker.

AA4001. A female in her 40s experienced an exacerbation of her pre-existing asthma while working in a mortgage lending office from exposure to a new air freshener and cleaning chemicals. She sought medical treatment in the emergency department. She was prescribed Dexamethasone and Famotidine. She formerly smoked for two years in her early twenties.

Exposure to Indoor and Outdoor Air Contaminants and Miscellaneous Chemicals and Dusts

RADS4006. A male in his 50s developed RADS after being exposed to dust from cutting cement outside his office at an insurance agency. He worked at this company for 9 years. He developed a cough, wheezing, chest tightness, and shortness of breath and sought medical treatment in the emergency department. He was

prescribed Prednisone and Albuterol. He was no longer exposed to the cement dust after the work was completed. He formerly smoked a half a pack of cigarettes per day for 37 years.

POA3920. A female in her 40s developed work-related asthma after working as a document scanner for a bank. She had been working this job for two months when custodians working with two cleaners caused a fire. She developed a cough, chest tightness and shortness of breath. She was prescribed Albuterol and Prednisone. On spirometry, her FVC was 109% of predicted, FEV1 was 110% of predicted, and FEV1/FVC was 82% of predicted. The same month she was out on workers' compensation and no longer exposed. Her asthma improved and she required less asthma medication. She formerly smoked two packs of cigarettes a day for 30 years.

CONSTRUCTION

Exposure to Cleaning Agents

AA4003. A male in his 40s experienced an exacerbation of his pre-existing asthma after an exposure to cleaning chemicals while working as a plumber. He developed a cough, shortness of breath, and chest tightness and sought medical treatment in the emergency department. He smoked a half a pack of cigarettes a day for 25 years.

Exposure to Miscellaneous Chemicals and Dusts

AA3974. A male in his 40s experienced an exacerbation of his pre-existing asthma while installing insulation for a construction company. He developed a cough, wheezing, chest tightness, and shortness of breath and sought medical treatment in the emergency department. He was prescribed Albuterol and Prednisone. He was a lifelong non-smoker.

POA3971. A male in his 40s developed work-related asthma from exposure to hot asphalt after working 20 years for an asphalt company. He developed shortness of breath and wheezing and sought treatment from a medical clinic. He was a lifelong non-smoker.

AA4041. A male in his 30s experienced an exacerbation of his pre-existing asthma from exposure to metal dust and fumes while working for a contracting company as a carpenter. He developed chest tightness and wheezing and sought medical treatment in the emergency department. He was prescribed Prednisone.

FOOD SERVICES

Exposure to Cleaning Agents

AA3905. A male in his 20s experienced an exacerbation of his pre-existing asthma after mixing bleach and Lime-A-Way while working as a dish washer for a banquet hall. He developed shortness of breath and sought treatment in the emergency department. He was prescribed Albuterol and Solumedrol. He continued to work this job. He was a lifelong non-smoker.

Exposure to Miscellaneous Substances

AA3938. A female in her 40s experienced an exacerbation of her pre-existing asthma from overexertion while working as a cook for a restaurant. She developed wheezing and shortness of breath and sought medical treatment in the emergency department. She was prescribed Albuterol. She was a lifelong non-smoker.

OA3951. A male in his 60s developed work-related asthma while working at a bakery. He developed a cough and shortness of breath and sought treatment in the emergency department. He was prescribed Albuterol, Fluticasone, and Prednisone. He was a lifelong non-smoker.

PUBLIC SERVICES

Exposure to Cleaning Agents

POA3986. A female in her 60s developed work-related asthma after exposure to cleaning chemicals being improperly mixed. She had worked as an office manager in a church for 25 years. She developed a cough, wheezing, chest tightness, and shortness of breath and sought medical treatment. She was prescribed Qvar, Pulmicort, Bevespi, and Albuterol. On spirometry, her FVC was 46% of predicted, FEV1 was 51% of predicted, and FEV1/FVC was 87% of predicted. She was a lifelong non-smoker.

Exposure to Miscellaneous Substances

RADS4027. A male in his 50s developed RADS after being exposed to flooring sealant being applied at a juvenile detention center where he had worked as a supervisor for 28 years. He developed a cough, wheezing, and shortness of breath and sought medical treatment in the emergency department. He was prescribed Prednisone, Albuterol, and Atrovent. On spirometry, his FVC was 100% of predicted, FEV1 was 107% of predicted, and FEV1/FVC was 106% of predicted. After the floor sealant was done being applied, his asthma improved. He formerly smoked an average of four cigarettes per day for 31 years.

RADS4022. A male in his 40s developed RADS after an exposure to smoke and fire extinguisher fumes from a motel fire. He worked for a police department for a year and a half before this incident. He developed a cough, wheezing, chest tightness, and shortness of breath. He was prescribed Albuterol, Qvar, and Prednisone. He continued to work this job. He was a lifelong non-smoker.

MISCELLANEOUS SERVICES & INDUSTRIES

Exposure to Cleaning Products

AA4014. A male in his teens experienced an exacerbation of his pre-existing asthma from exposure to cleaning agents while working for a car wash and self-storage facility. He developed a cough and wheezing and sought medical treatment in the emergency department. He was prescribed Prednisone. He smoked an average of 5 cigarettes per day.

POA4088. A male in his 40s developed work-related asthma from exposure to cleaning agents while working in residential housecleaning. He experienced shortness of breath and sought medical treatment in the emergency department. He was prescribed Prednisone and Albuterol. On spirometry, his FVC was 89% of predicted, FEV1 was 89% of predicted, and FEV1/FVC was 100% of predicted. He was a lifelong non-smoker.

AA4047. A female in her 20s experienced an exacerbation of her pre-existing asthma from exposure to cleaning agents at work. She developed chest discomfort and shortness of breath and sought treatment in the emergency department. She was prescribed Albuterol and Dexamethasone. She smoked a half a pack of cigarettes a day.

Exposure to Animal Dander

AA3973. A female in her 40s experienced an exacerbation of her pre-existing asthma when she inspected a house with cats while working for a property management company. She developed shortness of breath and sought medical treatment in the emergency department. She was prescribed Ventolin and Prednisone. She smoked cigarettes for 15 years.

Exposure to Miscellaneous Substances

RADS3932. A female in her 40s developed RADS after being exposed to fire extinguisher powder while working as a janitor for a commercial cleaning company. She developed a cough, wheezing, chest tightness, and shortness of breath. She sought treatment in the emergency department and was prescribed Prednisone, Albuterol, and Flovent. She quit working at the company. She formerly smoked a half a pack of cigarettes per day for 24 years.

AA3947. A female in her 40s experienced an exacerbation of her pre-existing asthma from carbon monoxide exposure while working as a housekeeper in a hotel. She developed chest tightness and shortness of breath and sought treatment in the emergency department. She smoked an average of seven cigarettes per day for 19 years.

RADS4032. A male in his 50s developed RADS after using a fire extinguisher to put out a fire while working as a mechanic. He developed a cough and shortness of breath and sought medical treatment in the emergency department. He was prescribed Albuterol and Prednisone. He continued working this job. He was a lifelong non-smoker.

AA3948. A male in his 30s experienced an exacerbation of his pre-existing asthma from intense exertion while working as a professional athlete. He was a lifelong non-smoker.

AA4028. A female in her 40s experienced an exacerbation of her pre-existing asthma from exposure to dust while working for a courier delivery company. She sought medical treatment from a medical clinic. On spirometry, her FVC was 87% of predicted, FEV1 was 86% of predicted, and FEV1/FVC was 80% of predicted. She smoked five cigarettes per day for the past five years.