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2019
ANNUAL REPORT
TRACKING WORK-RELATED
ASTHMA IN MICHIGAN



2019 ANNUAL REPORT

Work-Related Asthma Surveillance Program

TABLE OF CONTENTS

SUMMARY	1-2
BACKGROUND	2
PROCEDURES	2-3
RESULTS	4-27
DISCUSSION	28-31
REFERENCES	32
APPENDIX	33-40

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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

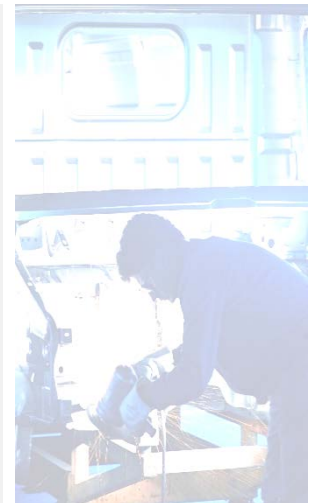
MIOSHA Michigan
Occupational Safety & Health
Administration

NAICS North American
Industrial Classification System

NIOSH National Institute for
Occupational Safety & Health

PEL Permissible Exposure
Limit

REL Recommended
Exposure Limit



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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.

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 29th 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.

- ◆ Since 2007, the number of cases identified each year has been declining.
- ◆ From 1988-2019, 3,765 WRA cases have been identified with MI's tracking system.
- ◆ We estimate there are 62,000-97,000 adults in MI with WRA.
- ◆ 79% of the MI WRA patients have new-onset asthma; 21% 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 (12.8%) and isocyanates (11.8%), are the most commonly reported exposures causing WRA in MI.
- ◆ Approximately 45,307 individuals in the MI workforce are employed in manufacturing where isocyanates are used.
- ◆ The average incidence rate of WRA among African Americans is 2.2 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 (LEO) 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

Patients are identified through mandatory reporting of any known *or suspected* occupational illnesses, including WRA.

SOURCES TO IDENTIFY PATIENTS

- ◆ **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**



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

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 Labor & Economic Opportunity *within 10 days of discovery.*

WRA Tracking Procedures in Michigan

STEP 1. IDENTIFY PATIENTS — Occupational Disease Reports submitted to LEO 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

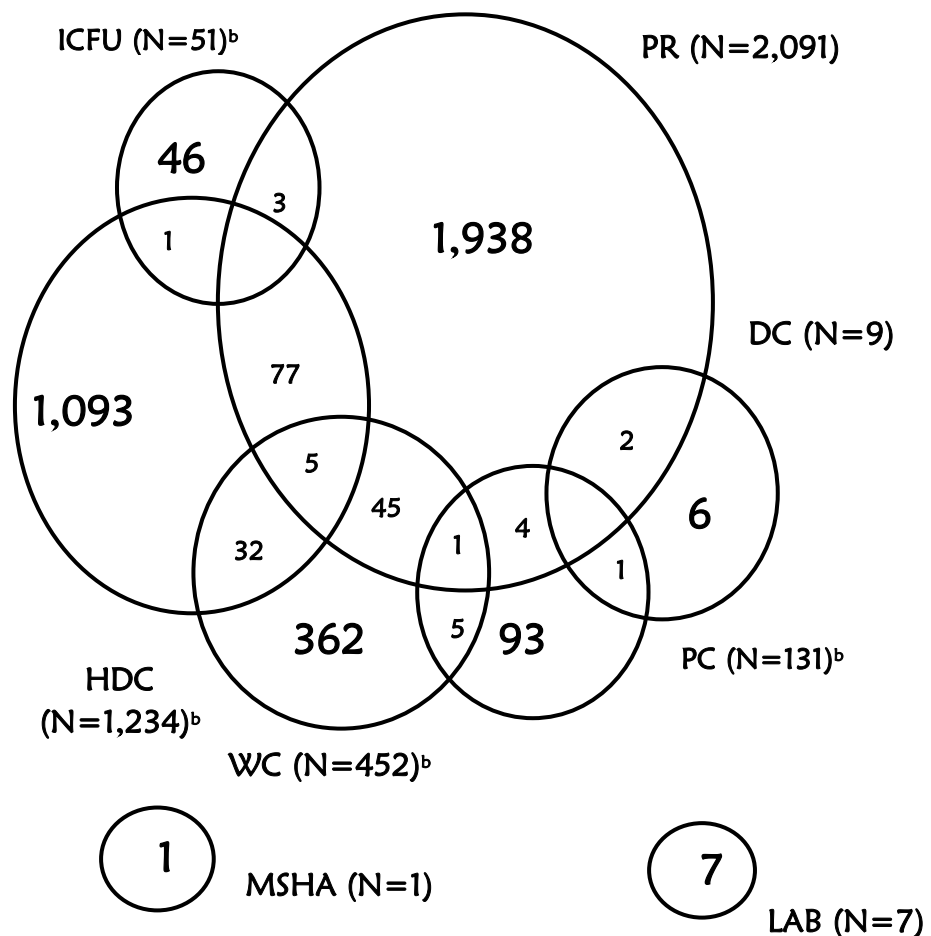
Table 1 shows that 3,765 people were confirmed with WRA between 1988—2019. The reports are divided into: occupational asthma (OA), possible occupational asthma (POA), aggravated asthma (AA) and Reactive Airways Dysfunction Syndrome (RADS). Ninety-two additional patients have been confirmed since last year’s report (4 for 2018 and 88 for 2019). Figure 1 shows the overlap of the patients by reporting sources for 1988—2019.

TABLE 1
Number of Confirmed Cases of WRA by
Year and Type
Disease Status

YEAR	OA	POA	AA	RADS	TOTAL
1988	23	7	0	1	31
1989	43	12	3	5	63
1990	87	35	14	8	144
1991	55	30	14	16	115
1992	81	36	14	18	149
1993	76	68	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	48	72	18	9	147
1999	49	65	16	12	142
2000	49	67	31	17	164
2001	51	50	20	19	140
2002	40	58	24	21	143
2003	30	63	28	23	144
2004	39	61	37	30	167
2005	44	65	21	23	153
2006	34	61	29	14	138
2007	20	41	34	28	123
2008	20	49	25	16	110
2009	21	40	31	8	100
2010	18	39	30	16	103
2011	21	24	19	3	67
2012	17	19	35	10	81
2013	17	25	37	6	85
2014	17	21	27	2	67
2015	16	21	33	13	83
2016	21	14	38	6	79
2017	10	24	43	5	82
2018	15	19	48	3	85 ^a
2019	17	21	39	11	88 ^a
Total	1,215	1,333	798	419	3,765

^aReports are still being processed for calendar years 2018 and 2019; an increase in these totals will be reflected in next year’s annual report.

FIGURE 1
Overlap of Reporting Sources for 3,765 Confirmed
WRA Patients: 1988-2019^a



^aNs 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.

^bThere was an overlap of PC-HDC for 24 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 2008-2019 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 1,030 reported from 2008 to 2019. 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 2008-2019 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 3.01 per 100,000 Michigan African American workers compared to 1.36 per 100,000 for Michigan Caucasian workers; this was a 2.2 times greater incidence (95% CI 1.302,3.736).

TABLE 2
Gender of WRA Patients by Time Period

	Time Period				
	All years	1988-1997	1998-2007	2008-2019	Change in Percentage
Gender	# (%)	# (%)	# (%)	# (%)	
Female	2,031 (54)	626 (49)	800 (55)	605 (59)	+ 20%
Male	1,734 (46)	648 (51)	661 (45)	425 (41)	- 20%

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 WRA Patients by Time Period

	Time Period				
	All years	1988-1997	1998-2007	2008-2019	Change in Percentage
Race	# (%)	# (%)	# (%)	# (%)	
Caucasian	2,718 (72)	973 (76)	1,074 (74)	671 (65)	-14%
African American	707 (19)	239 (19)	271 (19)	197 (19)	None
Hispanic	86 (2)	24 (2)	27 (2)	35 (3)	+ 50%
Alaskan/Am Indian	33 (1)	10 (1)	13 (1)	10 (1)	None
Asian	15 (<1)	4 (0.3)	7 (0.5)	4 (0.4)	+ 33%
Other	42 (1)	11 (1)	20 (1)	11 (1.1)	+10%
Unknown	164 (4)	13 (1)	49 (3)	102 (10)	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 (10.4 cases per 100,000), Clare (7.4 cases per 100,000), Genesee and Osceola (each with 4.7 cases per 100,000), Montmorency (4.5 cases per 100,000), and Huron and Saginaw (each with 4.4 cases per 100,000).

TABLE 4
Average Annual Incidence Rates of WRA Among Michigan Workers by County of Exposure: 1989-2017^a

County	Avg Annual Cases		County	Avg Annual Cases		Cases 1989-2017	
	# EE's ^b	Inc Rate ^c		# EE's ^b	Inc Rate ^c		
Alcona	3,734	0.9	1	Keweenaw	944	3.7	1
Alger	4,048	1.7	2	Lake	3,998	1.7	2
Allegan	49,958	3.8	55	Lapeer	41,905	2.9	35
Alpena	13,970	2.7	11	Leelanau	10,874	1.9	6
Antrim	11,088	0.9	3	Lenawee	45,730	2.5	33
Arenac	7,103	2.4	5	Livingston	89,055	1.5	39
Baraga	3,556	3.9	4	Luce	2,654	10.4	8
Barry	28,596	1.1	9	Mackinac	5,885	1.8	3
Bay	51,802	1.7	26	Macomb	396,780	2.7	305
Benzie	8,227	1.3	3	Manistee	10,779	1.3	4
Berrien	72,422	1.4	30	Marquette	32,565	2.3	22
Branch	21,277	3.9	24	Mason	13,773	1.5	6
Calhoun	66,888	2.3	44	Mecosta	18,531	1.5	8
Cass	25,616	0.7	5	Menominee	12,597	0.3	1
Charlevoix	13,105	2.6	10	Midland	38,738	2.8	32
Cheboygan	11,681	3.8	13	Missaukee	6,201	2.2	4
Chippewa	15,906	1.3	6	Monroe	72,474	1.5	31
Clare	12,133	7.4	26	Montcalm	27,319	2.5	20
Clinton	34,977	0.8	8	Montmorency	3,817	4.5	5
Crawford	6,234	3.3	6	Muskegon	82,728	1.1	27
Delta	18,700	2.2	12	Newaygo	21,238	2.9	18
Dickinson	13,496	3.6	14	Oakland	606,421	2.5	446
Eaton	55,176	0.8	13	Oceana	12,741	1.4	5
Emmet	18,249	1.1	6	Ogemaw	8,987	3.5	9
Genesee	194,369	4.7	265	Ontonagon	3,300	1.0	1
Gladwin	9,983	1.0	3	Osceola	9,575	4.7	13
Gogebic	7,217	1.0	2	Otsego	11,720	3.2	11
Gd Traverse	44,511	1.6	21	Ottawa	126,705	0.7	25
Gratiot	18,680	2.2	12	Roscommon	10,306	2.7	8
Hillsdale	20,675	2.2	13	Saginaw	90,548	4.4	116
Houghton	16,137	1.5	7	Sanilac	19,894	3.5	20
Huron	15,636	4.4	20	Schoolcraft	3,588	1.9	2
Ingham	143,327	3.3	139	Shiawassee	33,900	0.6	6
Ionia	28,133	1.5	12	St. Clair	78,920	2.7	61
Iosco	9,617	1.8	5	St. Joseph	28,932	1.5	13
Iron	5,480	2.5	4	Tuscola	26,833	3.0	23
Isabella	35,007	2.5	25	Van Buren	37,417	0.9	10
Jackson	72,274	2.4	51	Washtenaw	179,602	3.6	190
Kalamazoo	123,752	1.4	52	Wayne	837,179	3.4	828
Kalkaska	8,036	3.4	8	Wexford	13,468	1.5	6
Kent	297,020	1.2	102	All Counties^d	4,706,000	2.5	3,480

^a 1989 through 2017 represent complete years of reporting. Reporting in 1988 was begun mid-year and is incomplete. Reporting for 2018 and 2019 is not yet complete. Therefore, 1988, 2018 and 2019 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, 2004. Accessed 6/30/2020.

^c Rates are based on the average number of cases per year from 1989-2017 (29 years), per 100,000 Michigan workers.

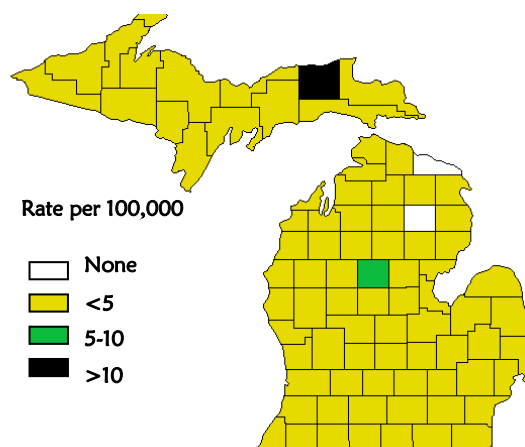
^d Fifty-nine cases had an out-of-state exposure and 22 had an unknown county of exposure, for the 1989-2017 reporting period.

Type of Industry – 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 1989-2017 time period. All of the top counties with the highest overall rates of WRA had a decrease of 10% or greater, except for Huron county, in the rate of WRA over time. Many of the rates increased during the 1998-2007 time period but then decreased during the 2008-2019 time period.

FIGURE 2
Average Annual Incidence Rate of WRA by County of Exposure: 1989-2017^a



^a 1989 through 2017 represent complete years of reporting. Reporting in 1988 was begun mid-year and is incomplete. Reporting for 2018 and 2019 is not yet complete. Therefore, 1988, 2018 and 2019 reports are not included in this figure.

TABLE 5
Average Annual Incidence Rate of WRA by County and Time Period

County	All years	1988-1997		1998-2007			2008-2019			Change in Percentage	
	Rate	# Cases	# EE's ^a	Rate	# Cases	# EE's ^b	Rate	# Cases	# EE's ^c		Rate
Branch	3.9	7	17,699	4.0	12	21,340	5.6	7	17,507	3.3	- 18%
Cheboygan	3.8	8	9,658	8.3	2	11,422	1.8	3	9,277	2.6	- 72%
Clare	7.4	8	9,100	8.8	11	11,761	9.4	10	10,592	7.9	-10%
Genesee	4.7	83	179,394	4.6	132	191,377	6.9	56	161,918	2.9	- 37%
Huron	4.4	7	14,941	4.7	8	15,499	5.2	11	14,567	6.3	+34%
Kalkaska	3.4	4	6,188	6.5	4	7,932	5.0	1	6,680	1.2	- 82%
Luce	10.4	4	2,021	19.8	2	2,660	7.5	2	2,163	7.7	- 61%
Montmorency	4.5	0	2,868	--	2	3,781	5.3	4	2,836	11.8	+123
Osceola	4.7	2	9,343	2.1	10	9,938	10.1	2	8,970	1.9	- 10%
Saginaw	4.4	31	91,307	3.4	67	90,388	7.4	26	79,625	2.7	- 24%
Sanilac	3.5	5	17,992	2.8	12	19,452	6.2	4	16,923	2.0	- 29%
All MI Counties	2.5	1,274	4,258,000	3.0	1,461	4,702,000	3.1	1,030	4,194,000	2.0	-33%

^aEE's =employees. Source: MI Dept of Tech, Mgt, & Budget, Labor Market Information, Annual Unemployment Statistics (LAUS) by County, 1992.

^bSource: MI Dept of Tech, Mgt, & Budget, Labor Market Information, Annual Unemployment Statistics (LAUS) by County, 2002.

^cSource: MI Dept of Tech, Mgt, & Budget, Labor Market Information, Annual Unemployment Statistics (LAUS) by County, 2010.

Type of Industry – Trends

Table 6 shows the Michigan industries by NAICS codes, with cases of work-related asthma from 1988 to 2019. The main industries were in manufacturing (56%) and health care and social assistance (13%).

The incidence rate of WRA by industry ranges from 0.1 cases per 100,000 in management of companies to a high of 10.0 cases per 100,000 in manufacturing. Industries with the next highest average annual incidence rates were: mining with 7.0 cases per 100,000 workers and health care and social assistance with 3.2 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 36.8% in 2008-2019. 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 WRA Patients, 1988-2019 by Primary Industrial Exposure and Average Annual Incidence Rate per 100,000 Workers, 1989-2017 (Years of Complete Reporting)

2002 N American Industry Classification System		WRA Cases		Number of Employees ^a	Average Ann. Incidence Rate ^b	
		1988-2019			Rate	# Cases
		#	%			
11	Agriculture, Forestry, Fishing, & Hunting	30	0.8	79,883	1.1	25
21	Mining	13	0.3	6,400	7.0	13
22	Utilities	22	0.6	35,300	2.0	20
23	Construction	102	2.7	189,690	1.8	98
31-33	Manufacturing	2,098	55.7	695,885	10.0	2,009
42	Wholesale Trade	41	1.1	169,735	0.8	38
44-45	Retail Trade	124	3.3	512,474	0.8	116
48-49	Transportation & Warehousing	78	2.1	100,137	2.4	70
51	Information	24	0.6	67,973	1.2	24
52	Finance & Insurance	36	1.0	156,375	0.7	34
53	Real Estate & Rental & Leasing	19	0.5	56,094	1.2	19
54	Professional, Scientific & Technical Svcs	34	0.9	244,858	0.4	30
55	Mgt of Companies & Enterprises	2	0.1	67,988	0.1	2
56	Administrative & Support & Waste Mgt	91	2.4	271,673	1.0	75
61	Educational Services	167	4.4	437,200	1.3	162
62	Health Care & Social Assistance	469	12.5	480,330	3.2	445
71	Arts, Entertainment & Recreation	34	0.9	61,137	1.7	31
72	Accommodation & Food Services	119	3.2	339,052	1.1	111
81	Other Services (except Public Admin)	88	2.3	178,600	1.5	80
92	Public Administration	149	4.0	252,700	1.9	138
00	Unknown	25	0.7	--	--	21
Total		3,765		4,456,600	2.8	3,561

^aSource: MI Dept of Tech, Mgt & Budget, Labor Market Information, Industry Employment (CES), 2004. Accessed 6/30/2020. The total non-farm employment in MI, 2004: 4,456,600. Agriculture: 2004 U.S. Census of Agriculture-State Data. Total Farm Employment. Denominator Source for Mining, Utilities, Education, Public Administration and Other Services: MDLEG Office of LMI, Industry Employment Series, MI, 2004, accessed 6/23/2005.

^bReporting in 1988 was begun mid-year, and reporting for 2018 and 2019 is not yet complete. Therefore, 1988, 2018 and 2019 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 1989-2017 (29 years), per 100,000 Michigan workers.

TABLE 7
2,009 WRA Patients from Manufacturing Industries:
1989-2017^a

2002 North American Industry Classification System		# WRA Cases	Avg Ann Rate ^a	# Employees ^b
311	Food Mfg	68	7.2	32,729
323	Printing & Related Support Activities	19	3.6	18,327
325	Chemical Mfg	105	13.1	27,704
326	Plastics & Rubber Products Mfg	112	9.0	43,056
327	Nonmetallic Mineral Product Mfg	18	3.8	16,512
331	Primary Metal Mfg	69	8.6	27,648
332	Fabricated Metal Product Mfg	119	4.9	83,121
333	Machinery Mfg	156	7.1	75,925
334	Computer & Electronic Product Mfg	14	2.5	19,165
336	Transportation Equipment Mfg	1,167	155.7	255,913
337	Furniture & Related Product Mfg	16	2.1	26,167
	Miscellaneous Mfg (*includes NAICS: 312-16,321-322,324,335,339)	146	7.2	69,619

^aAverage annual incidence rate, based on cases from 1989-2017 (29 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 2018 and 2019 is not yet complete. Therefore, 1988, 2018 and 2019 reports are not included in this table.

^bSource: Michigan Department of Technology, Management and Budget, Labor Market Information, Industry Employment and Wages-QCEW, 2004. Accessed 7/1/2020.

TABLE 8
Industry of WRA Patients by Time Period

NAICS	Industry	Time Period						Change in Percentage
		1988-1997		1998-2007		2008-2019		
		#	%	#	%	#	%	
11	Agriculture, Forestry, Fishing, & Hunting	4	0.3	12	0.8	14	1.4	+ 367%
21	Mining	5	0.4	6	0.4	2	0.2	- 50%
22	Utilities	3	0.2	5	0.3	14	1.4	+ 600%
23	Construction	32	2.5	37	2.5	33	3.2	+28%
31-33	Manufacturing	912	71.6	809	55.4	379	36.8	- 49%
42	Wholesale Trade	23	1.8	14	1.0	5	0.5	- 72%
44-45	Retail Trade	15	1.2	48	3.3	59	5.7	+ 375%
48-49	Transportation & Warehousing	14	1.1	35	2.4	29	2.8	+ 155%
51	Information	6	0.5	11	0.8	7	0.7	+ 40%
52	Finance & Insurance	2	0.2	17	1.2	17	1.7	+ 750%
53	Real Estate & Rental & Leasing	2	0.2	11	0.8	6	0.6	+ 200%
54	Professional, Scientific & Technical Services	9	0.7	16	1.1	9	0.9	+29%
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	54	5.2	+ 550%
61	Educational Services	40	3.1	73	5.0	54	5.2	+ 68%
62	Health Care & Social Assistance	105	8.2	194	13.3	170	16.5	+ 101%
71	Arts, Entertainment & Recreation	5	0.4	11	0.8	18	1.7	+ 325%
72	Accommodation & Food Services	19	1.5	49	3.4	50	4.9	+ 227%
81	Other Services (except Public Administration)	22	1.7	31	2.1	35	3.4	+100%
92	Public Administration	44	3.5	46	3.1	59	5.7	+ 63%
00	Unknown	2	0.2	8	0.5	15	1.5	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 481 (12.8%) of Michigan's WRA patients, and isocyanates (MDI, TDI, HDI and others) accounting for 446 (11.8%) of the WRA case exposures. Metal working fluids (coolants) accounted for 334 (8.9%) 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 (not including unknown manufacturing and unknown office exposures). 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 7.2% in 2008-2019. Cleaning agents increased from 4.6% of all the WRA exposures in 1988-1997 to 20.2% in 2008-2019. 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 1988-2019. 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: 1988-2019

Exposure Agent	#	%
Cleaning Solutions	481	12.8
Isocyanates	446	11.8
Metal Working Fluids	334	8.9
Unknown (Mfg.)	273	7.3
Unknown (Office)	210	5.6
Exhaust/Smoke/Fumes	174	4.6
Welding Fume-Stainless & Other	161	4.3
Solvents	114	3.0
Paint Fumes	93	2.5
Fungus	88	2.3
Epoxy	85	2.3
Acids	71	1.9
Formaldehyde	68	1.8
Fire	68	1.8
Latex/Rubber	63	1.7
Chlorine	55	1.5
Construction Exposures	55	1.5
Plastic Fumes	52	1.4
Animal Dander	46	1.2
Acrylates	39	1.0
Fragrances	36	1.0
Cobalt	33	0.9
Wood Dust	32	0.8
Flour	29	0.8
Ammonia	26	0.7
Styrene	23	0.6
Cigarette Smoke	23	0.6
Herbicide/Pesticide	22	0.6
Fiberglass	20	0.5
Aldehydes	19	0.5
Chromium	16	0.4
Amines	16	0.4
Medication	16	0.4
Cement Dust	15	0.4
Cosmetology Chemicals	14	0.4
Plants/Organic Matter	14	0.4
Asphalt	14	0.4
Caustics	14	0.4
Rust Inhibitor	13	0.3
Fire Extinguisher Powder	13	0.3
Grain Dust	13	0.3
Printing Inks	12	0.3
Anhydrides	11	0.3
Metal Dust	11	0.3
Heat	10	0.3
Insecticides	9	0.2
Meat Wrapper's Asthma	9	0.2
Sewage	9	0.2
Freon	8	0.2
Paper Dust	8	0.2
Other ^a	281	7.5
Total	3,765	

^aThere were 7 cases with exposure to: Azodicarbonamide, Cold Air, Enzymes, Polyurethane.

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

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

There were 4 cases each with exposure to: Asbestos, Coal Tar, Copier Toner, Hydraulic Oil, Lime Dust, Natural Gas, Pepper Gas, Rose Hips, Sand, Sulfonate, Trichloroethylene, X-Ray Developing Fluids.

There were 3 cases each with exposure to: Cadmium Solder, Colophony, Explosion, Fertilizer, Kerosene, Nickel, Ozone, Polyethylene, Sludge, Zinc, Zinc Oxide.

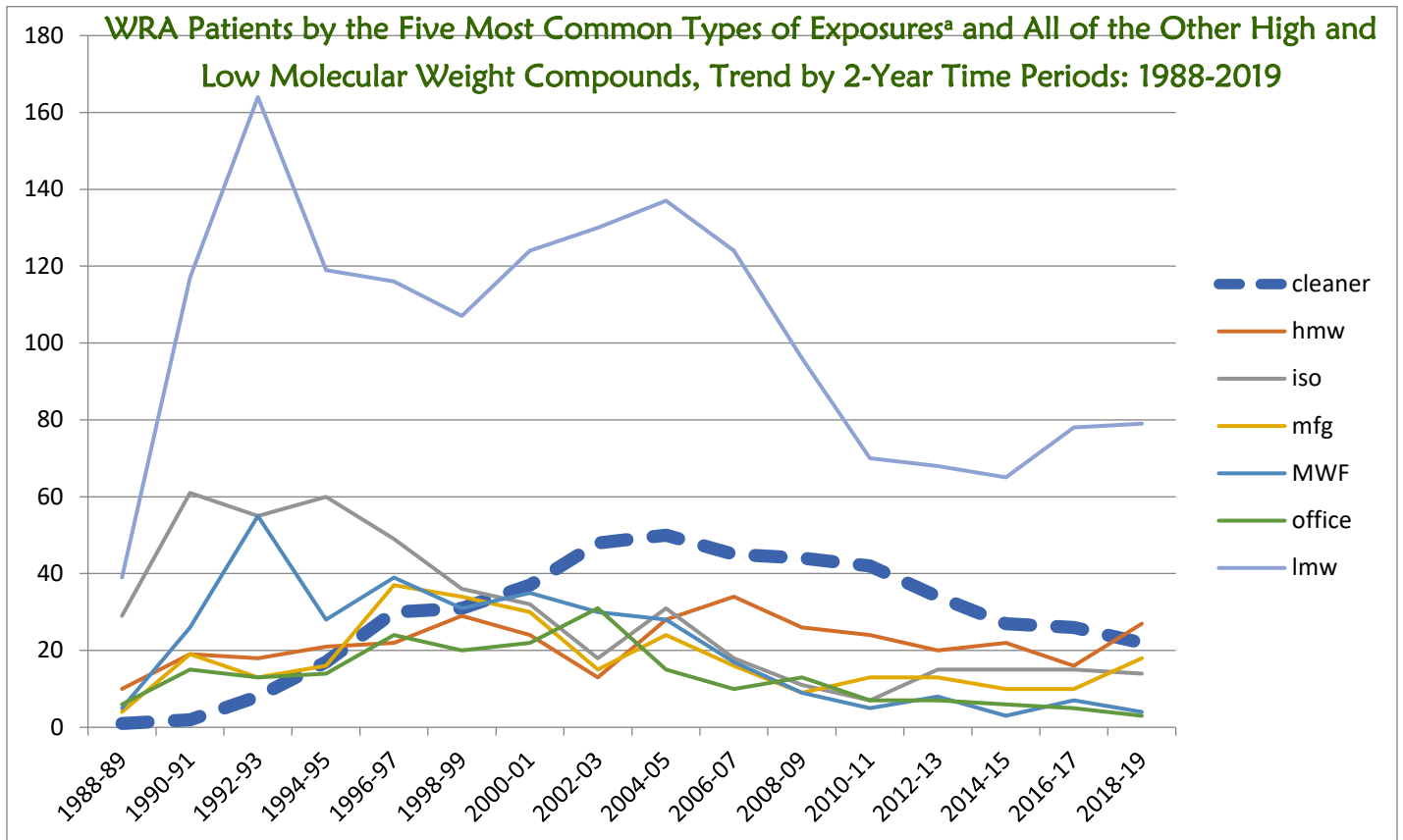
There were 2 cases each with exposure to: Ammonium Chloride, Calcium Chloride (used in Cherry Brine), Capsaicin, Cellulose, Concrete Sealer, Copper Oxide, Fireproofing Chemicals, Flux, Gas and Oil Refinery Exposures, Glaze, Heated Polyvinyl Chloride, Methamphetamine Lab, Odor, Perchloroethylene, Phosgene, Plating Chemicals, 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-Dimethyl Hydantoin, Agent Orange, Ammonium Bifluoride, Antifreeze, Barbeque Smoker, Benzoate Esters, Bitrex, Blood, Blue Prints, Calcium Carbonate, 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 Vinyl, Iodine, Isopropyl Alcohol, Laboratory Chemicals, Methanol, Mica, Monoammonium Phosphate, Ninhydrin, Nonylphenol polyethylene glycol ether, Nylon-polyhexamethylene Adipamide, Phenol, Pigment, Plasma Cutting, Platinum, Polyolefin, Potassium Aluminum Fluoride, Polybutadiene, Propane, Smoke from Burning Food, Soda Ash, Sodium Acetate, Sodium Chlorite, Soot, Stress, Swimming Pool Shock, Tetrahydrofuran, Titanium Tetrachloride, Tuberculosis Vaccine, Vaping Fumes, Vinegar, White Lithium, Wood Smoke, World Trade Center Exposure, Zinc Borate.

TABLE 10
Top Workplace Exposures of WRA Patients by Time Period

Exposure Type	Time Period				Change in Percentage
	All Years	1988-1997	1998-2007	2008-2019	
Cleaning Agents	481 (12.8)	59 (4.6)	214 (14.6)	208 (20.2)	+ 339%
Isocyanates	446 (11.8)	246 (19.3)	126 (8.6)	74 (7.2)	- 63%
Metalworking Fluids	334 (8.9)	153 (12.0)	144 (9.9)	37 (3.6)	- 70%
Welding Fume	161 (4.3)	63 (4.9)	62 (4.2)	36 (3.5)	- 29%
Solvents	114 (3.0)	51 (4.0)	52 (3.6)	11 (1.1)	- 73%
Paint	93 (2.5)	18 (1.4)	49 (3.4)	26 (2.5)	+ 79%
Epoxy	85 (2.3)	33 (2.6)	28 (1.9)	24 (2.3)	- 12%
Fungus	88 (2.3)	0	41 (2.8)	47 (4.6)	+ 64%
Formaldehyde	68 (1.8)	33 (2.6)	19 (1.3)	16 (1.6)	- 38%
Acids	71 (1.9)	27 (2.1)	24 (1.6)	20 (1.9)	- 10%
Latex/Rubber	63 (1.7)	25 (2.0)	33 (2.3)	5 (0.5)	- 75%

FIGURE 3



^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 very similar to the state average for 2017 (19.3%) (most recent year available, 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-five 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-five 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 5.4 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 was one WRA death in 2019; a waiter with a known fish allergy died when the regular cook was off and the replacement cook who was not aware of the procedures used to minimize the waiters' exposure to fish (Case ID 4167). 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 each in 2015 and 2018. In addition, we have published articles on some of the work-related asthma deaths^{4,5}.

TABLE 11
Cigarette Smoking Status of 3,622^a
Confirmed WRA Patients: 1988-2019

	Smoking Status						TOTAL
	Current		Ex-Smoker		Non-Smoker		
	#	% ^b	#	%	#	%	
OA	246	20.7	455	38.2	490	41.1	1,191
POA	199	15.3	519	39.9	582	44.8	1,300
AA	155	21.3	191	26.2	383	52.5	729
RADS	109	27.1	150	37.3	143	35.6	402
All	709	19.6	1,315	36.3	1,598	44.1	3,622

^aMissing data on 143 patients.

^bPercents may not add to 100 due to rounding.

TABLE 12
Cigarette Smoking Status of WRA Patients by Time Period

	Time Period				
	All Years	1988-1997	1998-2007	2008-2019	Change in Percentage
Smoking Status	# (%)	# (%)	# (%)	# (%)	
Current	709 (20)	243 (20)	295 (21)	171 (18)	- 10%
Ex-Smoker	1,315 (36)	540 (43)	479 (34)	296 (31)	- 28%
Non-Smoker	1,598 (44)	463 (37)	632 (45)	503 (52)	+ 41%
Total	3,622	1,246	1,406	970	

TABLE 13
Personal History of Allergies or Asthma Among
3,420^a Confirmed WRA Patients: 1988-2019

Personal History of...

	Allergies & Asthma		Asthma Only		Allergies Only		No Allergies or Asthma	
	#	%	#	%	#	%	#	%
OA	65	5.8	56	5.0	338	30.1	665	59.2
POA	90	7.5	60	5.0	413	34.5	633	52.9
AA	383	50.8	333	44.2	18	2.4	20	2.7
RADS	17	4.9	36	10.4	85	24.6	208	60.1
All	555	16.2	485	14.2	854	25.0	1,526	44.6

^aMissing data on 345 patients.

SYMPTOMS

Two thousand nine hundred fourteen (2,914) 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 still exposed, with breathing problems still present reported their symptoms were improving, compared to 50% among those no longer exposed; during 2008-2019, 24% of those still exposed reported an improvement in symptoms, compared to 44% 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 15% reporting the need for less asthma medication during 2008-2019, compared to 32% among those no longer exposed.

TABLE 15
Persistence of Symptoms and Medication Use in 3,358
Confirmed WRA Patients: 1988-2019

Still Exposed?	Total	Breathing Problems Still Present?				Still Taking Asthma Medications?			
		Yes		Less		Yes		Less	
		#	%	#	%	#	%	#	%
Yes	968	922	95.2	282	29.1	844	87.2	171	17.7
No	2,390	1,992	83.3	1,127	47.2	1,866	78.1	691	28.9
Total	3,358 ^a	2,914		1,409		2,710		862	

^aInformation missing on 407 individuals.

TABLE 14
Health Care Usage Among Confirmed
WRA Patients: 1988-2019

Lifetime History of Health Care Usage

ED Visit ^a		Hospitalized ^b	
Yes # (%)	No # (%)	Yes # (%)	No # (%)
2,336 (66)	1,197 (34)	1,163 (35)	2,174 (65)
Range 1-300 visits		Range 1-200 hospitalizations	
AVG 5.4 ±14.7		AVG 3.7±9.8	

^aMissing data on 232 patients.

^bMissing data on 428 patients.

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, continued...

TABLE 16
Persistence of Symptoms and Medication Use in Confirmed WRA Patients by Time Period

Time Period	Still Exposed?	Total	Breathing Problems Still Present?				Still Taking Asthma Medications?			
			#	%	#	%	#	%	#	%
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	
2008-2019	Yes	240	220	91.7	57	23.8	220	91.7	35	14.6
	No	615	459	74.6	273	44.4	473	76.9	194	31.5
	Total	855	679		330		693		229	
Change in Percentage	Yes			-5%		-30%		+8%		-31%
	No			-10%		-10%		+3%		+7%

PULMONARY FUNCTION TESTING

The percentage of WRA patients who had different types of pulmonary function testing overall 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 WRA Patients by Time Period

Test Type	Time Period				
	All Years	1988-1997	1998-2007	2008-2019	Change in Percentage
	(%)	(%)	(%)	(%)	
Pre-post Bronchodilatation	49	54	54	38	- 16%
Methacholine Challenge	17	25	16	9	- 64%
Peak Flow at Work & Home	3	3	3	5	^a
Pre-post Work-shift	3	2	4	2	^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, 39% were awarded, 17% were denied and 44% 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 2008-2019. The first two time periods showed 49% of patients applying for workers' compensation benefits, and the third period had 51% 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 50% in the most recent time period. The percentage of claims denied also increased over the time periods, from 16% to 17% to 20% in the most recent time period. Accordingly, the percentage of claims pending approval decreased from 48% to 50% to 29% in the most recent time period.

INDUSTRIAL HYGIENE

A total of 819 workplace inspections have been conducted since 1988 (Table 18); 123 of those facilities had been inspected more than once. Three completed inspection reports have been received since last year's report.

Air sampling was conducted during 585 inspections (Table 19); 31 (5.4%) of the 578 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: 1988-2019

Inspection Status	# Patients Represented	Companies	
		#	%
Inspected	1,279	819 ^a	30.3
No Follow-up Planned	2,269	1,683	62.3
Scheduled for Inspection	9	9	0.3
Out of Business	78	70	2.6
No Longer Use Occupational Allergen	27	26 ^b	1.0
Sent Company Letter to Check Exposures ^d	103	96	3.6
Total	3,765	2,703 ^c	

^a819 inspections were conducted in 696 different workplaces.

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

^cRepresents 2,580 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 819
Workplace Inspections: 1988-2019

Air Sampling – NIOSH Standard	#	%
Above NIOSH Standard	69	8.4
Below NIOSH Standard	485	59.2
No NIOSH Standard	33	4.0
Unknown (no report yet)	4	0.5
Did Not Sample for an Allergen	31	3.8
Did Not Sample	197	24.1
Total	819	
Air Sampling – MIOSHA Standard	#	%
Above MIOSHA Standard	31	3.8
Below MIOSHA Standard	547	66.8
No MIOSHA Standard	7	0.9
Unknown (no report yet)	4	0.5
Did Not Sample for an Allergen	33	4.0
Did Not Sample	197	24.1
Total	819	

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 1988-2019

	Above NIOSH REL		Above MIOSHA PEL	
	#	%	#	%
Asthma-Causing Agents				
Formaldehyde	28	41.8	1	3.3
Cobalt	8	11.9	6	20.0
Styrene	6	9.0	4	13.3
Metal-Working Fluids	5	7.5	1	3.3
Glutaraldehyde	4	6.0	3	10.0
HDI	4	6.0	No PEL	--
MDI	3	4.5	0	--
Wood Dust	3	4.5	2	6.7
Chromic Acid	1	1.5	1	3.3
Ethylene Oxide	1	1.5	0	--
Phthalic Anhydride	1	1.5	1	3.3
Starch	1	1.5	0	--
Total Dust (Dry Plant Materials)	1	1.5	0	--
Total Dust (Grinding on Fiberglass)	1	1.5	1	3.3
Welding Fume (Total Particulate)	No REL	--	8	26.7
Flour Dust	No REL	--	2	6.7
TOTAL	67	100.2 ^a	30	99.9 ^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 623 of the 819 inspections. Workers had daily or weekly breathing symptoms associated with work or new onset asthma since beginning to work at 403 of the 623 (65%) companies. The average percentage of co-workers with symptoms in these 403 companies was 20.4%. All 1,701 co-workers from the remaining 220 companies reported no daily or weekly breathing symptoms associated with work. One thousand six hundred thirty-five (1,635) of the 10,558 (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 586 workers from 137 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 2,221 symptomatic workers were identified during the 819 MIOSHA enforcement inspections.

TABLE 21
Breathing Symptoms Among Co-Workers of the 3,765
Confirmed WRA Patients:
1988-2019 and by Time Period

	# Workers Interviewed	Daily or Weekly SOB, Wheezing or Chest Tightness	%
	10,558	1,635	15.5
BY TIME PERIOD:			
1988-1997	6,293	1,125	17.9
1998-2007	3,200	380	11.9
2008-2019	1,065	130	12.2
Workers on OSHA Log		586	
	# Companies Inspected	# Companies w/Employee on Log	%
	819	137	16.7
BY TIME PERIOD:			
1988-1997	437	76	17.4
1998-2007	266	52	19.5
2008-2019	116	9	7.8
Total Workers with Symptoms ^a		2,221	

^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 Environment, Great Lakes, and Energy (EGLE, formerly the 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 104 companies that reported using isocyanates in 2019, which is slightly less than the 106 companies from 2018 and the 112 companies that reported using isocyanates in 2017. There were 111 companies in 2016 and 112 companies in 2015 reporting isocyanate use. 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 45,298 workers in 2019 are slightly less than the 45,458 workers potentially exposed to isocyanates in 2018. In 2017 there were 44,739 workers and in 2016 there were 40,490 potentially exposed to isocyanates.

TABLE 22
Michigan Workers Employed in Manufacturing Facilities in 2019
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	4,013	60,325	6.7
ARENAC	GLOBE FIRE SPRINKLER	222	5,663	3.9
BARRY	BRADFORD WHITE CORP	1,307	30,638	4.3
BAY	QUANTUM COMPOSITES INC	14	47,704	<0.1
BERRIEN	LECO CORP NILES STEEL TANK VAIL RUBBER WORKS INC	743	70,483	1.1
CALHOUN	BREMBO HOMER FOUNDRY COMCAST URETHANE TRANSCONTINENTAL	668	59,943	1.1
CHARLEVOIX	EAST JORDAN FOUNDRY	514	12,315	4.2
CLARE	LEAR CORP. FARWELL PLANT	184	11,010	1.7

Table 22. County	Company Name^{a,d}	# Workers Employed by Isocyanate-Using Facilities	Total # Workers in the County^b	% Workers Potentially Exposed to Isocyanates
CRAWFORD	WEYERHAEUSER	159	5,285	3.0
DICKINSON	GREDE, LLC IRON MOUNTAIN LOUISIANA-PACIFIC-SAGOLA OSB	456	11,777	3.9
EATON	ALLIANCE INTERIORSSIKAAXON US	165	55,295	0.3
GENESEE	ASI PACKAGING COMPANY CREATIVE FOAM LANDAAL PACKAGING SYSTEMS	139	173,888	0.1
HILLSDALE	ESSEX SPECIALTY PRODUCTS	14	19,592	0.1
HURON	VALLEY ENTERPRISES	121	14,723	0.8
INGHAM	HUNTSMAN ADVANCED MATERIALS SA AUTOMOTIVE WILLIAMSTON PRODUCTS INC	400	145,943	0.3
ISABELLA	THE DELFIELD CO. UNIFIED BRANDS	1,046	33,405	3.1
JACKSON	MILSCO MICHIGAN SEAT TAC MFG	1,193	71,335	1.7
KALAMAZOO	AZON USA PARKER HANNIFIN CORP-HYDRAULIC SYS STRYKER INSTRUMENTS	3,848	129,316	3.0
KENT	CLIPPER BELT LACING CO, DBA FLEXCO INC GRAND RAPIDS FOAM TECHNOLOGIES HB FULLER LACKS WHEEL TRIM SYSTEMS, BARDEN PLATER PLASAN CARBON COMPOSITES PURFORMS INC RICHWOOD INDUSTRIES INC	3,494	349,535	1.0
LENAWEE	ANDERSON DEVELOPMENT INSULSPAN INTEVA PRODUCTS	983	44,663	2.2
LIVINGSTON	ANTOLIN-HOWELL PACKAGE DESIGN MFG INC	787	100,768	0.8
LUCE	LOUISIANA-PACIFIC CORP-NEWBERRY SIDING	175	2,172	8.1
MACOMB	AXALTA COATING SYSTEMS FCA US ASSEMBLY PLANT INTERNATIONAL CASTING CORP MOON ROOF CORP OF MI NEXEO SOLUTIONS NJT ENTERPRISES ROMEO RIM INC SHELBY FOAM SYSTEM WOLVERINE BRONZE	1,921	432,001	0.4
MARQUETTE	ARGONICS—MI PLANT	60	30,975	0.2
MASON	GREAT LAKES CASTING	211	12,996	1.6
MECOSTA	ORIGINAL FOOTWEAR INC	600	17,390	3.5
MIDLAND	CENTRAL WAREHOUSE –MIDLAND DOW CHEMICAL CO– 1790 BLDG	2,175	38,826	5.6
MONTCALM	KENT FOUNDRY MARVEL REFRIGERATIONMARVEL REFRIGERATION	215	27,196	0.8

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
MUSKEGON	DIVERSIFIED MACHINE-MONTAGUE MUSKEGON COMPOSITES, INC	702	73,860	1.0
OAKLAND	ARMALY SPONGE EAGLE INDUSTRIES FANUC ROBOTICS—CORP HDQTRS GALE INSULATION LYMTAL INTERNATIONAL INC RECTICEL UREPP N AMERICA SERVICE PARTNERS SIKAAXSON US WEBASTO ROOF SYSTEMS	1,754	657,035	0.3
OCEANA	BARBER STEEL FOUNDRY CORP	64	11,403	0.6
OTTAWA	MAGNA ENGINEERED GLASS ROYAL TECH	1,050	156,664	0.7
SAGINAW	GLASTENDER NEXTEER AUTOMOTIVE CORP POREX TECHNOLOGIES SAGINAW METAL CASTING OPERATIONS	6,282	82,533	7.6
SANILAC	ASCO LP GRUPO ANTOLIN MIDWEST RUBBER CO TRELLEBORG YSH INC (VIBRACOUSTIC)	741	18,565	4.0
ST CLAIR	AURIA SOLUTIONS ST CLAIR (IAC) IAC PORT HURON	357	72,546	0.5
ST JOSEPH	IAC MENDON	589	26,783	2.2
VAN BUREN	BASF CORP SPECIAL-LITE INC	166	33,559	0.5
WASHTENAW	EXTANG CORP FAURECIA INTERIOR SYSTEMS	1,885	192,472	1.0
WAYNE	ALPHA RESINS BASF CORP—LIVONIA PLANT BASF CORP—WYANDOTTE PLANT BAY LOGISTICS CYGNET AUTOMATED CLEANING EQ DETROIT FCA US JEFFERSON NORTH ASSEMBLY PLANT PLASTOMER CORP PROGRESSIVE DISTRIBUTIONS CENTERS WINDSOR MACHINE & STAMPING (US) LTD WOODBRIIDGE CORP	5,408	767,123	0.7
WEXFORD	REC BOAT HOLDINGS-CRUISER PLANT	473	14,185	3.3
TOTAL		45,298	4,736,000	1.0

^aSource: Manta.com, accessed 5-18-2020.

^bSource: Michigan Labor Market Information, Data Explorer, www.milmi.org accessed 7/6/2020.

^cSource: U.S. Environmental Protection Agency. Toxics Release Inventory, Michigan Companies Using Isocyanates in 2018 (most recent available), data accessed 10/17/2019.

^dSource: MI Dept of Environment, Great Lakes, and Energy (EGLE), FOIA Request for SARA Title III Emergency Planning & Release Reporting of isocyanates, for calendar year 2019, received 4/24/2020.

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 EGLE SARA Title III Emergency Planning and Release Reporting for calendar year 2019.

Additional chemical exposures associated with WRA in Michigan can be found in a 2018 report at: https://oem.msu.edu/images/resources/WRAsthma/2018_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)•

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
ALLEGAN	ADVANCED ARCHITECTURAL PRODUCTS	S	BERRIEN	BUCHANAN AGRON. & PETRO.	A
	CONAGRA FOODS LLC	A,CH		BUCHANAN WATER & WWTP	CH
	DOUGLAS MARINE CORP	S		CHAMPLAIN SPECIALTY METALS	A
	HUDSONVILLE CREAMERY & ICE CREAM	A		COLOMA FROZEN FOODS INC	A
	JBS PLAINWELL, INC.	A		FREEZER/REPACK CTR	A
	OTSEGO, CITY WELLS #3, #4, #5 & WWTP	CH		GREG ORCHARD	A
	SHERWIN WILLIAMS CO- HOLLAND	A		HANSON COLD STORAGE	A
	TIARA YACHTS INC	S		LETIZ FARMS	A
	THE AMERICAN BOTTLING COMPANY	A		NCP COATINGS	A,P
	WATER RENEWAL	CH		NEW BUFFALO WATER PLT	CH
ANTRIM	BFI ELK RAPIDS	A		NILES, CITY - DECKER, FRONT WELLS & IRON REMOVAL	CH
	JORDAN RIVER NAT FISH HATCHERY	F		OLD EUROPE CHEESE INC	A
ARENAC	WHITESTONE PUMPING STATION	CH		SAINT JOSEPH WATER PLT	CH
BARRY	CALEDONIA FARMERS ELEVATOR	A	BRANCH	CLEMENS FOOD GROUP	A
BAY	BAY CARBON INC	CH		QUINCY	CH
	QUANTUM COMPOSITES, INC.	S	REAL ALLOY RECYCLING INC	CH	
	WEST BAY CTY REGIONAL WW	CH	REAL ALLOY SPECIFICATIONS INC	CH	
BENZIE	GRACELAND FRUIT, INC.	A		WATER TREATMENT PLT/COLDWATER	CH
	PLATTE RIVER ST FISH HATCHERY	F	CALHOUN	ALBION PLANT	A
	SMELTZER ORCHARD COMPANY	A		ANATECH, LTD.	F
BERRIEN	ADVANCE PRODUCTS CORP	A		ARMSTRONG FACILITY	S
	BLUEWATER THERMAL SOLUTIONS	A		BATTLE CREEK WATER & WWTP	CH

Table 23, continued...

COUNTY	COMPANY NAME	EXPOSURE	COUNTY	COMPANY NAME	EXPOSURE
CALHOUN	BLEISTAHL	CO	GENESEE	STOKES STEEL TREATING CO	A
	HOMER	A		WATER POLLUTION CONTROL FAC	CH
	MARSHALL CITY WATER	CH		WOODWORTH INC. FLINT	A
	MUSASHI AUTO PARTS-MICHIGAN INC	A	GRATIOT	ALMA WASTEWATER PLANT	CH
	POST FOODS - BATTLE CREEK	CH		CITY OF ST. LOUIS WWTP	CH
	PRAIRIE FARMS DAIRY INC	A	HILLSDALE	BEF FOODS INC.	A
	RBT J SWALWELL WWTP	CH		CONAGRA FOODS INC	A
CASS	THE MENNEL MILLING CO. OF MI	CH		HILLSDALE WWTP	CH
	UNION HIGH SCHOOL	F		PRATTVILLE FERTILIZER & GRAIN	A
CHEBOYGAN	CHEBOYGAN WELLHOUSE #4,#7 & WWTP	CH		THE ANDERSONS LITCHFLD FARM	A
CHIPPEWA	PENDILLS CREEK NFH	F	HOUGHTON	KOPPERS PERFORMANCE CHEM	A
	PULLAR COMMUNITY BUILDING	A		WARM RAIN CORP	S
	SULLIVAN CREEK NFH	F	HURON	BAD AXE WWTP	CH
CLINTON	MAHLE ENGINE COMPONENTS USA, INC.	A		DOW AGROSCIENCES LLC	A
	MARTIN BROWER	A		FARMERS CO-OP GRAIN CO.	A
	MICHIGAN MILK PRODUCERS ASSOC	A		HARBOR BEACH WATER & WWTP	CH
	NUTRIEN AG SOLUTIONS 879	A		THUMB TOOL & ENGINEERING	A
	SAVE-A-LOT LTD	A	INGHAM	ALDI INC - WEBBERVILLE	A
	SCCMUA	CH		ARCTIC GLACIER—LANSING	A
	ST JOHNS WWTP	CH		ATMOSPHERE ANNEALING LLC	A
CRAWFORD	ARCTIC GLACIER INC	A		AURORA SPECIALTY CHEMISTRIES	E
DELTA	ESCANABA WATER & WWTP	CH		CREMER FARM CENTER, INC.	A
	VERSO ESCANABA LLC	A,CH		DYE WATER CONDITIONING PLANT	A
EATON	ETM ENTERPRISES INC.	S		E LANSING-MERIDIAN WATER & SEWER	A
	LANSING PLANT	A,CH		JORGENSEN FARM ELEVATOR	A
	MEIJER LANSING DISTRIBUTION	A		MASON P.O.T.W. PLANT	CH
	SIKA ADVANCED RESINS US	S		MICHIGAN STATE UNIVERSITY	A,CH
	INTERTOWN	CH		NITREX INC - MICHIGAN OPERATION	A
	LIMEKILN	CH		TECOMET-LANSING	CO
	NORTHMAN WELL HOUSE	CH		WATER TREATMENT PLANT	CH
EMMET	ODEN STATE FISH HATCHERY	F		WISE WATER CONDITIONING PLANT	A
	PRESERVE WELLHOUSE	CH	IONIA	BELDING TANK TECHNOLOGIES, INC	S
GD TRAVERSE	CENTRE ICE	A		CARGILL KITCHEN SOLUTIONS	A
	CENTURY SUN METAL TREATING	A		FARM DEPOT 3 LTD	S
	SARA LEE FROZEN BAKERY LLC	A		GALLAGHERS	A
	TCS TRAVERSE COLD STORAGE LLC	A		HENNERY	A
	TRAVERSE CITY	CH		MAIN FARM	A
GENESEE	A RAGNONE TREATMENT PLANT	CH		ROBROY ENCLOSURES	S
	CENTER ROAD, N PUMP STATION	CH		THK RHYTHM AUTOMOTIVE	A
	HENDERSON ROAD PUMP STATION	CH		TWIN CITY FOODS	A, CH
	KOEGEL MEATS INC.	A			

Table 23, continued...

COUNTY	COMPANY NAME	EXPOSURE	COUNTY	COMPANY NAME	EXPOSURE
IOSCO	HURON SHORE REGIONAL UTILITY A	CH	KENT	LACKS TRIM SYSTEM - AIRLANE PLANT	F
	TAWAS UTILITY AUTHORITY WWTP	CH		LACKS WHEEL SYSTEMS	F
JACKSON	CHEMETALL US INC	A,MA		LOWELL WWTP & WATER TREATMENT	CH
	CITY OF JACKSON WATER TREATMENT	CH		MICHIGAN NATURAL STORAGE CO	A
	COVENTRY PARK	CH		MICHIGAN TURKEY PRODUCERS	A
	INDUSTRIAL STEEL TRAINING	A		MONROE, LLC	MMA
	JCC WELL HOUSE	CH		NBHX TRIM USA	S
	KIMMEL ROAD WELL HOUSE	CH		NORTH RIDGE ORCHARD	A
	MEADOW HEIGHTS WELL	CH		PATTERSON ICE CENTER	A
	SOUTHVIEW PUMP STATION	CH		PLAINFIELD TWP WATER DEPT	CH
	WESTCHESTER PUMP STATION	CH		PLASTIC PLATE INC (KRAFT)	F
	WSU	CH		REMICO STREET FACILITY	F
KALAMAZOO	BELL'S BREWERY INC	A		RIVERIDGE PACKING	A
	CITY OF KALAMAZOO- STATIONS #28,#39	CH		ROSKAM BAKING CO-S1 & S2	A
	KALAMAZOO	A		SPARTA FACILITY	A
	KALAMAZOO WATER DIV/STA #1-#5, #8, #9, #11, #12, #14, #17, #18, #22, #24, #25, #31	CH		SPARTAN NASH DISTRIBUTION	A
	KNAPPEN MILLING CO	CH		SUPERIOR SEAFOOD INC.	A
	PHARMACIA & UPJOHN LLC	A,CH,E,F		SUPERIOR STONE PRODUCTS INC	MMA,S
	PRECISION HEAT TREATING COMPANY	A		SYSCO GRAND RAPIDS, LLC	A
	RICHARD-ALLAN SCIENTIFIC	F		THE HOME CITY ICE CO	A
	WESTERN MICHIGAN UNIVERSITY	A		UNIVAR USA	B
	29th STREET WAREHOUSE	S		VILLAGE OF SPARTA WATER & WWTP	CH
KENT	ARCANUM ALLOYS	CO		WYOMING CLEAN WATER PLANT	CH
	ARKEMA INC.	B,P,S	KEWEENAW	YOUNG'S FARMS	A
	BODYCOTE- GRAND RAPIDS	A	LAPEER	CITY OF LAPEER WWTP	CH
	BRENTAG GREAT LAKES LLC	B,S		GENESEE COUNTY WATER	CH
	BRETON INDUSTRIAL PARK WAREHOUSE	B,MMA,S		LAPEER PLATING & PLASTICS	F
	CHASE STORAGE & CHASE ORCHARDS	A	LENAWEE	ADC MAIN PLANT	MA,MMA,S
	COCA-COLA GRAND RAPIDS	A		AIRGAS USA LLC	A
	COUNTRY FRESH LLC	A		DAIRY FARMERS OF AMERICA	A
	DISTRIBUTION CENTER #1	A		NUTRIEN AG SOLUTIONS 634	A
	FINISHMASTER INC #990 DIST CR	S		WAR-AG FARMS HOME	A
FORTY-FOURTH STREET FACILITY	F		WELLHOUSE #3 #8—#12 & #14	CH	
FRUIT RIDGE APPLE CO	A		WILBUR-ELLIS COMPANY - MUNSON	A	
GM COMPONENTS HOLDINGS, LLC	A	LIVINGSTON	ASAHI KASEI PLASTICS NA	MA	
GORDON FOOD SERVICE	A		BRIGHTON WWTP	CH	
GRANDVILLE	A,CH		CHEMCO PRODUCTS, INC.	F	
HEEREN LLC	A		COR-MET INC.	CO	
JACK BROWN PRODUCE INC	A		GORDON FOOD SERVICE	A	
KING MILLING COMPANY	CH		GREEN OAK DC	A	

Table 23, continued...

COUNTY	COMPANY NAME	EXPOSURE	COUNTY	COMPANY NAME	EXPOSURE	
LIVINGSTON	HOWELL WATER PLANT & WWTP	CH	MONTCALM	WILBUR-ELLIS COMPANY LLC- EDMORE	A	
	PEPSI HOWELL	A	MUSKEGON	BASF CORP	A	
	THIRD STREET PUMP STATION	CH		COLE'S QUALITY FOODS, INC.	A	
MACKINAC	ST IGNACE WATER PLANT	CH		HOWMET CORP - PLT 10	B	
MACOMB	AXALTA COATING SYSTEMS	B,M,MMA,S		ICD CRESTON WAREHOUSE	B	
	BOSCOS PIZZA	A		L-3 HARRIS COMBAT PROPULSION SYSTEMS	A	
	DEPOR SHELBY	B,F		MUSKEGON COMPOSITES INC	S	
	EVERFRESH / LA CROIX BEVERAGES	A		PARAMELT (M. ARGUESO)	B	
	EXCO EXTRUSION DIES INC	A		SNAPPY APPLE FARMS INC	A	
	FORMSPRAG LLC	A		SUN CHEMICAL CORPORATION	A	
	GM GLOBAL TECHNICAL CENTER	A		WEBB CHEMICAL SERVICE CORP	F	
	METALLURGICAL PROCESSING CO	A	NEWAYGO	GERBER PRODUCTS COMPANY	A	
	NITRO-VAC HEAT TREATING	A		RICE LAKE FARMS PACKAGING LLC	A	
	REINHART FOODSERVICE LLC	A		WILBUR-ELLIS COMPANY LLC- GRANT	A	
	RIVIERA BUILDING 2	A	OAKLAND	ARAMCO RESEARCH CENTER- DETROIT	A	
SPECIALTY STEEL TREATING, INC.	A		CHEMICAL BLENDING	MMA		
MARQUETTE	KI SAWYER WWTP	CH		CHOR INDUSTRIES	A	
MASON	HOUSE OF FLAVORS INC	A		COMMERCIAL STEEL TREATING	A	
	LUDINGTON WASTEWATER PLANT	CH		DEPOR INDUSTRIES	B,F	
MECOSTA	ICE MTN NATURAL SPRING WATER	A		DETROIT STEEL TREATING CO.	A	
	LEPRINO FOODS COMPANY REMUS	A		ENGINEERED HEAT TREAT INC	A	
MENOMINEE	L.E. JONES COMPANY	CO		FARMINGTON HILLS ICE ARENA	A	
	MENOMINEE WATER & WWTP	CH		GENERAL MOTORS - PROVING GD	CH	
	RULEAU BROTHERS INC	A		HAZEL PARK VIKING ARENA	A	
MIDLAND	CITY OF MIDLAND - WATER & WWTP	CH		MACDERMID INCORPORATED	F	
	CPI FLUID ENGINEERING	F		MAHLE BEHR AMERICA INC	A	
	DOW AGROSCIENCES LLC	A,CH		MATHESON WIXOM	A	
	DOW SILICONES CORP- MIDLAND PLT	A,CH		OERLIKON	A	
	DUPONT MICHIGAN OPERATIONS	A		SPECIALTY STEEL TREATING INC	A	
	MIDLAND STORE	A		STONE SOAP COMPANY INC	F	
	SK SARAN	A,M		SULZER METCO (US) INC	CO	
	TRINSEO, LLC MICHIGAN OPERATIONS	MMA,S		SUN STEEL TREATING INC	A	
	MONROE	ADVANCED HEAT TREAT CORP	A		US FOODS INC.	A
		HOME CITY ICE COMPANY- TOLEDO	A		VILLAGE OF HOLLY WWTP	CH
INDEPENDENT DAIRY INC		A		WATERFORD IRON REMOVAL 5-1, 12-1, 14-1, 16-1 & 2, MS-1, 19-1, 24-1, 25-1 & 2, 28-1,31-1	CH	
MAYBEE FARMERS INC		A		WOODWORTH INC PONTIAC	A	
MEIJER NEWPORT DISTRIBUTION		A	OCEANA	2ND STREET STORAGE	A	
MONROE POWER PLANT		A		ARBRE FARMS CORPORATION	A	
	OTTAWA LAKE CO-OP ELEVATOR	A		HART DIVISION	A	

Table 23, continued...

COUNTY	COMPANY NAME	EXPOSURE	COUNTY	COMPANY NAME	EXPOSURE
OCEANA	MICHIGAN FREEZE PACK	A	SHIAWASSEE	AIRGAS SPECIALTY PRODUCTS - OWOSSO	A
	OCEANA CTY FREEZER STORAGE	A		CIE NEWCOR MFG-PLANT 1	A
	PETERSON FARMS MAIN CAMPUS	A		HARVEST MILLS	A
OGEMAW	HYPERION MATERIAL AND TECH	CO	ST CLAIR	DUNN PAPER, INC.	CH
OSCEOLA	ADVANCED FIBERMOLDING	S		LK HURON WATER TREATMENT	CH
	VENTRA EVART, LLC	F		PORT HURON	A
	YOPLAIT REED CITY	A		Z F MARYSVILLE AXLE DRIVES LLC	A
OTSEGO	GAYLORD	CH	ST JOSEPH	ABBOTT NUTRITION - STURGIS	A
OTTAWA	ALLENDALE PLANT	A		AQUATIC CO.	S
	BOAR'S HEAD PROVISIONS CO INC	A		MICHIGAN MILK PRODUCERS ASSOC	A
	BODYCOTE-HOLLAND	A		NUTRIEN AG SOLUTIONS 635 & 641	A
	CREME CURLS BAKERY, INC.	A		STURGIS WWTP	CH
	DIETRICH ORCHARDS	A		THREE RIVERS WWTP	CH
	HOMESTEAD ORCHARDS STORAGE	A	TUSCOLA	CARO WWTP	CH
	HUDSONVILLE PLANT	A		CASS CITY WWTP	CH
	J.B.SIMS GENERATING STATION	CH		FARM DEPOT	S
	JOHN F. DONNELLY PLANT	A	VAN BUREN	ALLOY STEEL TREATING CO INC	A
	MEAD JOHNSON AND CO LLC	CH		DECATUR	A
	MICHIGAN CELERY PROMOTION	A		GRAND JUNCTION FACILITY	A
	MICHIGAN NATURAL STORAGE	A		HARTFORD WAREHOUSE	A
	MIEDEMA PRODUCE INC.	A		HONEE BEAR CANNING	A
	POLYPLY COMPOSITES LLC.	S		IQF FACILITY	A
	QUINCY STREET, INC	A		LAWRENCE FREEZER CORP.	A
	SUPERIOR SALES INC	A		MINS PAW PAW LOGISTIC CENTER	A
	VERTELLUS ZEELAND LLC	MA		PAW PAW PLANT	A
	ZEELAND FACILITY	A		PAW PAW RIVER PRODUCE	A
	ZEELAND FARM SERVICES, INC	A		SHAFFER LAKE FRUIT, INC	A
SAGINAW	ADVANCED MICRONUTRIENT PRODUCTS	A		SHAWSA WWTP	CH
	BRIDGEPORT WWTP	CH		SILL FARMS MARKET, INC	A
	FRANKENMUTH CITY OF WATER & WWTP	CH		ST. JULIAN WINE COMPANY INC	A
	HEALTH CARE INDUSTRIES MATERIAL SITE	A		WELCH FOODS, INC.	A
	HI-TECH STEEL TREATING, INC.	A	WASHTENAW	ANN ARBOR, CITY OF WTP	A
	NEXTEER AUTOMOTIVE	A		ANN ARBOR ICE CUBE	A
	SAGINAW TWP RETENTION BASIN	CH		ARBOR HILLS ENERGY LLC	A
	UMBRA GROUP, LINEAR MOTION LLC	A		ARCTIC COLISEUM	A
	WATER & WWTP, SAGINAW CHARTER TWP	CH		ARCTIC GLACIER INC	A
SANILAC	DGP INCORPORATED	S		CHELSEA MILLING CO	CH
	MIDWEST RUBBER CO.	CH		DAPCO INDUSTRIES	A

Table 23, continued...

COUNTY	COMPANY NAME	EXPOSURE	COUNTY	COMPANY NAME	EXPOSURE
WASHTENAW	LOCH ALPINE SANITARY AUTHORITY	CH	WAYNE	PEPSI BOTTLING GROUP	A
	NUTRIEN AG SOLUTIONS 881	A		PLYMOUTH	CO,MMA
	PHOTO SYSTEMS INC	F		POLYCHEMIE INC	F
	UNIVERSITY OF MICHIGAN	A		PRAXAIR DISTRIBUTION INC	A,CH
WAYNE	A&R PACKING CO INC	A		PROGRESSIVE DISTRIBUTION CENTERS INC	B,E,F,MMA,S
	ARCTIC EDGE ICE ARENA	A		PVS TECHNOLOGIES, INC.	CH,F
	ARCTIC LOGISTICS LLC	A		SOUTHWEST WATER PLANT	CH
	BASF CORPORATION	MMA, S		SPRINGWELLS WATER TREATMENT PLT	CH
	BODYCOTE THERMAL PROCESSING	A		SYSCO DETROIT, LLC	A
	C. F. BURGER CO	A		TRENTON CHANNEL POWER PLANT	A
	CANTON	A		UNIVAR USA—ROMULUS	MA
	CANTON RENEWABLES	A		USA HOCKEY ARENA	A
	CARDINAL HEALTH	F		WATER RESOURCE RECOVERY FACILITY	CH
	CHAMPION FOODS	A		WATER WORKS PARK PLANT	CH
	COOPER HEAT TREATING LLC	A		WESTLAND FACILITY	MMA, S
	COSTCO WHOLESALE	A		WOLVERINE PACKING CO DISTRIBUTION PLANT	A
	COUNTRY FRESH, LLC - LIVONIA	A		YACK ARENA	A
	CREST INDUSTRIES INC	S	WEXFORD	AAR MOBILITY SYSTEMS	F
	DEARBORN ICE SKATING CENTER	A		FOUR WINNS-CRUISER DIVISION	MMA, S
	DETROIT PRODUCTION CENTER	A		FOUR WINNS-SPORT DIVISION	S
	DBA ALDOA COMPANY	E, F		HARING TOWNSHIP WATER SUPPLY	CH
	DYNAMIC SURFACE TECH INT'L	A			
	FCA US LLC-JEFFERSON PLANT	E, F			
	FISHER BUILDING	A			
	FREEZER SERVICES OF MI LLC	A			
	FRITZ PRODUCTS	CH			
	HOME CITY ICE CO - DETROIT	A			
	INLAND WATERS POLLUTION CONTROL INC	S			
	JCI JONES CHEMICALS INC.	CH			
	KENNEDY RECREATION CENTER	A			
	LINCOLN DISTRIBUTING	S			
	MASTRONARDI PRODUCE	A			
	MCLANE FOOD SERVICE - PLYMOUTH	A			
	MICHIGAN DAIRY	A			
	NORTHEAST WATER PLANT	CH			
	PENSKE LOGISTICS, LLC.	A			

Source: 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 2019 from a report generated by the Michigan DEQ on 4/24/2020.

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

In 2020, we reviewed the Michigan work-related asthma surveillance system from 1988 -2018.¹⁰ Highlights of the data collected over the 31 years:

- Overall, the confirmed cases of WRA in Michigan have decreased over the 31 years. The cumulative incidence rate of WRA decreased from 3.5 during 1988-1997 to 2.0 cases per 100,000 Michigan workers during 2008-2018. Surveillance systems in other countries have also reported a downward trend in WRA.
- There were decreases in cases from specific exposures to well-known causes of WRA such as isocyanates and metal working fluids and in the cumulative incidence rate in the overall manufacturing sector (11.6 to 5.6 cases per 100,000 workers). This decrease was consistent with improved workplace engineering and controls such as enclosure of work processes, product substitution and use of personal protective gear.
- However, for cleaning products, which are found across all industries, generally with less standardized work practices than those applied in a manufacturing setting there was an increase over time in the number of cases and percentage of cases associated with cleaning products from 5% to 20%.
- Sixty-six percent of WRA cases had an emergency department visit, with a median of two and an average of five visits, and 35% were hospitalized for their WRA, with a median of one and average of four hospitalizations.
- Despite the high morbidity and cost of WRA, only 49% had applied for workers' compensation.
- Nine individuals died from an asthma attack from a workplace exposure (the paper describes one of the deaths). The decedents ranged from 19 to 77 years. Five were men. Five worked in manufacturing and one each worked in construction, agriculture, food services, and automotive repair. Four were exposed to isocyanates, and one case each was exposed to secondhand cigarette smoke, milk tank cleaning agents, construction chemicals, mold machine release spray, and welding fume.

- WRA cases are useful for targeting workplace enforcement inspections. The confirmed cases worked in 2,601 facilities. Michigan OSHA inspected 806 of those facilities. During the inspections, 10,493 co-workers of the index cases completed a confidential respiratory questionnaire; 1,622 (15%) reported being bothered at work by daily or weekly chest tightness, shortness of breath or wheezing, or having new-onset asthma since beginning to work at the facility. Symptomatic co-workers decreased over time from 18% to 12%.

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.¹¹ 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 2.2 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 under-counting 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 (12.8%), isocyanates (11.8%) and metal working fluids (8.9%). Until recently, metal working fluids were the second most frequently reported exposure, and until 2014, isocyanates were the most frequently reported exposure.

The trend of fewer individuals with the known causes of WRA such as isocyanates, metal-working fluids and high molecular weight compounds would suggest improvements in controls when these agents are used since the number of facilities using isocyanates has increased. The increase in

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

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. In conjunction with four other states that conduct surveillance for work-related asthma, we published a summary of work-related asthma associated with cleaning agents.¹² Work-related asthma was associated with 12.4% of the cases across all five states. 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 Luce county 8.1% of the workforce is potentially exposed to isocyanates, and in Saginaw county approximately 7.6% of the workforce is exposed. In Allegan, 6.7% and in Midland, 5.6% of the workforce is employed in facilities where isocyanates are used. Health care providers can use this information to heighten their awareness of potential exposures to isocyanates among their patients with asthma.

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

Asthma symptoms may persist despite removal from the precipitating work exposures (Tables 15 & 16). Studies show that the sooner an individual is removed from the exposure after symptoms develop, the more likely the individual's symptoms will resolve.⁸ On the average, among the 2,390 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.¹³ 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 1,635 fellow workers with symptoms compatible with WRA (Table 21). Five hundred eighty-six

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.¹⁴

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.

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APPENDIX

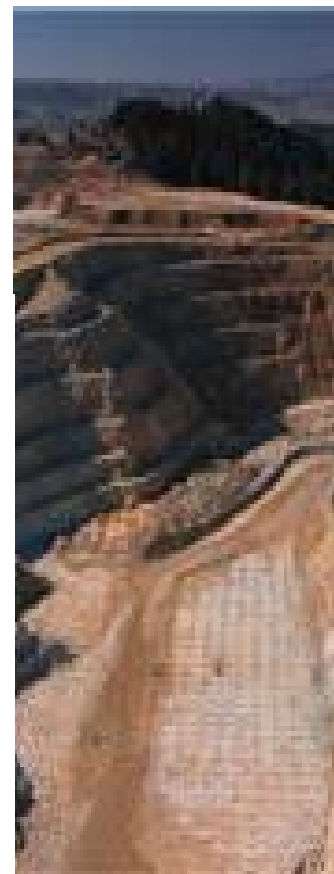
2019 PATIENT NARRATIVES BY TYPE OF INDUSTRY & EXPOSURE

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.

TABLE OF CONTENTS	Pages
Manufacturing	33-35
Educational Services	36
Health Care Services	36-37
Repair Services	37
Wholesale & Retail Services	37
Office	37-38
Agriculture	38
Transportation Services	38
Food Services	38
Public Services	39
Miscellaneous Services	39-40



MANUFACTURING

Exposure to Isocyanates

OA4270. A female in her 50s developed work-related asthma after exposure to isocyanates while working for an auto parts manufacturer. She developed shortness of breath and sought medical treatment. She was prescribed albuterol. She smoked an average of 10 cigarettes a day for 18 years. She quit this job because of her breathing problems.

OA4263. A male in his 40s developed work-related asthma after exposure to isocyanates while working at a polyurethane products manufacturer. He developed wheezing and shortness of breath and sought medical treatment in the emergency department. He was prescribed albuterol and Decadron. He was a lifelong non-smoker.

OA4149. A female in her 70s developed work-related asthma from exposure to isocyanates after working in an auto parts manufacturer for 7 years. She developed dyspnea and a cough and sought medical treatment multiple times in the emergency department where she was prescribed prednisone and Qvar. She was placed on disability leave; despite this her asthma continued to worsen.

OA4154. A male in his 40s developed work-related asthma while working for a kitchen appliance manufacturing company where he was exposed to isocyanates. He developed a cough, wheezing, chest tightness, and shortness of breath and sought medical treatment. He was prescribed Flovent, Spiriva, and Singulair. He smoked an average of 10 cigarettes per day for 28 years.

OA4125. A male in his 20s developed work-related asthma while working as a chemical engineer where he was exposed to isocyanates. He developed a cough, wheezing, chest tightness, and shortness of breath and sought medical treatment. He was prescribed albuterol. He formerly smoked 5 cigarettes a day for 11 years.

OA4122. A female in her 60s developed work-related asthma from isocyanate exposure while working for a company that manufactured auto parts. She developed shortness of breath and wheezing and sought medical treatment in the emergency department. She was prescribed Qvar, ProAir, and Singulair. She smoked an average of 20 cigarettes a day for 45 years.

OA4135. A male in his 60s developed work-related asthma while working for a car parts manufacturer where he was exposed to isocyanates. He developed a cough, chest tightness, wheezing, and shortness of breath and sought medical treatment in the emergency department. He was prescribed Qvar and Ventolin. He quit working this job because of his breathing problems. He was a lifelong non-smoker.

OA4279. A female in her 30's developed work-related asthma after being exposed to isocyanate-based spray liners for trucks while working for an automobile manufacturer. She developed shortness of breath and sought medical treatment in the emergency department. She was prescribed a rescue inhaler. She was a lifelong non-smoker.

Exposure to Welding Fume

AA4228. A female in her 20s experienced an exacerbation of her pre-existing asthma after exposure to smoke fumes from a welding machine at an auto parts manufacturer. She developed a cough, wheezing, chest tightness, and shortness of breath and sought medical treatment in the emergency department. She quit this job because of her breathing problems. She was a lifelong non-smoker.

AA4237. A male in his 20s experienced an exacerbation of his pre-existing asthma from exposure to welding fumes while working for an auto parts manufacturer. He developed a cough, chest tightness, wheezing, and shortness of breath and sought medical treatment in the emergency department. He was given a respirator. He smoked a pack of cigarettes a day for 8 years.

Exposure to Metal Working Fluids

AA4253. A male in his 20s experienced an exacerbation of his pre-existing asthma while working for a manufacturer where he was exposed to coolant. He developed chest tightness and shortness of breath and sought medical treatment in the emergency department. He was a lifelong non-smoker.

Exposure to Fiberglass

AA4116. A female in her 50s experienced an exacerbation of her pre-existing asthma while working for a car parts manufacturer where she was exposed to fiberglass. She developed a cough, wheezing, shortness of breath, and chest tightness and sought medical treatment. She was prescribed albuterol, Symbicort, Brovana, Singulair, and Spiriva. She was a lifelong non-smoker.

Exposure to Wood Dust

OA4180. A male in his 60s developed work-related asthma from exposure to wood dust after working for a countertop manufacturer for 45 years. He developed wheezing, a cough, chest tightness, and dyspnea and sought out medical treatment where he was given Advair and Symbicort. He quit this job on doctor's advice and hasn't experienced asthma symptoms since leaving work.

OA4249. A male in his 20s developed work-related asthma after exposure to saw dust while working in a lumber mill. He developed a cough, wheezing, chest tightness, and shortness of breath and sought medical treatment in the emergency department. He was prescribed albuterol. He was a current, every day smoker, smoking an average of 4 cigarettes per day.

AA4287. A male in his 20's experienced an exacerbation of his pre-existing asthma after exposure to sawdust while working for an office furniture manufacturer. He developed a cough, chest tightness, and shortness of breath and sought medical treatment in the emergency department. He was prescribed albuterol. He had a history of smoking.

Exposure to Cleaning Agents

RADS4230. A male in his 40s developed Reactive Airways Dysfunction Syndrome after exposure to a spill of an industrial cleaner while working at an aerospace manufacturer. He developed a cough, wheezing, chest tightness, and shortness of breath and sought medical treatment in the emergency department. He was prescribed Symbicort and prednisone. He was no longer exposed when the company replaced the cleaner with a new product. He smoked a half pack of cigarettes a day for 9 years.

AA4284. A male in his 50's experienced an exacerbation of his pre-existing asthma after exposure to cleaning chemical fumes while working in a food processing plant. He developed wheezing and shortness of breath and sought medical treatment in the emergency department. He was prescribed albuterol, fluticasone, and montelukast. He was a lifelong non-smoker.

Exposure to Miscellaneous Chemicals and Dusts

OA4144. A female in her 50s developed work-related asthma while working for an auto parts manufacturer where she was exposed to hot glue and other chemicals. She developed a cough, wheezing, chest tightness, and shortness of breath. She sought medical treatment and was prescribed Ventolin, Symbicort, and Incruse. She smoked an average of 10 cigarettes per day for 30 years.

POA4229. A male in his 30s developed work-related asthma from exposure to heated hydraulic oil while working for an auto parts manufacturer. He developed a cough, chest tightness, wheezing, and shortness of breath and sought medical treatment in the emergency department. He was prescribed prednisone. He quit this job because of his breathing symptoms. He was a lifelong non-smoker.

POA4194. A male in his 20s developed work-related asthma while working for a welding company. He developed a cough, wheezing, chest tightness, and shortness of breath and sought medical treatment. He was prescribed albuterol. He smoked an average of 10 cigarettes per day.

AA4501. A male in his 30s experienced an exacerbation of his pre-existing asthma while working for a steel manufacturer where he was exposed to dust. He developed chest tightness and shortness of breath and sought medical treatment in the emergency department. He was prescribed albuterol and Decadron. He was a current, daily smoker, smoking an average of 5 cigarettes per day.

RADS4251. A female in her 50s developed Reactive Airways Dysfunction Syndrome while working for an auto parts manufacturer where she was exposed to fire extinguisher fumes. She developed a cough and shortness of breath and sought medical treatment in the emergency department. She was prescribed an inhaler and steroids. She had a history of smoking cigarettes.

RADS4128. A male in his 20s developed Reactive Airways Dysfunction Syndrome from exposure to chemicals in a storage room where he was checking how the chemicals were stored. He developed a sore throat, shortness of breath, wheezing, and a headache. He was prescribed an albuterol inhaler. He found new employment to avoid further chemical exposure.

POA4181. A female in her 50s developed work-related asthma after repeated exposure to a cleaning mixture of vinegar and bleach while working for 15 years for a pickle company. She developed a cough, chest tightness, and dyspnea and was given an inhaler. She smoked cigarettes for 34 years.

RADS4190. A male in his 40s developed Reactive Airways Dysfunction Syndrome after a pipe burst that contained paint solvent in an area he was working. He developed a cough, wheezing, chest tightness, and shortness of breath and sought medical treatment in the emergency department. He was prescribed albuterol. His symptoms continue to worsen. After this incident, he was fired from his job. He smoked an average of 5 cigarettes per day for 22 years.

RADS4115. A male in his 50s developed Reactive Airways Dysfunction Syndrome while working as a welder where he was exposed to hydrochloric acid. He developed a cough, shortness of breath, wheezing, and chest tightness and sought medical treatment in the emergency department. He was prescribed prednisone. He smoked an average of 10 cigarettes a day for 25 years.

AA4278. A male in his 40s experienced an exacerbation of his pre-existing asthma after exposure to smoke from a fire while working as a machine operator at a cereal manufacturer. He developed a cough, chest tightness, wheezing, and shortness of breath and sought medical treatment in the emergency department. He was prescribed albuterol and Advair. He was a lifelong non-smoker.

POA4242. A female in her 40s developed work-related asthma after exposure to glue and vinyl fumes while working in a manufacturing plant. She developed a cough, chest tightness, and shortness of breath and sought medical treatment in the emergency department. She was prescribed albuterol and DuoNeb. She had a history of smoking cigarettes.

AA4233. A male in his late teens experienced an exacerbation of his pre-existing asthma after exposure to dust particles while working for a steel manufacturer. He developed chest tightness and shortness of breath and sought medical treatment in the emergency department. He was prescribed albuterol. He was a lifelong non-smoker.

AA4243. A female in her 30s experienced an exacerbation of her pre-existing asthma while working for a chemical manufacturer. She developed chest tightness and shortness of breath and sought medical treatment in the emergency department. She was prescribed albuterol. She was a lifelong non-smoker.

AA4257. A male in his 20s experienced an exacerbation of his pre-existing asthma after exposure to a brine solution where he worked at a fruit processing company. He developed a cough, wheezing, and chest tightness and sought treatment in the emergency department.

AA4285. A male in his 40's experienced an exacerbation of his pre-existing asthma after exposure to steel filings and dust while working in a steel mill. He developed a cough, 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.

POA4280. A female in her 30's developed work-related asthma after exposure to plating chemicals while working for a plating and plastic manufacturer. She developed shortness of breath and sought medical treatment in the emergency department. She was prescribed albuterol. She was provided a respirator at work, which she used intermittently. The manufacturer installed new air filters and ventilation right before she quit this job. She smoked an average of 15 cigarettes a day for the past 16 years.

Exposure to Indoor Air Contaminants

POA4126. A male in his 40s developed work-related asthma from exposure to mold at an auto parts manufacturing company where there was a leaky roof and evidence of water damage. He developed a headache and difficulty breathing and was prescribed Symbicort and two inhalers. He quit breathing problems he developed and noticed his asthma improved shortly after quitting.

EDUCATIONAL SERVICES

Exposure to Indoor Air Contaminants

AA4234. A male in his 20s experienced an exacerbation of his pre-existing asthma from exposure to chemicals while working in a university lab. He developed chest tightness and sought medical treatment in the emergency department. He was prescribed albuterol.

Exposure to Cleaning Products

AA4232. A female in her 60s experienced an exacerbation of her pre-existing asthma from exposure to chemical cleaners while working in a school. She developed wheezing and shortness of breath and sought medical treatment in the emergency department. She was prescribed prednisone and albuterol. She was a lifelong non-smoker.

Exposure to Animal Dander

OA4186. A female in her 20s developed work-related asthma from exposure to guinea pigs at work. She developed a cough, wheezing, chest tightness, and dyspnea and sought medical treatment in a hospital. She was prescribed albuterol. Shortly after this incident, she was fired from her job. She was a lifelong non-smoker.

Exposure to Miscellaneous Chemicals and Dusts

RADS4265. A female in her 40s developed Reactive Airways Dysfunction Syndrome after exposure to a formalin spill while she worked as a lab technician for a university. She developed a cough, wheezing, chest tightness, and shortness of breath and sought medical treatment in the emergency department. She was prescribed albuterol and a steroid. She was a lifelong non-smoker.

HEALTH CARE SERVICES

Exposure to Disinfectants

AA4255. A female in her 40s experienced an exacerbation of her pre-existing asthma from exposure to disinfectants and other cleaning agents while working in a hospital. She developed wheezing and sought medical treatment in the emergency department. She was prescribed an inhaler. She had a history of smoking cigarettes.

OA4148. A female in her 50s developed work-related asthma while working in a hospital where she was exposed to bleach and other chemicals. She developed a cough, wheezing, chest tightness, and shortness of breath and sought medical treatment in the emergency department. She was prescribed prednisone, Advair, and albuterol. She was fired shortly after seeking medical treatment for her breathing problems and her asthma improved. She was a lifelong non-smoker.

Exposure to Indoor Air Contaminants and Miscellaneous Chemicals and Dusts

AA4225. A female in her 30s experienced an exacerbation of her pre-existing asthma from exposure to smoke from a fire while working in a plasma center. She developed a cough, chest tightness, wheezing, and shortness of breath and sought medical treatment in the emergency department. She was prescribed Ventolin. She smoked 10 cigarettes a day for about 20 years.

AA4261. A female in her 40s experienced an exacerbation of her pre-existing asthma from exposure to burning food smoke while working as a lab tech in a hospital. She developed wheezing and sought treatment in the emergency department. She was prescribed Solu-Medrol. She had a history of smoking cigarettes but quit several years ago.

AA4244. A female in her 60s experienced an exacerbation of her pre-existing asthma while working in a hospital where she was exposed to pepper spray fumes. She developed a cough, wheezing, and shortness of breath and sought medical treatment in the emergency department. She was a lifelong non-smoker.

Exposure to Latex

OA4217. A female in her 40s developed work-related asthma while working at a pharmacy as a pharmacy technician. She was also exposed to cleaning agents and fragrances. She experienced wheezing, cough and shortness of breath. She was hospitalized and prescribes asthma

medication. She was a lifelong non-smoker.

Exposure to Animal Dander

OA4184. A female in her 40s developed work-related asthma after exposure to dust and animal dander when she was working as an in-home health aid. She developed a cough, wheezing, chest tightness, and shortness of breath. She sought medical treatment and was prescribed albuterol. She no longer went to the home that triggered her asthma, and her asthma improved. She was a lifelong non-smoker.

Exposure to Construction Dust

POA4188. A female in her 60s developed work-related asthma while working in a medical center that was undergoing construction. She developed a cough, wheezing, chest tightness, and shortness of breath and sought medical treatment. She was prescribed fluticasone, albuterol, and Singulair. She smoked an average of 8 cigarettes a day for 28 years.

AA193. A female in her 30s experienced an exacerbation of her pre-existing asthma while working in a hospital where she was exposed to a countertop adhesive during a renovation. She developed a cough, wheezing, chest tightness, and shortness of breath and sought medical treatment. She was prescribed Singulair, Symbicort, Flovent, and albuterol. She smoked an average of 10 cigarettes a day for 3 years.

REPAIR SERVICES

Exposure to Metal Dust

POA4152. A male in his teens developed work-related asthma while working in an autobody shop where he was grinding metal without a respirator. He developed dyspnea, a cough, and chest tightness and sought medical treatment. He was prescribed where he was given albuterol, Zyrtec, and prednisone. His asthma improved with the prescribed medications and he continued to work this job.

Exposure to Cleaning Products

POA4131. A female in her 60s developed work-related asthma while working as a vehicle mechanic where she was exposed to cleaning agents and gasoline. She developed a cough and chest tightness and sought medical treatment. She was prescribed albuterol and Cymbalta. She was a lifelong non-smoker.

WHOLESALE & RETAIL SERVICES

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

AA4227. A female in her 20s experienced an exacerbation of her pre-existing asthma from exposure to smoke from a fire at the building next door to the market where she worked. She developed wheezing and sought medical treatment in the emergency department. She was prescribed albuterol and prednisone. She was a lifelong non-smoker.

AA4240. A female in her 40s experienced an exacerbation of her pre-existing asthma from exposure to concrete dust while working as a manager in a retail store while construction was being done at the store next door. She developed a cough, chest tightness, wheezing, and shortness of breath and sought medical treatment in the emergency department. She was prescribed Qvar, albuterol, and Ventolin. She was a lifelong non-smoker.

AA4258. A male in his 50s experienced an exacerbation of his pre-existing asthma from exposure to heat while working in a retail store. He developed wheezing and sought medical treatment in the emergency department. He was prescribed albuterol and Pulmicort. He was a lifelong smoker, smoking an average of 7 cigarettes per day.

AA4166. A male in his 20s experienced an exacerbation of his pre-existing asthma while working at a hardware store where he was exposed to sodium hydroxide. He developed a cough and shortness of breath and sought medical treatment in the emergency department. He was a current smoker.

OFFICE/INDOOR AIR

Exposure to Indoor Air Contaminants

AA4169. A female in her 40s experienced an exacerbation of her pre-existing asthma after her office was painted with latex paint. She developed wheezing and chest tightness and sought medical treatment. She was given a breathing treatment in the ER and her asthma improved.

POA4165. A female in her 30s developed work-related asthma while working for a company whose workplace was undergoing construction. She developed a cough, wheezing, chest tightness, and shortness of breath and sought medical treatment. She was prescribed Symbicort, Spiriva, and Ventolin. She was a lifelong non-smoker.

AA4129. A female in her 50s developed work-related asthma while working for a call center where she was exposed to mold and chemicals. She developed shortness of breath and wheezing and sought medical treatment in the emergency department. She was prescribed Symbicort. She was a former smoker for 30 years.

AGRICULTURE

Exposure to Cleaning Agents

RADS4197. A female in her 50s developed Reactive Airways Dysfunction Syndrome from an acute exposure to mixed cleaning agents at the dairy farm where she had worked for 11 years. She developed wheezing, a cough, shortness of breath and chest tightness. She was taken to an emergency department and subsequently hospitalized. She was prescribed asthma medication. Since the incident, new engineering controls were installed. Her asthma improved and she required less asthma medication. She smoked a half a pack of cigarettes per day since her mid-teens.

Exposure to Miscellaneous Chemicals and Dusts

POA4183. A female in her 40s developed work-related asthma from exposure to chemicals where she worked at a farm. She developed acute dyspnea, wheezing, and a mild non-productive cough and sought medical treatment in the emergency department. She was given prednisone, DuoNeb, and albuterol.

TRANSPORTATION SERVICES

Exposure to Cleaning Agents

POA4168. A female in her 60s developed work-related asthma while working for an airline where she was exposed to exhaust from airplanes and cleaning agents. She developed a cough, wheezing, shortness of breath, and chest tightness and was hospitalized. She was prescribed Symbicort, Ventolin, and Spiriva. She was a lifelong non-smoker.

Exposure to Miscellaneous Chemicals and Dusts

POA4142. A female in her 50s developed work-related asthma from exposure to dust and dirt while working as a truck driver. She developed wheezing, a cough, chest tightness, and dyspnea and sought medical treatment in the emergency department where she was given an inhaler. She quit her job because of her asthma.

POA4195. A female in her 60s developed work-related asthma while working for an airline where she was exposed to multiple substances including dust, mold, and sewage. She developed a cough, wheezing, chest tightness, and shortness of breath and sought medical treatment. She was prescribed Singulair and Advair. She noticed her asthma improved when she was off work. She was placed on short term disability leave. She was a lifelong non-smoker.

RADS4130. A male in his 50s developed Reactive Airways Dysfunction Syndrome while working as a truck driver. He developed chest tightness and shortness of breath and sought medical treatment in the emergency department. He was prescribed ProAir and Symbicort. His symptoms improved when he was away from work. He smoked an average of six cigarettes a day for 10 years.

FOOD SERVICES

Exposure to Miscellaneous Substances

AA4167. A male in his 20s with pre-existing asthma died from an acute asthma attack. He was a waiter at a restaurant. He was mopping the floor during cleanup at the end of the work day when he asked a co-worker to take him to the hospital because he couldn't breathe. He stopped breathing when he arrived at the emergency department. Prior to mopping, he had picked up a food order in an area where a cook had previously made fish tacos. He was extremely allergic to fish. He was resuscitated in the emergency department but never regained consciousness. He died 10 days later in the hospital. He had asthma since childhood. He had multiple allergies, including to fish. He had previously been hospitalized and intubated after exposure to fish. He had worked at the restaurant for a year before he died.

AA4191. A male in his 20s experienced an exacerbation of his pre-existing asthma while working in food production where he was exposed to ammonia after a refrigerator leak. He developed a cough, wheezing, and shortness of breath and sought medical treatment in the emergency department. He was prescribed albuterol, azithromycin, and prednisone. He smoked 20 cigarettes a day on average.

AA4286. A female in her 40's experienced an exacerbation of her pre-existing asthma after exposure to smoke while working in a restaurant. She developed shortness of breath and sought medical treatment in the emergency department. She was prescribed Albuterol and Ventolin. The restaurant installed new engineering controls. She was a lifelong non-smoker.

PUBLIC SERVICES

Exposure to Miscellaneous Substances

AA4235. A male in his 30s experienced an exacerbation of his pre-existing asthma from exposure to smoke while working as a fire fighter. He developed a cough, wheezing, chest tightness, and shortness of breath and sought medical treatment in the emergency department. He was prescribed prednisone. He was a lifelong non-smoker.

RADS4252. A male in his 50s developed Reactive Airways Dysfunction Syndrome after exposure to smoke while working as a fire fighter. He developed a cough, chest tightness, and shortness of breath and sought medical treatment in the emergency department. He was prescribed Proventil.

RADS4204. A male in his 50s developed Reactive Airways Dysfunction Syndrome while working as a fire fighter, after exposure to smoke from a fire. He experienced wheezing, a cough and shortness of breath. He was hospitalized and prescribed asthma medication. Since the incident, he required more asthma medication. He was a lifelong non-smoker.

AA4245. A female in her 50s experienced an exacerbation of her pre-existing asthma while working as a security guard where she was exposed to mold and mildew. She developed a cough, wheezing, and shortness of breath and sought medical treatment in the emergency department. She was prescribed albuterol and Symbicort. She was reassigned to a new building. She smoked an average of one cigarette per day for 10 years.

OA4160. A female in her 50s developed work-related asthma while working as a chemistry technician where she was exposed to wastewater and chemical mixtures. She developed a cough, wheezing, chest tightness, and shortness of breath and sought medical treatment in the emergency department. She was prescribed albuterol and prednisone. She was a lifelong non-smoker.

POA4271. A male in his 50s developed work-related asthma after working in a wastewater plant where he was exposed to sewage and lime dust. He developed a cough, wheezing, chest tightness, and shortness of breath and sought medical treatment. He was prescribed Symbicort, albuterol, and steroids. He was a lifelong smoker, smoking an average of a pack a day.

MISCELLANEOUS SERVICES & INDUSTRIES

Exposure to Cleaning Products

AA4246. A female in her 30s experienced an exacerbation of her pre-existing asthma after exposure to disinfectants while working at a hotel. She developed a cough and sought treatment in the emergency department. She was prescribed albuterol. She was a lifelong non-smoker.

RADS4266. A female in her 50s developed Reactive Airways Dysfunction Syndrome from an acute exposure to disinfectants while working for a house keeping company. She developed wheezing and shortness of breath and sought medical treatment in the emergency department. She was prescribed DuoNeb and Solu-Medrol. She was a daily smoker, smoking an average of a pack of cigarettes a day.

POA4151. A female in her 50s developed work-related asthma while working for a cleaning company where she was exposed to cleaning products. She developed a cough, wheezing, chest tightness, and shortness of breath and sought medical treatment. She was prescribed albuterol. She smoked an average of 10 cigarettes a day.

OA4153. A female in her 40s developed work-related asthma while working for a gym where she was exposed to cleaning products. She developed a cough, wheezing, chest tightness, and shortness of breath. She sought medical treatment and was prescribed albuterol, Symbicort, Singulair, and prednisone, and Benzonatate. She was a lifelong non-smoker.

AA4216. A male in his 20s experienced an exacerbation of his pre-existing asthma while working as a janitor for a building janitorial service. He was exposed to cleaning agents and dirt/dust. He developed wheezing and a cough. He was treated in an emergency department and prescribed asthma medication. After this incident, he was reassigned to a new job. He smoked a pack a day of cigarettes since his early 20s.

AA4218. A male in his 50s experienced an exacerbation of his pre-existing asthma from exposure to a new brand of car wash soap, at the car wash where he worked as an attendant. He experienced wheezing, chest tightness and shortness of breath. He was treated in an emergency department and prescribed asthma medication. He was a lifelong non-smoker.

Exposure to Miscellaneous Substances

POA4273. A male in his 50s developed work-related asthma while working at a waste management company where he was exposed to paper and cardboard dust. He developed a cough and shortness of breath and sought medical treatment in the emergency department. He was prescribed albuterol and Symbicort. He was a lifelong smoker.

POA4272. A female in her 50s developed work-related asthma after being exposed to sulfur. She developed chest tightness and shortness of breath and sought medical treatment in the emergency department. She was prescribed albuterol. She was a lifelong non-smoker.

AA4239. A male in his 30s experienced an exacerbation of his pre-existing asthma after exposure to chlorine and other gases while at work. He developed a cough and shortness of breath and sought medical treatment in the emergency department. He was prescribed albuterol. He was a lifelong smoker, smoking an average of 10 cigarettes per day.

AA4238. A male in his 40s experienced an exacerbation of his pre-existing asthma after exposure to chlorine while working maintenance at a country club. He developed shortness of breath and sought medical treatment in the emergency department. He was prescribed albuterol and Symbicort. Following this incident, the country club started a new method of adding chlorine to the pool. He was a lifelong non-smoker.

AA4247. A male in his 30s experienced an exacerbation of his pre-existing asthma after exposure to an adhesive chemical from an aerosol can while at work. He developed a cough, wheezing, and shortness of breath and sought medical treatment in the emergency department. He was prescribed prednisone and benzonatate. He was a lifelong smoker.

AA4260. A female in her 30s experienced an exacerbation of her pre-existing asthma after exposure to strong odors while working in a hotel. She developed a cough, wheezing, and shortness of breath and sought medical treatment in the emergency department. She was a lifelong non-smoker.

POA4250. A female in her 20s experienced an exacerbation of her pre-existing asthma after a chemical exposure while working for a lawn care company. She developed a cough, wheezing, and shortness of breath and sought medical treatment in the emergency department. She was prescribed albuterol, Singulair, benzonatate, Breo-Ellipta, and a Medrol Dosepak. She was a lifelong smoker, smoking an average of seven cigarettes a day.

POA4248. A male in his 40 developed work-related asthma after exposure to mold, hay, and dust while cleaning out a pole barn for work. He developed a cough, wheezing, and shortness of breath and sought medical treatment in the emergency department. He was prescribed albuterol, prednisone, and Symbicort. He had a history of formerly smoking cigarettes.

AA4254. A female in her 40s experienced an exacerbation of her pre-existing asthma from exposure to perfume while working for a call center. She developed a cough, wheezing, and shortness of breath and sought medical treatment in the emergency department. She was prescribed Symbicort, Qvar, and albuterol.

AA4147. A female in her 20s experienced an exacerbation of her pre-existing asthma while working as a building security guard when she was outside and exposed to cold air for long periods of time. She developed a cough, wheezing, and shortness of breath and was hospitalized. She was a lifelong non-smoker.

POA4123. A female in her 50s developed work-related asthma while working for an engraving company where she was exposed to smoke from wood cutting and debris. She developed a cough and wheezing and sought medical treatment. She was prescribed prednisone, albuterol, and Flovent. Shortly after this incident she was fired from her job. She was a lifelong non-smoker.