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2014 ANNUAL REPORT

TRACKING WORK-RELATED ASTHMA IN MICHIGAN



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Work-Related Asthma Surveillance Program

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

Summary

This is the 24th 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

Acronyms

OA Occupational Asthma

AA Work-Aggravated Asthma

POA Possible Occupational Asthma

RADS Reactive Airways Dysfunction Syndrome

LARA MI Department of Licensing & Regulatory Affairs

MIOSHA Michigan Occupational Safety & Health Administration

NAICS North American Industrial Classification System

NIOSH National Institute for Occupational Safety & Health

PEL Permissible Exposure Limit

REL Recommended Exposure Limit



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

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

caused or aggravated by their work, and yet only 22% reported having a discussion with their health care provider about their concern about the effect of work on their asthma¹. These same individuals were

more symptomatic and had more health care usage than other Michigan adults with asthma. This study highlights the importance of health care providers considering whether their patients with asthma have work-related triggers.



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

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

Summary, continued...

- ◆ Since 2006, the number of cases identified each year has been less than the overall average of 135.
- ◆ From 1988-2014, 3,333 WRA cases have been identified through the MI tracking system.
- ◆ We estimate there are 65,000-97,000 adults in MI with WRA.
- ◆ 82% of the MI WRA patients have new-onset asthma; 18% have pre-existing asthma aggravated by an exposure at work.
- ◆ MIOSHA enforcement inspections at the workplaces where an individual with WRA was reported revealed that, on average, one out of every six of their fellow workers has asthma or respiratory symptoms compatible with asthma.
- ◆ Isocyanates-12.2%, and cleaning agents- 12.0%, are the most commonly reported exposures causing WRA in MI.
- ◆ About 1% of the MI workforce is employed in manufacturing where isocyanates are used.
- ◆ The average incidence rate of WRA among African Americans is 1.5 times greater than that of Caucasians.

Background

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

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

Work-Related Asthma Tracking Procedures...

SOURCES TO IDENTIFY PATIENTS

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

WRA Tracking Procedures in Michigan

IDENTIFY PATIENTS	INTERVIEW PATIENTS	WORKPLACE INSPECTION	FOLLOW UP ACTIVITIES
<ul style="list-style-type: none"> ◆ Review OD Reports -Submitted to LARA ◆ Known or Suspected -Work-Related Asthma ◆ Letter to Patient 	<ul style="list-style-type: none"> ◆ Telephone Interview -Medical and work history ◆ Obtain Medical Records -Breathing test results ◆ Physician Review 	<ul style="list-style-type: none"> ◆ Inspection Referral -MIOSHA determines inspection type ◆ On-Site Inspection -Assess exposures, conduct air monitoring -Injury & Illness Log -MSU interviews workers -Evaluate medical program 	<ul style="list-style-type: none"> ◆ Inspection Results -Company -Workers -Reporting Physician ◆ Letters to Individual Co-Workers -See doctor if breathing problems reported during interview ◆ Analyze Data -Annual Report -Other outreach & educational materials



INTERVIEW PATIENTS

A telephone interview with the suspected WRA patient is conducted, and medical records are obtained, including any pulmonary function test results. A board-certified internist and occupational medicine physician reviews all collected information.

WORK-RELATED ASTHMA REQUIRES

- A) Physician diagnosis of asthma.
- B) Onset of respiratory symptoms associated with a particular job that resolve or improve away from work.
- C) Work with a known allergen, or an association between work exposure and a decrease in pulmonary function.

THESE ARE THE SUBCATEGORIES OF WRA

New Onset

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

Exacerbation

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

A study of Michigan asthma patients found that as much as 54% of adult asthma was caused or aggravated by exposures in their job.¹

Workplace Inspections

After the patient interview is completed and the work-relatedness is determined, a 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 is conducted.
- ◆ The company’s health and safety program is reviewed.

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.

OTHER FOLLOW UP ACTIVITIES

Outreach, educational activities, and recommendations may be developed based on the findings. An annual report summarizing the activity is completed each year.



Welding activities expose workers to heated metal fume, as well as surface contaminants such as oils or dirt and dust.

Results

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

REPORTS

Table 1 shows that 3,333 people were confirmed with WRA between 1988—2014. The reports are divided into: occupational asthma (OA), possible occupational asthma (POA), aggravated asthma (AA) and Reactive Airways Dysfunction Syndrome (RADS). Sixty-one additional patients have been confirmed since last year’s report (two for 2013 and 59 for 2014). Figure 1 shows the overlap of the patients by reporting sources for 1988—2014.

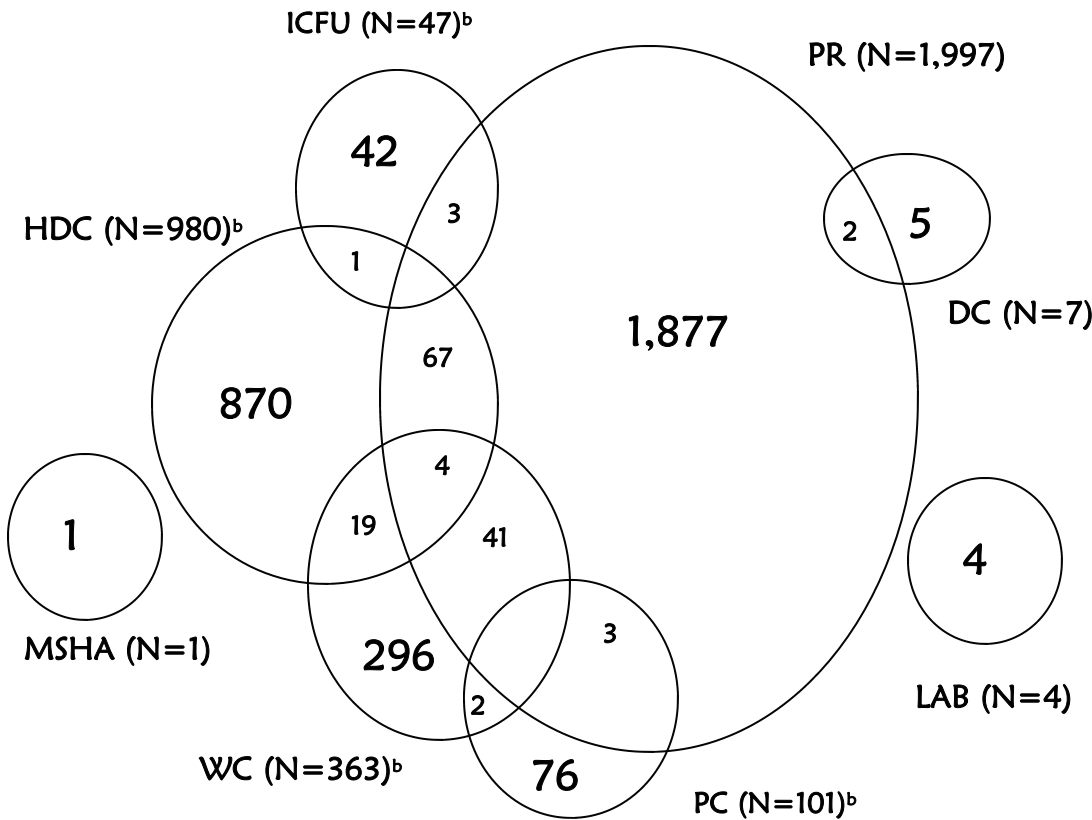
TABLE 1
Number of Confirmed Cases of Work-Related Asthma by Year and Type

YEAR	Disease Status				TOTAL
	OA	POA	AA	RADS	
1988	23	7	0	1	31
1989	43	12	3	5	63
1990	87	35	14	8	144
1991	55	30	14	16	115
1992	82	36	14	18	150
1993	75	69	13	19	176
1994	65	59	15	13	152
1995	57	34	19	17	127
1996	61	59	24	11	155
1997	53	74	19	16	162
1998	46	74	18	9	147
1999	48	65	16	12	141
2000	49	67	31	17	164
2001	50	51	20	19	140
2002	39	59	24	21	143
2003	29	64	28	23	144
2004	39	61	37	30	167
2005	43	66	21	23	153
2006	34	61	29	14	138
2007	20	41	34	28	123
2008	16	53	25	16	110
2009	20	41	31	8	100
2010	16	41	30	16	103
2011	19	26	19	3	67
2012	16	19	35	10	80
2013	15	27	31	6	79 ^a
2014	15	18	24	2	59 ^a
Total	1,115	1,249	588	381	3,333

^aReports are still being processed for calendar years 2013 and 2014; an increase in these totals will be reflected in next year’s annual report.

82% of WRA in Michigan is new onset; 18% is pre-existing asthma aggravated by exposure to an allergen or trigger at work.

FIGURE 1
Overlap of Reporting Sources for 3,333 Confirmed
Work-Related Asthma Patients: 1988-2014^a



Doctors are the most frequent reporters of workers with occupational diseases.

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.

^a Ns represent the total number for that source.

Reporting Source: HDC=Hospital Discharge; PR=Physician Referral; DC=Death Certificate; WC=Workers' Compensation; ICFU=Index Case Follow-Up; MSHA=Mine Safety & Health Administration; PC=Poison Control Center; LAB= Laboratory IgE.

^b There was an overlap of PC-HDC for 18 individuals and of one individual for PC-ICFU, and WC-PC-HDC for one individual each.

Demographics

GENDER

- ◆ Women 1,801, 54%
- ◆ Men 1,532, 46%

YEAR OF BIRTH

- ◆ Range 1905—1995
- ◆ Average 1958

RACE

- ◆ Caucasian 2,463, 74%
- ◆ African American 620, 19%
- ◆ Hispanic 73, 2%
- ◆ Alaskan/American Ind. 25, 1%
- ◆ Asian 14, <1%
- ◆ Other 36, 1%
- ◆ Unknown 102, 3%

ANNUAL INCIDENCE RATE

- ◆ African American 2.56
- ◆ Caucasian 1.73

The annual incidence rate for African Americans is 1.5X greater than that of Caucasians (95% CI 0.85, 2.57).

Numerator is the average number of WRA cases by race for 2008-2012 reporting years. Denominator Source: American Community Survey Civilian Labor Force by Race in MI, 2008-2012.

Location in State



Table 2 and Figure 2 show the annual average incidence rates of WRA among the working population, by county. The highest rates were in Luce (12.4 cases per 100,000), Clare (8.2 cases per 100,000), Osceola (5.3 cases per 100,000), Genesee (5.2 cases per 100,000), Huron (5.1 cases per 100,000), and Saginaw (5.0 cases per 100,000).

TABLE 2
Average Annual Incidence Rates of Work-Related Asthma
Among Michigan Workers by County of Exposure: 1989-2012^a

County	Avg Annual		Cases 1989-2012	County	Avg Annual		Cases 1989-2012
	# EE's ^b	Inc Rate ^c			# EE's ^b	Inc Rate ^c	
Alcona	3,701	1.1	1	Keweenaw	934	4.5	1
Alger	4,082	1.0	1	Lake	4,078	2.0	2
Allegan	51,890	3.5	44	Lapeer	41,930	3.2	32
Alpena	13,883	3.3	11	Leelanau	10,451	1.6	4
Antrim	10,773	0.8	2	Lenawee	47,409	2.6	30
Arenac	6,827	2.4	4	Livingston	86,477	1.8	37
Baraga	3,466	3.6	3	Luce	2,678	12.4	8
Barry	28,195	0.7	5	Mackinac	5,996	1.4	2
Bay	51,280	1.9	23	Macomb	396,836	2.9	277
Benzie	7,828	1.6	3	Manistee	11,000	1.1	3
Berrien	73,886	1.6	29	Marquette	31,306	2.7	20
Branch	21,410	4.3	22	Mason	13,628	0.9	3
Calhoun	65,736	2.7	42	Mecosta	17,904	1.6	7
Cass	24,866	0.8	5	Menominee	12,260	0.3	1
Charlevoix	12,704	2.3	7	Midland	39,455	2.6	25
Cheboygan	11,260	4.8	13	Missaukee	6,220	2.7	4
Chippewa	15,632	1.1	4	Monroe	72,714	1.6	28
Clare	11,718	8.2	23	Montcalm	27,030	2.6	17
Clinton	34,384	1.0	8	Montmorency	3,781	3.3	3
Crawford	6,164	3.4	5	Muskegon	78,772	1.4	26
Delta	18,237	1.4	6	Newaygo	20,992	2.4	12
Dickinson	13,230	3.8	12	Oakland	613,059	2.7	398
Eaton	55,075	0.9	12	Oceana	12,255	1.0	3
Emmet	17,085	1.2	5	Ogemaw	8,852	3.8	8
Genesee	194,623	5.2	243	Ontonagon	3,234	1.3	1
Gladwin	10,067	0.8	2	Osceola	10,174	5.3	13
Gogebic	7,230	1.2	2	Otsego	11,317	3.3	9
Grand Traverse	42,943	1.7	18	Ottawa	123,438	0.8	25
Gratiot	18,133	2.8	12	Roscommon	9,630	3.0	7
Hillsdale	21,637	2.3	12	Saginaw	90,666	5.0	108
Houghton	15,701	1.9	7	Sanilac	19,843	3.8	18
Huron	15,387	5.1	19	Schoolcraft	3,448	2.4	2
Ingham	144,855	3.4	118	Shiawassee	33,207	0.8	6
Ionia	27,764	1.7	11	St. Clair	78,702	2.8	52
Iosco	9,639	2.2	5	St. Joseph	28,518	1.5	10
Iron	5,278	2.4	3	Tuscola	26,543	3.3	21
Isabella	33,403	2.1	17	Van Buren	36,707	0.8	7
Jackson	72,768	2.6	45	Washtenaw	178,274	4.0	171
Kalamazoo	123,404	1.5	43	Wayne	851,213	3.7	752
Kalkaska	7,816	4.3	8	Wexford	13,447	1.5	5
Kent	294,931	1.1	77	All Michigan Counties^d	4,702,000	2.7	3,090

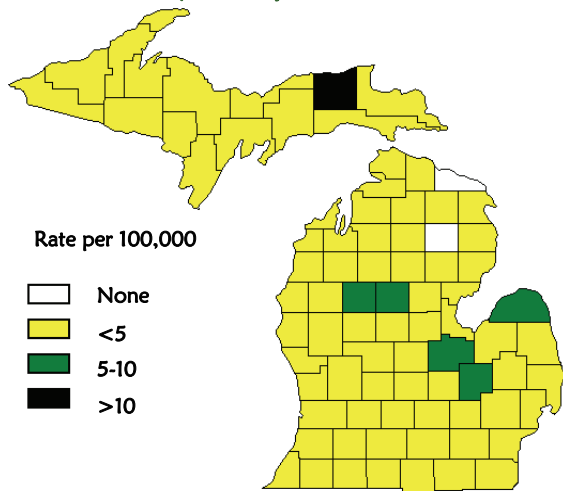
^a 1989 through 2012 represent complete years of reporting. Reporting in 1988 was begun mid-year and is incomplete. Reporting for 2013 and 2014 is not yet complete. Therefore, 1988, 2013 and 2014 reports are not included in this table.

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

^c Rates are based on the average number of cases per year from 1989-2012 (24 years), per 100,000 Michigan workers.

^d Fifty-two cases had an out-of-state exposure and 22 had an unknown county of exposure, for the 1989-2012 reporting period.

FIGURE 2
Average Annual Incidence Rate of WRA by County of Exposure: 1989-2012^a



^a 1989 through 2012 represent complete years of reporting. Reporting in 1988 was begun mid-year and is incomplete. Reporting for 2013 and 2014 is not yet complete. Therefore, 1988, 2013 and 2014 reports are not included in this figure.

Type of Industry

Table 3 shows the Michigan industries by NAICS codes, where the exposures to occupational allergens occurred from 1988 to 2014. The predominant industries were in manufacturing (58%) and health care and social assistance (12%).

The incidence rate of WRA by industry type ranges from 0.1 cases per 100,000 in management of companies to a high of 10.2 cases per 100,000 in manufacturing. Industries with the next highest annual average incidence rates were: mining with 5.8 cases per 100,000 workers and health care and social assistance with 3.2 cases per 100,000 workers.

Table 4 shows the average annual incidence rates for WRA cases *within manufacturing*.

TABLE 3
Number of Work-Related Asthma Patients, 1988-2014 by Primary Industrial Exposure and Annual Average Incidence Rate per 100,000 Workers, 1989-2012 (Years of Complete Reporting)

2002 North American Industry Classification System		WRA Cases 1988-2014		Number of Employees ^a	Ann. Average Incidence Rate ^b	
		#	%		Rate	# Cases
11	Agriculture, Forestry, Fishing, & Hunting	22	0.7	81,664	1.0	19
21	Mining	12	0.4	8,600	5.8	12
22	Utilities	17	0.5	35,300	1.8	15
23	Construction	86	2.6	199,800	1.7	81
31-33	Manufacturing	1,939	58.2	761,400	10.2	1,863
42	Wholesale Trade	40	1.2	175,400	0.9	37
44-45	Retail Trade	93	2.8	530,700	0.7	86
48-49	Transportation & Warehousing	65	2.0	92,900	2.8	63
51	Information	24	0.7	70,400	1.2	20
52	Finance & Insurance	29	0.9	157,700	0.7	26
53	Real Estate & Rental & Leasing	16	0.5	55,700	1.2	16
54	Professional, Scientific & Technical Services	28	0.8	258,700	0.4	26
55	Management of Companies & Enterprises	1	<0.1	73,600	0.1	1
56	Administrative & Support & Waste Management	71	2.1	267,000	1.0	62
61	Educational Services	152	4.6	332,000	1.8	141
62	Health Care & Social Assistance	395	11.9	499,300	3.2	381
71	Arts, Entertainment & Recreation	30	0.9	53,500	2.1	27
72	Accommodation & Food Services	94	2.8	345,200	1.1	89
81	Other Services (except Public Administration)	77	2.3	256,100	1.1	67
92	Public Administration	129	3.9	390,400	1.3	120
00	Unknown	13	0.4	--	--	12
Total		3,333	100.2^c	4,568,564	2.9	3,164

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

^bReporting in 1988 was begun mid-year, and reporting for 2013 and 2014 is not yet complete. Therefore, 1988, 2013 and 2014 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 1989-2012 (24 years), per 100,000 Michigan workers.

^cPercentage does not add to 100 due to rounding.

TABLE 4
1,863 Work-Related Asthma Cases from Manufacturing Industries:
1989-2012^a

	2002 North American Industry Classification System	WRA Cases #	Ann Avg Rate ^a	# Employees ^b
311	Food Mfg	62	8.1	31,900
323	Printing & Related Support Activities	19	3.9	20,200
325	Chemical Mfg	99	12.2	33,800
326	Plastics & Rubber Products Mfg	100	9.5	43,700
327	Nonmetallic Mineral Product Mfg	18	4.3	17,600
331	Primary Metal Mfg	66	9.7	28,300
332	Fabricated Metal Product Mfg	102	5.0	84,500
333	Machinery Mfg	139	7.3	79,700
334	Computer & Electronic Product Mfg	12	2.4	21,100
336	Transportation Equipment Mfg	1,113	15.6	296,900
337	Furniture & Related Product Mfg	13	1.7	31,000
	Miscellaneous Mfg (*includes NAICS: 312-16,321-322,324,335,339)	120	6.9	72,700

^aAverage annual incidence rate, based on cases from 1989-2012 (24 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 2013 and 2014 is not yet complete. Therefore, 1988, 2013 and 2014 reports are not included in this table.

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

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



Type of Exposure

Table 5 shows the exposures associated with WRA among Michigan workers. The most frequent exposures reflect the importance of the vehicle manufacturing industry in the State, and the widespread use of cleaning products across all industry sectors. Most frequently identified exposures include: isocyanates (MDI, TDI, HDI and others) accounting for 407 (12.2%) of the WRA case exposures and cleaning products, associated with 399 (12.0%) of Michigan’s WRA patients. Metal working fluids (coolants) accounted for 320 (9.6%) of Michigan worker exposures.

There is ongoing interest in ingredients in cleaning products that can cause new-onset asthma and aggravate existing asthma. These products, used both in the home and in all industry sectors (services, manufacturing, etc.) can con-

tain disinfectants, often in the form of quaternary amines, which have been repeatedly shown to cause asthma among workers who either use them or are in the area when they are being used. The Michigan WRA Tracking Program has developed a brochure on the hazards of cleaning agents. It is available at: www.oem.msu.edu, and can be found under the **Resources Section**.

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

TABLE 5
Top Workplace Exposures Associated with
Confirmed WRA Patients: 1988-2014

<u>Exposure Agent</u>	<u>#</u>	<u>%</u>
Isocyanates	407	12.2
Cleaning Solutions	399	12.0
Metal Working Fluids	320	9.6
Unknown (Mfg.)	247	7.4
Unknown (Office)	200	6.0
Exhaust/Smoke/Fumes	162	4.9
Welding Fume-Stainless & Other	149	4.5
Solvents	113	3.4
Paint Fumes	83	2.5
Epoxy	74	2.2
Fungus	70	2.1
Formaldehyde	66	2.0
Acids	64	1.9
Latex/Rubber	61	1.8
Chlorine	50	1.5
Fire	47	1.4
Plastic Fumes	46	1.4
Chemicals Used in Construction	41	1.2
Acrylates	39	1.2
Cobalt	31	0.9
Animal Dander	31	0.9
Flour	27	0.8
Fragrances	26	0.8
Wood Dust	26	0.8
Ammonia	23	0.7
Styrene	23	0.7
Cigarette Smoke	21	0.6
Herbicide/Pesticide	21	0.6
Fiberglass	19	0.6
Aldehydes	18	0.5
Amines	14	0.4
Chromium	14	0.4
Cosmetology Chemicals	14	0.4
Caustics	13	0.4
Cement Dust	13	0.4
Plants/Organic Matter	13	0.4
Grain Dust	12	0.4
Printing Inks	12	0.4
Rust Inhibitor	12	0.4
Anhydrides	11	0.3
Medication	11	0.3
Asphalt	8	0.2
Fire Extinguisher Powder	8	0.2
Insecticides	8	0.2
Meat Wrapper's Asthma	8	0.2
<u>Other^a</u>	<u>258</u>	<u>7.7</u>
Total	3,333	99.8^b

^aThere were 7 cases with exposure to Paper Dust.

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

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

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

There were 3 cases each w/exposure to: Cadmium Solder, Coal Tar, Colophony, Copier Toner, Dimethyl Benzyl Ammonium Chloride, Hydraulic Oil, Kerosene, Lime Dust, Natural Gas, Nickel, Ozone, Polyethylene, Sand, Sludge, Vinyl Acetate Acrylic, Zinc Oxide.

There were 2 cases each w/exposure to: Ammonium Chloride, Cellulose, Cold Air, Concrete Sealer, Cooking Oil, Copper Oxide, Exercise, Explosion, Fertilizer, Fireproofing Chemicals, Gas and Oil Refinery Exposures, Glaze, Methamphetamine Lab, Pepper Gas, Perchloroethylene, Phosgene, Polyester, Polyvinyl Butyrate, Sulfite, Talcum Powder, Teflon, Zinc.

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

^bPercentage does not add to 100 due to rounding.

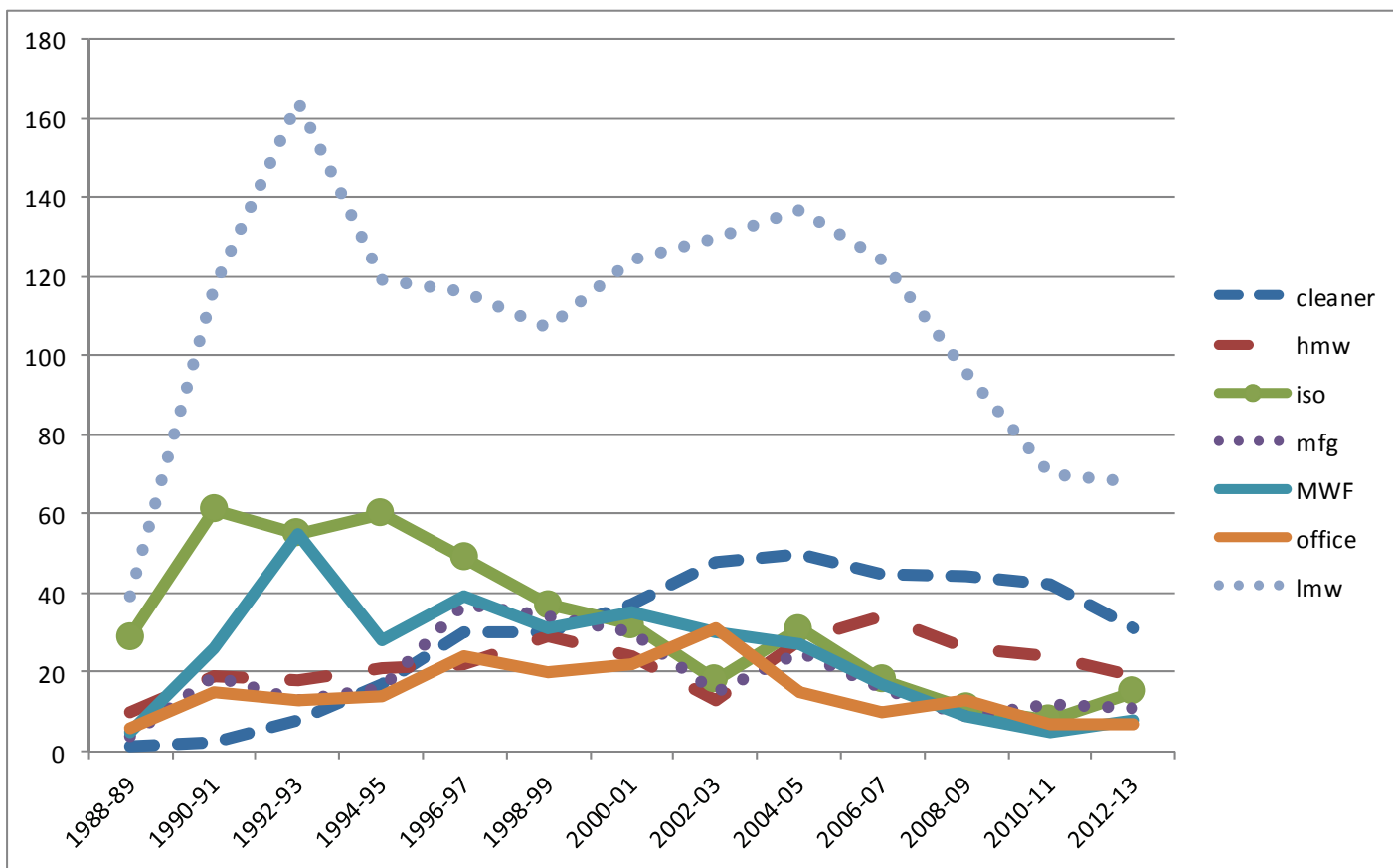
Type of Exposure, continued...

EXPOSURE TRENDS

Figure 3 shows the number of individuals with work-related asthma by type of exposure from 1988-2013. 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, manufacturing, and animal or plant products with high molecular weights appear unchanged and cleaning agents appear to be trending upward except for 2012-2013; however, the 2012-2013 data are provisional at this time and cases are still being identified and interviewed about their exposures. 2014 data is available but not reported in Figure 3 since the years are reported in 2-year time periods.

FIGURE 3
WRA Patients by the Five Most Common Types of Exposures* and All of the Other High and Low Molecular Weight Compounds, Trend by 2-Year Time Periods: 1988-2013**



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

**2014 data is available but not reported in this figure since the data in this figure is presented in 2-year groupings.

Medical Results

The percentage of Michigan adult smokers has varied over time, from a high of 28.4% in 1998, to a low of 20.5% in 2010, an increase in 2011 to 23.3%, and a decrease to 21.4% in 2014.

SMOKING STATUS

Table 6 shows patients' cigarette smoking status. Slightly less than 20% of patients were smoking when their asthma developed. This is slightly lower than the state average (21.4%) and markedly lower than that found in blue collar working populations.

ALLERGIES AND ASTHMA

Forty-four percent of WRA patients had a

family history of allergies (data not shown).

Fifteen percent of the asthma patients had a personal history of allergies and asthma (Table 7). Forty-seven percent had no history of allergies or asthma.

HEALTH CARE USAGE

Sixty-five percent of the WRA patients had at least one visit to the Emergency Department in their lifetime, and 35% had at least one hospitalization for their work-related asthma (Table 8). The average number of ED visits was 5.7 and the average number of hospitalizations was 3.8.

TABLE 6
Cigarette Smoking Status of 3,220^a
Confirmed WRA Patients: 1988-2014

	Smoking Status						
	Current		Ex-Smoker		Non-Smoker		TOTAL
	#	%	#	%	#	%	
OA	230	21.1	425	39.0	436	40.0	1,091
POA	188	15.4	504	41.3	528	43.3	1,220
AA	113	20.8	151	27.8	280	51.5	544
RADS	103	28.2	138	37.8	124	34.0	365
All	634	19.7	1,218	37.8	1,368	42.5	3,220

^aMissing data on 113 patients.

TABLE 7
Personal History of Allergies or Asthma Among
3,040^a Confirmed WRA Patients: 1988-2014

	Personal History of...							
	Allergies & Asthma		Asthma Only		Allergies Only		No Allergies or Asthma	
	#	%	#	%	#	%	#	%
OA	56	5.4	49	4.7	307	29.7	621	60.1
POA	79	6.9	54	4.7	390	34.2	617	54.1
AA	299	54.0	225	40.6	12	2.2	18	3.2
RADS	17	5.4	35	11.2	77	24.6	184	58.8
All	451	14.8	363	11.9	786	25.9	1,440	47.4

^aMissing data on 293 patients.

TABLE 8
Health Care Usage Among Confirmed
WRA Patients: 1988-2014

Lifetime History of Health Care Usage			
ED Visit ^a		Hospitalized ^b	
Yes	No	Yes	No
# (%)	# (%)	# (%)	# (%)
2,031 (65)	1,097 (35)	1,039 (35)	1,939 (65)
Range		Range	
1-300 visits		1-200 hospitalizations	
AVG 5.7 ±15.3		AVG 3.8 ±10.2	

^aMissing data on 205 patients.

^bMissing data on 355 patients.

SYMPTOMS

Two thousand six hundred eighty-seven of the patients with WRA had persistence of their asthma symptoms (Table 9). 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.

Medical Results, continued...

OBJECTIVE MEDICAL TESTING

The percentage of WRA patients who had different types of pulmonary function testing was:

- ◆ Pre-post bronchoprovocation 55%
- ◆ Methacholine challenge 19%
- ◆ Peak flow monitoring at work & home 3%
- ◆ Pre-post work-shift 3%
- ◆ Specific antigen challenge <1%

Workplace Investigations

WORKERS' COMPENSATION

About half of the WRA patients applied for Workers' Compensation benefits; about a third of those who applied for benefits were awarded compensation for their breathing problems.

- ◆ Applied 49%....among those who applied:
 - Pending approval 46%
 - Received benefits 37%
 - Denied benefits 17%

TABLE 9
Persistence of Symptoms and Medication Use in 3,040
Confirmed WRA Patients: 1988-2014

Still Exposed?	Total	Breathing Problems Still Present?				Still Taking Asthma Medications?			
		Yes		Less		Yes		Less	
		#	%	#	%	#	%	#	%
Yes	890	854	96.0	263	29.6	773	86.9	161	18.1
No	2,150	1,833	85.3	1,034	48.1	1,703	79.2	623	29.0
Total	3,040 ^a	2,687		1,297		2,476		784	

^aInformation missing on 293 individuals.

TABLE 10
Status of Facilities Where Confirmed WRA Patients Were Exposed to Allergens: 1988-2014

Inspection Status	# Patients Represented	Companies	
		#	%
Inspected	1,226	788 ^a	33.0
No Follow-up Planned	1,896	1,405	58.8
Scheduled for Inspection	6	6	0.3
Out of Business	76	68	2.8
No Longer Use Occupational Allergen	27	26 ^b	1.1
Sent Company Letter to Check Exposures ^d	102	96	4.0
Total	3,333	2,389 ^c	100.0

^a788 inspections were conducted in 665 different workplaces.

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

^cRepresents 2,266 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.

INDUSTRIAL HYGIENE

A total of 788 workplace inspections have been conducted since 1988 (Table 10); 123 of those facilities had been inspected more than once. Seven inspections have been completed since last year's report.

Air sampling for allergens was conducted during 568 inspections (Table 11); 29 (5.2%) of the 561 facilities with a MIOSHA standard for the allergen were above the enforceable permissible exposure limit.

TABLE 11
Air Monitoring Results from 788
Workplace Inspections: 1988-2014



Many substances have no method for air monitoring or have not been evaluated for their asthma-causing potential.

<u>Air Sampling – NIOSH Standard</u>	<u>#</u>	<u>%</u>
Above NIOSH Standard	68	8.6
Below NIOSH Standard	472	59.9
No NIOSH Standard	30	3.8
Unknown (no report yet)	2	0.3
Did Not Sample for an Allergen	28	3.6
<u>Did Not Sample</u>	<u>188</u>	<u>23.9</u>
Total	788	100.1^a

<u>Air Sampling – MIOSHA Standard</u>	<u>#</u>	<u>%</u>
Above MIOSHA Standard	29	3.7
Below MIOSHA Standard	532	67.5
No MIOSHA Standard	7	0.9
Unknown (no report yet)	2	0.3
Did Not Sample for an Allergen	30	3.8
<u>Did Not Sample</u>	<u>188</u>	<u>23.9</u>
Total	788	100.1^a

^aPercentage does not add to 100 due to rounding.

AIR MONITORING

Table 12 shows the allergens that were above the NIOSH and/or MIOSHA limits. The top four allergens found to be above the NIOSH REL were:

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

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

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

TABLE 12

Allergens Above the MIOSHA Permissible Exposure Limit (PEL) and/or NIOSH Recommended Exposure Limit (REL): Michigan 1988-2014

<u>Asthma-Causing Agents</u>	<u>Above NIOSH REL</u>		<u>Above MIOSHA PEL</u>	
	<u>#</u>	<u>%</u>	<u>#</u>	<u>%</u>
Formaldehyde	28	42.4	1	3.6
Cobalt	7	10.6	5	17.9
Styrene	6	9.1	4	14.3
Metal-Working Fluids	5	7.6	1	3.6
Glutaraldehyde	4	6.1	3	10.7
HDI	4	6.1	No PEL	--
MDI	3	4.5	0	--
Wood Dust	3	4.5	2	7.1
Chromic Acid	1	1.5	1	3.6
Ethylene Oxide	1	1.5	0	--
Phthalic Anhydride	1	1.5	1	3.6
Starch	1	1.5	0	--
Total Dust (Dry Plant Materials)	1	1.5	0	--
Total Dust (Grinding on Fiberglass)	1	1.5	1	3.6
Welding Fume (Total Particulate)	No REL	--	7	25.0
<u>Flour Dust</u>	<u>No REL</u>	<u>--</u>	<u>2</u>	<u>7.1</u>
TOTAL	66	99.9^a	28	100.1^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

Co-workers were interviewed during 608 of the 788 inspections. Workers had daily or weekly breathing symptoms associated with work or new onset asthma since beginning to work at 394 of the 608 (65%) companies. The average percentage of co-workers with symptoms in these 394 companies was 20.4%. All 1,654 co-workers from the remaining 214 companies reported no daily or weekly breathing symptoms associated with work. One thousand five hundred eighty-eight of the 10,251 (15.5%) co-workers interviewed had symptoms consistent with work-

related asthma (Table 13).

The MIOSHA Injury and Illness Logs (Form 300) kept by employers listed 583 workers from 135 companies with asthma or asthma-like symptoms. Only 10 workers identified in the interviews with daily or weekly chest tightness, shortness of breath or wheezing were also listed on the MIO-OSHA Log. Combining the information from the interviews and Injury and Illness Log, a total of 2,171 symptomatic workers were identified during the 788 MIOSHA enforcement inspections.



1 in 6 co-workers of the index patient with asthma reported similar breathing problems in the workplace.

TABLE 13
Breathing Symptoms Among Co-Workers of the 3,333 Confirmed WRA Patients: 1988-2014

Symptoms	Disease Status of the Index Patient									
	ALL		OA		POA		AA		RADS	
	#	%	#	%	#	%	#	%	#	%
Daily or Weekly SOB, Wheezing or Chest Tightness	1,588	15.5	1,115	15.8	429	14.9	6	12.0	38	13.9
Workers Interviewed	10,251		7,046		2,881		50		274	
Workers on OSHA Log	583		405		165		2		11	
# Companies w/Ee on Log	135	17.1	93	20.3	37	12.8	1	6.7	4	15.4
# Companies Inspected	788		458		289		15		26	
Total Workers w/Symptoms ^a	2,171		1,520		594		8		49	

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

Work-Related Asthma Deaths

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

There were no work-related asthma

deaths identified in calendar years 2009 through 2014.

We have published articles on some of the work-related asthma deaths^{4,5}.



Limiting asthma management to just the treatment of symptoms is an unacceptable way to manage work-related asthma.

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, the most commonly reported cause of WRA in Michigan (Table 14). Our estimate under-counts non-manufacturing-exposed employees such as at auto body paint shops because the EPA does not include non-manufacturing establishments. Conversely, our estimate over-counts manufacturing employees because we included the total number of employees at each facility that reported isocyanates, even though not all workers at these facilities would have worked with or around isocyanates.

Another source to identify chemical exposures associated with WRA comes from the Michigan Department

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

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

Between the two reporting sources, there were 107 companies that reported the use of isocyanates in calendar year 2014, which is down from 113 companies in 2013. The number of workers employed in companies that use isocyanates, the total number of workers in these counties, and the percentage of workers who work in facilities where isocyanates are used is listed in Table 14. The 36,371 workers potentially exposed to isocyanates in 2014 is down from the 37,835 potentially exposed in 2013.

TABLE 14

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

County	Company Name ^{c,d}	# Workers Employed ^a by Isocyanate-Using Facilities	Total # Workers in the County ^b	% Workers Potentially Exposed to Isocyanates
ALLEGAN	HAWORTH INC JOHNSON CONTROLS INTERIORS PMSC JOHNSON CONTROLS INTERIORS—MAPLEWOOD FAC	2049	56253	3.6
BARRY	BRADFORD WHITE CORP	1100	28539	3.9
BAY	RENOSOL-BAY CITY PLANT	20	49488	<0.1
BENZIE	MAGNA INTERIOR TRIM COMPONENTS	125	7997	1.6
BERRIEN	LECO CORP NILES STEEL TANK VAIL RUBBER WORKS INC	875	68413	1.3
CALHOUN	COMCAST URETHANE CONVERIS FLEXIBLES US	173	60083	0.3
CHARLEVOIX	EAST JORDAN FOUNDRY	504	12061	4.2
CLARE	LEAR FARWELL PLANT	300	10735	2.8

Table 14, continued...

County	Company Name ^{c,d}	# Workers Employed ^a by Isocyanate-Using Facilities	Total # Workers in the County ^b	% Workers Potentially Exposed to Isocyanates
CLINTON	INNOVATIVE POLYMERS INC	10	37675	<0.1
CRAWFORD	WEYERHAEUSER	125	4868	2.6
DICKINSON	GREDE LOUISIANA-PACIFIC-SAGOLA OSB	580	12106	4.8
EATON	AXSON N AMERICA GM LANSING DELTA TWP	1045	52953	2.0
GENESEE	ASI PACKAGING COMPANY FERGUSON BLOCK CO INC	26	170160	<0.1
HILLSDALE	DOW CHEMICAL	45	19011	0.2
INGHAM	HUNTSMAN ADVANCED MATERIALS S GROUP AUTOMOTIVE WILLIAMSTON PRODUCTS INC	290	136616	0.2
ISABELLA	DELFIELD CO UNIFIED BRANDS	900	33389	2.7
JACKSON	MILSCO MICHIGAN SEAT TAC MFG WOLVERINE SIDING SYSTEMS	854	68084	1.3
KALAMAZOO	AZON USA STRYKER INSTRUMENTS	843	120362	0.7
KENT	GRAND RAPIDS FOAM TECHNOLOGIES HB FULLER LEON PLASTICS NA FUELS SYSTEM REMFG PURFORMS INC RICHWOOD INDUSTRIES INC UNIVAR USA	700	319227	0.2
LENAWEE	ANDERSON DEVELOPMENT HI-LEX CONTROLS INSULSPAN INTEVA PRODUCTS	645	45075	1.4
LIVINGSTON	ATREUM HOWELL (INTIER AUTOMOTIVE)	400	88565	0.5
LUCE	LOUISIANA-PACIFIC CORP-NEWBERRY SIDING	111	2279	4.9
MACOMB	AXALTA COATING SYSTEMS CHRYSLER STERLING HTS ASSY FAURECIA INTERIOR SYSTEMS INTERNATIONAL CASTING CORP NJT ENTERPRISES ROMEO RIM INC SHELBY FOAM SYSTEM WOLVERINE BRONZE	6399	384087	1.7
MARQUETTE	ARGONICS—MI PLANT	60	31494	0.2
MASON	GREAT LAKES CASTING	240	13710	1.8
MECOSTA	WOLVERINE WORLD WIDE	540	17468	3.1
MIDLAND	CENTRAL WAREHOUSE –MIDLAND DOW CHEMICAL CO– 1790 BLDG & 1100 BLDG	2009	38993	5.2
MISSAUKEE	TJ'S WAREHOUSE	4	6571	0.1
MONTCALM	AGA MARVEL KENT FOUNDRY	147	25921	0.6

Table 14, continued...

County	Company Name ^{c,d}	# Workers Employed ^a by Isocyanate-Using Facilities	Total # Workers in the County ^b	% Workers Potentially Exposed to Isocyanates
MUSKEGON	DIVERSIFIED MACHINE-MONTAGUE	400	71123	0.6
OAKLAND	ARMALY SPONGE AXSON TECH USA BEHR AMERICA, MAHLE EAGLE INDUSTRIES EXOTIC RUBBER & PLASTICS CORP FANUC ROBOTICS—CORP HDQTRS ITW FUTURA COATING, ITW POLYMERS LYMTAL INTERNATIONAL INC RECTICEL UREPP N AMERICA	1653	584634	0.3
OCEANA	BARBER STEEL FOUNDRY CORP	50	11635	0.4
OTTAWA	DAKE OEM EAGLE PACKAGING MAGNA ENGINEERED GLASS	444	141774	0.3
SAGINAW	ESSENTRA POROUS TECHNOLOGIES GLASTENDER GRUPO ANTOLIN NEXTEER AUTOMOTIVE CORP SAGINAW METAL CASTING OPERATIONS	3040	82718	3.7
SANILAC	GRUPO ANTOLIN MIDWEST RUBBER CO NUMATICS SANDUSKY MAIN TRELLEBORG YSH INC	784	18067	4.3
ST CLAIR	IAC PORT HURON IAC ST CLAIR	500	66598	0.8
ST JOSEPH	IAC MENDON	600	27356	2.2
VAN BUREN	BASF CORP SPECIAL-LITE INC	182	32733	0.6
WASHTENAW	EXTANG CORP FAURECIA INTERIOR SYSTEMS THETFORD CORP	2779	177805	1.6
WAYNE	ALPHA RESINS BASF CORP—LIVONIA PLANT BASF CORP—WYANDOTTE PLANT BAY LOGISTICS CHRYSLER JNAP CYGNET AUTOMATED CLEANING EFTEC EQ DETROIT GREEN POLYMERIC MATERIALS IMA FOAM PLANT PLASTOMER CORP UNIVAR USA—ROMULUS WINDSOR MACHINE & STAMPING (US) LTD WOODBIDGE CORP	4816	689763	0.7
WEXFORD	REC BOAT HOLDINGS-CRUISER PLANT	4	13453	<0.1
TOTAL		36,371	4,402,000	0.8

^aSource: 2014 Michigan Manufacturers' Directory.

^bSource: Michigan Labor Market Information, Data Explorer, www.milmi.org accessed April 16, 2015.

^cSource: U.S. Environmental Protection Agency, Toxics Release Inventory, Michigan Companies Using Isocyanates in 2014, data accessed 10-9-2015.

^dSource: MI Dept of Environmental Quality, FOIA Request for SARA Title III Emergency Planning & Release Reporting of isocyanates, for calendar year 2014, received 5-14-2015.

Michigan Workforce Exposed to Select Causes of WRA, continued

Table 15 summarizes the companies, by county, using other chemicals that are known to cause asthma and those that are irritants and capable of causing Reactive Airways Dysfunction Syndrome. Those that can cause asthma are: Bisphenol A, Cobalt, Epichlorohydrin, Formaldehyde, Methyl Acrylate, Phthalic and Maleic Anhydride and Styrene. Ammonia and Chlorine are classified as irritants. These companies were identified through the MI DEQ SARA Title III Emergency Planning and Release Reporting for calendar year 2014.

Additional chemical exposures associated with WRA in Michigan can be found at: http://www.oem.msu.edu/userfiles/file/Resources/2014MIWorkforceExposedtoSelectAsthma_CausingAgents.pdf

TABLE 15

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

SUBSTANCES CAPABLE OF CAUSING ASTHMA:

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

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

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

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

Table 15, continued...

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

Table 15, continued...

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

Table 15, continued...

COUNTY	COMPANY NAME	EXPOSURE	COUNTY	COMPANY NAME	EXPOSURE
KENT	MICHIGAN TURKEY PRODUCERS	A	LIVING-STON	KELSEY HAYES CO	CH
	NBHX TRIM USA	S		PEPSI HOWELL	A
	NORTH RIDGE ORCHARD LLC	A		WATER PLANT & WWTP	CH
	PATTERSON ICE CENTER	A			
	PLASTIC PLATE INC (KRAFT)	F	MACKINAC	WATER TREATMENT PLANT & WWTP	CH
	REMICO STREET FACILITY	CH, F	MACOMB	AXALTA COATING SYSTEMS	B,M,MMA,S
	RIDGEKING APPLE PACKING & STORAGE	A		BOSCOS PIZZA	A
	RIVERIDGE PACKING	A		CARBIDE TECHNOLOGIES	A
	S1	A		EVERFRESH / LA CROIX BEVERAGES	A
	SPARTA FACILITY	A		FORMSPRAG LLC	A
	SPARTAN NASH DISTRIBUTION	A		GM WARREN LLC TECHNICAL CENTER	A
	SUPERIOR SEAFOOD INC.	A		METALLURGICAL PROCESSING CO	A
	SUPERIOR STONE PRODUCTS INC	MMA, S		MTSUBISHI CHEMICAL PERFORMANCE POLYMERS	B
	SYSCO GRAND RAPIDS, LLC	A		NITRO-VAC HEAT TREATING	A
	THE HOME CITY ICE CO	A		NORBROOK PLATING	A
	UNIVAR USA	B		REINHART FOODSERVICE LLC	A
	VI-CHEM CORPORATION	S		RIVIERA BUILDING 2	A
	VILLAGE OF SPARTA WATER DEPT	CH		SPECIALTY STEEL TREATING, INC.	A
	WYOMING CLEAN WATER PLANT	CH		TURRI'S ITALIAN FOODS, INC	A
KEWEENAW	SUSANS DAIRY	A,CH	MAR-QUETTE	KI SAWYER WWTP	CH
	SUSANS FARM	A	MASON	HOUSE OF FLAVORS INC	A
LAPEER	LAPEER PLATING & PLASTICS	F		JOS. SANDERS INC	A
LEELANAU	CHERRY GROWERS-PLT 2	A		LUDINGTON WASTEWATER PLANT	CH
LENAWEE	ADC MAIN PLANT	MA,MMA,S		MICHIGAN FOOD PROCESSORS	A
	AIRGAS CARBONIC, INC	A		NORON COMPOSITE TECHNOLOGIES	MMA,S
	CROP PRODUCTION SVCS 634 & 641	A	MECOSTA	LEPRINO FOODS COMPANY REMUS	A
	DAIRY FARMERS OF AMERICA	A		UNITED STATES MARBLE INC.	S
	GREAT LAKES CHEMICAL	A,CH	MENOMINEE	L.E. JONES COMPANY	CO
	WAR-AG FARMS SERVICES LLC	A		MENOMINEE WATER & WWTP	CH
	WELLHOUSE #3 #8—#12 & #14	CH		RULEAU BROS INC	A
	WILBUR-ELLIS COMPANY - MUNSON	A	MIDLAND	CITY OF MIDLAND - WATER & WWTP	CH
LIVING-STON	AMERICAN COMPOUNDING SPECIALTIES	MA		DOW- MICHIGAN OPERATIONS	A, B, CH, MMA, S
	ASAHI KASEI PLASTICS NA	MA		DOW CORNING - MIDLAND PLANT	A, CH
	CHEMCO PRODUCTS, INC.	F		HOMESTEAD TOOL - SMC PLANT	S
	GORDON FOOD SERVICE	A		MIDLAND STORE	A

Table 15, continued...

COUNTY	COMPANY NAME	EXPOSURE	COUNTY	COMPANY NAME	EXPOSURE
MIDLAND	TRINSEO, LLC MICHIGAN OPERATIONS	MMA,S	OAKLAND	NOVI ICE ARENA	A
MONROE	ADVANCED HEAT TREAT CORP	A		ONYX-ROCHESTER ICE ARENA	A
	DETROIT EDISON - MONROE POWER PLT	A		RMT WOODWORTH, SOUTHFIELD	A
	HOME CITY ICE COMPANY- Toledo	A		SPECIALTY STEEL TREATING INC	A
	INDEPENDENT DAIRY INC	A		STONE SOAP COMPANY INC	F
	MAYBEE FARMERS INC	A		SULZER METCO (US) INC	CO
	MEIJER NEWPORT DISTRIBUTION	A		SUN STEEL TREATING INC	A
	OTTAWA LAKE CO-OP ELEVATOR	A	OAKLAND	US FOODS INC.	A
MUSKEGON	ALLOY RESOURCE CORPORATION	CH		VILLAGE OF HOLLY WWTP	CH
	BAYER CROPSCIENCE USA	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
	COLE'S QUALITY FOODS, INC.	A		WOODWORTH INC PONTIAC	A
	ESCO COMPANY, LLC	P	OCEANA	2ND STREET STORAGE	A
	GMI COMPOSITES, INC	S		ARBRE FARMS CORPORATION	A
	HOWMET CORP - PLTS 1, 3, 5 & 10	B, CO		HART DIVISION	A
	L-3 COMBAT PROPULSION SYSTEMS	A		MICHIGAN FREEZE PACK	A
	LAKE WELDING SUPPLY CO INC	A		OCEANA CTY FREEZER STORAGE	A
	PARAMELT (M. ARGUESO)	B		PETERSON FARMS MAIN CAMPUS	A
	SNAPPY APPLE FARMS INC	A	OGEMAW	SANDVIK HARD MATERIALS	CO
	SUN CHEMICAL CORPORATION	A	OSCEOLA	ADVANCED FIBERMOLDING	S
	WEBB CHEMICAL SERVICE CORP	F		VENTRA EVART, LLC	F
NEWAYGO	GERBER PRODUCTS COMPANY	A		YOPLAIT REED CITY	A
OAKLAND	BEHR AMERICA INC (MAHLE)	A	OTSEGO	GAYLORD	CH
	CHEMICAL BLENDING	F	OTTAWA	ALLENDALE PLANT	A
	COMMERCIAL STEEL TREATING	A		BOAR'S HEAD PROVISIONS CO INC	A
	DEPOR INDUSTRIES	F		BODYCOTE-HOLLAND	A
	DETROIT SKATING CLUB	A		BROWN'S FARM	A
	DETROIT STEEL TREATING CO.	A		CREME CURLS BAKERY, INC.	A
	ENGINEERED HEAT TREAT INC	A		DIETRICH ORCHARDS	A
	FARMINGTON HILLS ICE ARENA	A		GEORGETOWN ICE CENTER	A
	FERNDALE	A, CH		HLCZ—HUDSONVILLE	A
	FOGLERS ORCHARD & FARM MKT	A		J.B.SIMS GENERATING STATION	CH
	GENERAL MOTORS PROVING GD	CH		JOHN F. DONNELLY PLANT	A
	HAZEL PARK VIKING ARENA	A		LAKE WELDING SUPPLY CO INC	A
	JOHN LINDELL ICE ARENA	A		LEO DIETRICH & SONS	A
	LAKELAND ARENA	A		MEAD JOHNSON AND CO LLC	CH
	MACDERMID INCORPORATED	F		MICHIGAN CELERY PROMOTION	A
	MARBELITE CORPORATION	S		MIEDEMA PRODUCE INC	A
	MATHESON VALLEY	A		POLYPLY COMPOSITES LLC.	S

Table 15, continued...

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

Table 15, continued...

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

^aSource: Michigan Department of Environmental Quality (DEQ). Michigan Facilities' Guide to SARA Title III, Emergency Planning and Release Reporting, December 2007, 6th edition. The chemicals listed in this table are subject to reporting under the Emergency Planning and Community Right-to-Know Act (EPCRA) section 313, which is triggered by threshold amounts of 25,000 pounds manufactured or processed or 10,000 pounds otherwise used at facilities in Michigan. The companies listed in this table were current as of calendar year 2014 from a report generated by the Michigan DEQ on 5-14-15.

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 16 shows how this percentage varied by age, gender, race, annual income and education. Among those individuals who responded their asthma was caused or made worse by work, only 22% had a discussion about work's effect on their asthma with their health care provider.¹ At minimum, the data suggest that providers are not addressing concerns of their patients and probably missing the identification of WRA triggers.

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

On average, 135 new people each year have been reported to the Michigan Department of Licensing and Regulatory Affairs (LARA) with confirmed WRA. In recent years, the number of reports has decreased. Eighty reports were confirmed in 2012, the most recent year with complete data. The number of individuals with exposure to a known occupational sensitizer (disease category OA) shows a downward trend since the 1990s. The reason for this trend is unknown and may be related to changes in reporting sources or to the success of workplaces in better controlling their employees' exposures to known sensitizers.

Based on responses from the 2005 BRFSS random

sample of Michigan residents, we estimate that up to 62,000 (95% CI 42,000—83,000) Michigan adults have their asthma caused or aggravated by work.¹ Based on the medical literature we would estimate that there are 97,500 Michigan adults with WRA.⁶ Using capture-recapture analysis, we estimate 228—801 adults in Michigan develop WRA each year.⁹

Workers are generally young to middle-age Caucasian men and women, with the greatest number being reported from the Detroit metropolitan area. However, the rate of WRA in African Americans is 1.5 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, especially in light of reduced production schedules, more temporary workers are being hired on an as-needed basis. The transient nature of temporary work underscores the potential for under-counting of cases of WRA when employees move from job to job, especially those jobs that have a high potential for exposure to sensitizing agents.

Individuals in the Michigan workforce tend to 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 isocyanates (12.2%), cleaning products (12.0%) and metal working fluids (9.6%). Until recently, metal working fluids were the second most frequently reported exposure at work.

The trend of fewer individuals with the known causes of WRA such as diisocyanates, 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 lack of change in cases secondary to office and manufacturing exposures, and the increase in WRA secondary to cleaning agents suggests that exposures in these situations have proven more difficult to control (Figure 3).

We updated the table first presented in the 2002 Work-Related Asthma Annual Report (Table 14) on the number of manufacturing workers in companies that use isocyanates. In Dickinson, Luce and Midland counties, approximately 5% of the work force is employed in facilities where isocyanates are used. Health care providers can use this information to heighten their awareness of potential exposures to isocyanates among their patients with asthma.

Table 15 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 (Table 9). Studies show that the sooner an individual is removed from the exposure after symptoms develop, the more likely the individual's symptoms will resolve.¹⁰ On the average, among the 2,150 individuals who are no longer exposed to the causal agent, almost three years elapse from onset of respiratory symptoms at work to date last exposed. We do not have data on how much of this delay is secondary to the individual not seeking medical care and how much is related to the physician not recommending that the individual leave the exposure.

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

TABLE 16

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

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



Personal habits like cigarette smoking and individual susceptibility measured through personal or family history of allergies do not predict who develops WRA. About 50% of the WRA patients identified through the Michigan Tracking System have no personal or family history of allergies and 80% are not smoking cigarettes at the time their asthma symptoms develop (Tables 6,7).

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 1,588 fellow workers with symptoms compatible with WRA (Table 13). Five hundred eighty-three individuals were listed on the MIOSHA Injury and Illness Log (Form 300) as having WRA or symptoms compatible with WRA. There was only an overlap of 10 individuals of co-workers reporting symptoms on co-worker interviews and those being reported on the MIOSHA Log. Part of the reason for the lack of overlap is that half of the symptomatic individuals indicate they have never seen a doctor for their respiratory symptoms.

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

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

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

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

The report of a patient with known or suspected WRA is a sentinel health event that is critical to effective occupational disease surveillance. Case reporting from physicians offers the opportunity for the most timely workplace interventions, compared to receiving reports from hospitals. With continued support and increasing awareness of WRA by physicians and other health professionals, we can continue to provide timely intervention in the workplace, offer suggestions for reducing workplace exposures even if they are below the current permissible exposure limits, document the need for the development of new standards, identify new occupational allergens, and prevent co-workers from developing disease.

The potential that 54% of Michigan adults with asthma report that work causes or aggravates their work-related asthma must be integrated into all asthma initiatives planned on surveillance and education, both for health care providers and the public.

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APPENDIX

2014 PATIENT NARRATIVES BY TYPE OF INDUSTRY & EXPOSURE

Abbreviations:

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

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

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MANUFACTURING

EXPOSURE TO ISOCYANATES

OA3502. A male operations maintenance technician at a wood panel manufacturing mill developed work-related asthma in his 40s after working at the facility for over 15 years. He was exposed to isocyanates, as well as phenol formaldehyde and wood dust. He experienced wheezing, a cough, shortness of breath and chest tightness which became worse during his work shift and got better on weekends and vacations. He was prescribed Advair, Singulair, Zyrtec, Ventolin, Dulera, DuoNeb and Proventil. On spirometry, his FVC was 86% of predicted, FEV₁ was 78% of predicted, and his FEV₁/FVC was 91% of predicted. Pre- and post-bronchodilation showed a significant $\geq 12\%$ improvement in FEV₁. He continued to work at the plant an additional 10 years after his asthma developed, until he was placed on disability leave. Since that time, his asthma improved although he required the same amount of asthma medication. He smoked a cigarette a day in his mid-teens to his mid-20s.

OA3544. A male in his 50s developed asthma shortly after starting work as a machinist at an automotive parts manufacturing facility. He was exposed to methylene diisocyanate (MDI) when there was a leak in his department. He became short of breath and was treated in an emergency department. He was prescribed Albuterol. Since that time, he continued to work at the facility. His asthma worsened and his asthma medication usage increased. He was a life-long non-smoker.

OA3547. A male foam sprayer at a company that made stainless steel food service equipment developed work-related asthma in his 30s from exposure to isocyanates. He worked at the company for almost 20 years before he was moved to the foam sprayer job; within a few weeks he developed wheezing, chest tightness, a cough and shortness of breath. He was prescribed Albuterol and Prednisone. On spirometry, his FVC was 72% of predicted, FEV₁ was 80% of predicted, and his FEV₁/FVC was 112% of predicted. He continued to do this job for almost 10 years before he was awarded workers' compensation. Since that time, his asthma worsened and he required a greater amount of asthma medication. He was a life-long non-smoker.

EXPOSURE TO METAL WORKING FLUIDS

OA3596. A male developed work-related asthma in his 30s shortly after starting to work as a machine operator at an auto manufacturing facility. He was exposed to metal-working fluid. He developed a cough and shortness of breath and sought treatment at an emergency department. He was prescribed Qvar, Singulair, Claritin and Albuterol. On spirometry, his FVC was 110% of predicted, FEV₁ was 94% of predicted, and his FEV₁/FVC was 86% of predicted. His peak flow meter results were consistent with work-related asthma. Almost half a year since his diagnosis, he continued to work at this job, his asthma worsened and he required a greater amount of asthma medication. He smoked cigarettes since his mid-teens, and cut down from a pack a day to four cigarettes per day.

EXPOSURE TO WELDING & SOLDERING FUME

AA3539. A male in his 40s experienced an exacerbation of his pre-existing asthma at his job at an auto manufacturer. His job was a paint line repairer. He was exposed to welding fume when an outside contractor assigned repair welders to the area near where he was assigned. After the welding work was completed, he no longer experienced any asthma exacerbations. He was a lifelong non-smoker.

AA3527. A male in his 50s experienced an exacerbation of his pre-existing asthma while working as a welder at a metal plate manufacturer. He was exposed to mig welding fume from his welding duties and also paint fume from nearby ovens where parts were cured. He worked at this job for over 30 years before he finally quit because of his lung problems. Since then, his asthma improved and he required less asthma medication. He smoked approximately five cigarettes a day since his mid-30s.

POA3501. A female in her 50s developed work-related asthma after working for an auto parts manufacturing company. She was a die maker for over 20 years, and was exposed to welding fume as well as factory dust in the metrology lab from the filters not being changed out often enough. She was prescribed Albuterol by the company physician. She continued to work at the company in her same job.

OA3554. A female developed work-related asthma in her 30s, just two years after beginning to work as a MIG welder at an auto parts manufacturer. She developed a cough, wheezing, chest tightness and shortness of breath. She was prescribed Ventolin, Advair, Proventil and Qvar. She made numerous trips to the emergency department and was hospitalized twice for her asthma. She continued to work at the facility for six years, until she was fired because of her attendance record, which was poor due to her asthma. Her asthma improved after she was fired and she no longer performed welding, although she still required the same amount of asthma medication. Since her late teens, on average, she smoked a pack of cigarettes a day.

EXPOSURE TO MISCELLANEOUS CHEMICALS AND DUSTS

POA3603. A female developed work-related asthma in her 40s after working for two years at an auto manufacturing plant. She was exposed to a product sprayed on the weather stripping of the automobiles, which contained triethanolamine. She developed a cough, wheezing, shortness of breath and chest tightness and was prescribed Symbicort, Singulair, Albuterol and Allegra. She continued to work at the facility. Her symptoms and asthma medication requirements remained unchanged. She smoked a pack of cigarettes a day.

AA3579. A male in his 20s experienced an exacerbation of his pre-existing asthma shortly after he began working at an auto manufacturing facility in the parts packing department. The dust from the cardboard boxes and general work area triggered his asthma.

POA3494. A female hired through a temporary employment agency developed work-related asthma in her 20s after working at an automotive plastic injection molded parts manufacturer. She was a machine operator. She experienced a worsening cough, wheeze, shortness of breath and chest tightness shortly after starting to work at the facility. She was treated at the emergency department twice in two days, prescribed Prednisone and ProAir, and took her doctor's advice to quit this job. Since leaving that job, her asthma improved although she still occasionally experienced wheezing and chest tightness. She was able to discontinue taking her asthma medication. She smoked about five cigarettes a day since her early 20s. She subsequently found other employment in a retail setting.

POA3477. A female developed work-related asthma in her 40s after working at an automotive parts manufacturing facili-

ty. She had been working as a sander/finisher/painter for about one year before she developed wheezing, a cough, shortness of breath and chest tightness. She continued to work in this environment and about five years after her asthma symptoms began, she was prescribed Symbicort, Albuterol, Spiriva and Singulair. On spirometry, her FVC was 92% of predicted, FEV₁ was 33% of predicted, and her FEV₁/FVC was 29% of predicted. Pre- and post-bronchodilation showed a significant $\geq 12\%$ improvement in FEV₁. Five years since being prescribed asthma medication, she continued to work at the facility, her asthma worsened and she required a greater amount of asthma medication. She smoked a couple cigarettes a day since her late 20s.

POA3529. A female developed work-related asthma in her 40s after over 15 years at a plastic automotive parts manufacturer. She was exposed to smoke from heated vinyl chloride and isocyanates in foam. She developed shortness of breath, a cough, wheezing and chest tightness. She was prescribed Advair and Ventolin. Shortly after her asthma developed, she went on medical leave. Since that time, her asthma symptoms and asthma medication use remained unchanged. She smoked a half a pack of cigarettes a day since her mid-teens.

AA3522. A male in his 20s experienced an exacerbation of his pre-existing asthma at his job at a plastic sheet extrusion facility. He was exposed to styrene and polyolefin, which immediately triggered chest tightness and shortness of breath. He was treated at an emergency department. He smoked cigarettes.

POA3576. A male in his 20s developed work-related asthma at a grey iron foundry where he continued to work for over 40 years. He was exposed to an unknown chemical after which he developed shortness of breath. He was prescribed Symbicort, Ventolin and Prednisone. On spirometry, his FVC was 43% of predicted, FEV₁ was 18% of predicted, and his FEV₁/FVC was 43% of predicted. His asthma symptoms remained unchanged and he still required asthma medication. He smoked two packs of cigarettes per day from his late teens until his mid-50s.

POA3597. A male developed work-related asthma in his 20s while spraying glue on automotive panels. He was prescribed Advair and Qvar. The company went out of business, but he was able to find employment elsewhere, and worked for 30 years. He was a life-long non-smoker.

AA3553. A female in her 20s experienced an exacerbation of her pre-existing asthma from exposure to acetone. She worked at a furniture manufacturer. The acetone, which she used to clean the furniture surfaces, triggered wheezing and chest tightness. She sought treatment at an emergency department where she was administered Albuterol, Atrovent and Prednisone. She was a life-long non-smoker.

AA3551. A female in her 50s experienced an exacerbation of her pre-existing asthma at her job at a tool and die shop for the automotive industry. Dusts, chemicals, and epoxy triggered her asthma. On spirometry, her FVC was 77% of predicted, FEV₁ was 77% of predicted, and her FEV₁/FVC was 103% of predicted. Pre- and post-bronchodilation showed a significant $\geq 12\%$ improvement in FEV₁. After she stopped working at the shop, her asthma remained unchanged and she required a greater amount of asthma medication. Her prescriptions included Xopenex, Xolair, Symbicort and Singulair. She smoked a pack of cigarettes a day from her early teens until her 40s.

POA3484. A female developed work-related asthma in her 40s after working for a wood products manufacturer for over 10 years. She was exposed to a new type of glue that caused her to have chest tightness and shortness of breath, despite wearing a respirator. She was prescribed Albuterol. She continued to work at the company for several months until she was awarded workers' compensation. Since leaving the job, her asthma improved and she required less asthma medication. She smoked approximately five cigarettes per day since her late teens.

POA3591. A female developed work-related asthma in her 30s less than a year after beginning to work at a plastic injection mold manufacturing company. She worked at the facility through a temporary employment agency. She developed wheezing, chest tightness and shortness of breath, and was prescribed Singulair, Ventolin, Prednisone and Qvar. She eventually was fired from this job, for leaving work when she had asthma symptoms. She smoked a half a pack of cigarettes a day.

AA3566. A male in his 20s experienced an aggravation of his pre-existing asthma when he began working at a chemical production plant. His job was to package calcium chloride for shipment. The exposure triggered a cough, chest tightness and shortness of breath. He was treated in an emergency department and prescribed Albuterol; he had not required asthma medication for two years prior to this. He continued to work at the facility. He smoked a pack of cigarettes a day.

POA3543. A female developed work-related asthma in her 60s. She worked at an automotive assembly facility for seven years with exposure to fiberglass. She developed a cough, chest tightness and shortness of breath. She was treated at an emergency department and prescribed Advair, Albuterol, Atrovent and Prednisone. Her asthma symptoms became worse during the shift when she worked, were worse on her first day back to work, got better when she was away from work on weekends or vacations and got worse throughout the work week. She continued to work for over a year after her diagnosis before she quit because of her asthma. Since then, her asthma worsened and she required a greater amount of asthma medicine. She smoked an average of three cigarettes a day since her mid-teens.

EDUCATIONAL SERVICES

EXPOSURE TO CLEANING PRODUCTS

OA3568. A female developed work-related asthma in her 50s, after working as a janitor at a university for six years. She developed wheezing, a cough and shortness of breath shortly after using a disinfectant that contained quaternary amines. She was treated at an emergency department and prescribed Albuterol, Duo-Neb and Prednisone. Since that incident, she continued to work at the university but was restricted from using the disinfectant that caused her asthma. Her asthma symptoms improved and she required less asthma medication. She smoked about a half a pack of cigarettes a day.

EXPOSURE TO INDOOR AIR CONTAMINANTS

AA3559. A female teacher in her 60s experienced an exacerbation of her pre-existing asthma when she was exposed to dust from cement related to renovations at the school. She was immediately bothered by wheezing, a cough, chest tightness and shortness of breath, and was treated at an emergency department. She was prescribed an Albuterol inhaler, Symbicort and Prednisone. Since that exposure, her asthma improved although she required a greater amount of asthma medication. She was a life-long non-smoker.

AA3560. A female in her 50s experienced an exacerbation of her pre-existing asthma while working as a secretary at a university. Exposure to fumes from cooking grilled items in a kitchen nearby her work station triggered wheezing, a cough and shortness of breath. She continued to work at this job. She smoked between a quarter to a half a pack of cigarettes a day for about five years in her early 20s.

EXPOSURE TO ANIMAL DANDER

OA3520. A male in his 20s developed work-related asthma after working with rats in a university lab for two years. He developed wheezing and a cough while handling the rats; approximately three months later he sought treatment in an emergency department where he was prescribed Qvar and Albuterol. On spirometry, his FVC was 86% of predicted and his FEV₁ was 77% of predicted. His peak flow meter results were consistent with work-related asthma. He continued to work in the lab and his asthma symptoms and asthma medication use remained unchanged. He was a life-long non-smoker.

OA3469. A female developed work-related asthma in her 20s from exposure to mouse dander. She worked in a research lab at a university. She developed wheezing, a cough, shortness of breath and chest tightness, which improved when she was away from work on weekends or vacations. She was prescribed Singulair and Albuterol. She was able to work in a different research lab which did not have mice. Since then, her asthma improved and she required less asthma medication. She was a life-long non-smoker.

HEALTH CARE SERVICES

EXPOSURE TO CLEANING PRODUCTS

AA3488. A female in her 30s experienced an exacerbation of her pre-existing asthma when she was exposed to the fumes from floor strippers and floor wax at the hospital where she worked. She experienced coughing and wheezing and was treated with Albuterol in the hospital's emergency department. She was a lifelong non-smoker.

AA3492. A female in her 50s experienced an exacerbation of her pre-existing asthma when she was exposed to cleaning agents in a group home for mentally disabled adults where she was a direct care worker. A co-worker was boiling the cleaning agent in the kitchen as an air freshener. The fumes triggered her cough, shortness of breath, wheezing and chest tightness. She continued to work at the group home. She smoked a half a pack of cigarettes a day for less than five years in her teens.

AA3583. A male in his 20s experienced an exacerbation of his pre-existing asthma from exposure to cleaning agents at his job. He was a direct care staff member at an adult foster care home. He was exposed to a cloud of fumes from an unintentional mixture of a quaternary amine-based bathroom cleaner with a bleach-based toilet cleaner for almost an hour. The exposure triggered a cough, shortness of breath and chest tightness.

OA3548. A female nurse in her 40s who worked at a skilled care nursing home developed work-related asthma from exposure to floor and carpet cleaning products that contained quaternary amines. Within a month of beginning work at the nursing home, she developed wheezing, a cough, shortness of breath and chest tightness. She was treated at an emergency department where she was prescribed Albuterol. She continued to work at the nursing home for a couple more months, but then quit because of her respiratory symptoms after four additional trips to the emergency department. The nursing home continued to use the same cleaning products. Since leaving this job, her asthma remained unchanged and she required the same amount of asthma medication. She was a life-long non-smoker.

AA3565. A female in her 40s experienced an aggravation of her pre-existing asthma at the assisted living nursing home where she was a housekeeper/cleaner. She mixed toilet bowl cleaner and bleach, which required treatment in the emergency department. She smoked a half a pack of cigarettes a day since her early 30s.

EXPOSURE TO INDOOR AIR CONTAMINANTS AND MISCELLANEOUS CHEMICALS AND DUSTS

RADS3507. A female surgical nurse in her 30s developed Reactive Airways Dysfunction Syndrome (RADS) from exposure to an incorrect mixture of floor stripping chemicals. She worked at the hospital for approximately two years before this incident. When the exposure occurred, she immediately experienced a cough, wheezing, chest tightness and shortness of breath. She was treated at the hospital's emergency department and prescribed Flovent and Albuterol. On spirometry, her FVC was 100% of predicted, FEV₁ was 92% of predicted, and her FEV₁/FVC was 93% of predicted. Pre- and post-bronchodilation showed a significant $\geq 12\%$ improvement in FEV₁. A year later she was prescribed Singulair and Xopenex, and three years later Xolair shots and Dulera were added to her treatment. After the initial exposure, many irritants aggravated her asthma, including scented products such as perfume on coworkers or patients, paint fumes, cold air and cleaning chemicals. She continued to work at the hospital, despite a worsening of her asthma and requiring a greater amount of asthma medication. She smoked a half a pack of cigarettes per day for over 15 years but quit when she developed RADS.

WHOLESALE & RETAIL SERVICES

EXPOSURE TO ANIMAL DANDER

OA3530. A female developed work-related asthma in her 20s after working at a pet and feed store for three years. Exposure to guinea pig and rat dander caused her to experience wheezing and shortness of breath. She was prescribed Albuterol. She continued to have exposure to rat and mice dander in a new job at a university as a research animal caretaker. She began wearing a respirator when handling the rats and mice. Her asthma worsened although she required the same amount of asthma medication. She was a life-long non-smoker.

EXPOSURE TO INDOOR AIR CONTAMINANTS AND MISCELLANEOUS CHEMICALS AND DUSTS

AA3540. A female office worker in her 50s experienced an exacerbation of her pre-existing asthma when she was exposed to lingering fumes from a fire that had taken place earlier in the day, at the wholesale florist building where she worked. She was taken to the emergency department in an ambulance. Shortly after the building fire, the company was sold and she lost her job. Since that time her asthma improved and she required less asthma medication. She was a life-long non-smoker.

POA3470. A female sales floor associate at a large retail store developed work-related asthma in her 50s from exposure to fertilizers sold in the gardening section of the store. She worked for the store almost 20 years. She developed shortness of breath and was prescribed Albuterol, a nebulizer and Pulmicort. She continued to work at the store, and her asthma and asthma medication usage remained unchanged. She smoked a pack and a half of cigarettes a day since her mid-teens.

AA3518. A female in her 50s experienced an exacerbation of her pre-existing asthma at her job at a bridal wear shop. The chemicals used to clean the dresses and shoes, as well as air fresheners, mold and dust in the shop triggered her asthma symptoms, including a cough, wheezing, chest tightness and shortness of breath. She quit this job after a year because of her breathing problems. Since that time, her asthma improved and she no longer required asthma medication. She smoked one cigarette a day for 10 years from her early 20s to her early 30s.

OFFICE/INDOOR AIR

EXPOSURE TO INDOOR AIR CONTAMINANTS

POA3476. A female medical record reviewer developed work-related asthma in her 50s, a couple of years after beginning to work for a health insurance company. She developed wheezing and shortness of breath and was prescribed Pulmicort and Albuterol. On spirometry, her FVC was 79% of predicted, FEV₁ was 79% of predicted, and her FEV₁/FVC was 102% of predicted. She had a positive methacholine challenge test result. She described the office setting where she worked as having poor air quality and possibly mold. After she was diagnosed, she continued to work for the company, from her home. Her asthma symptoms improved although she required the same amount of asthma medication. She smoked a half a pack of cigarettes a day for a couple years in her late teens.

POA3525. A female in her 40s developed work-related asthma while performing office work. She developed wheezing, a cough, chest tightness and shortness of breath after working for two years at this job. She was prescribed Singulair, Advair and Albuterol. On spirometry, her FVC was 75% of predicted and her FEV₁ was 78% of predicted. Her peak flow meter results were consistent with work-related asthma. She described the office environment as having poor indoor air quality, including mold. Since her diagnosis, she worked mainly from home, and limited working in the office to one day a week. Her asthma improved although she still required the same amount of asthma medication. She was a life-long non-smoker.

POA3535. A female developed work-related asthma in her 50s while working in an office that vented dust and fumes from delivery trucks in the parking lot into her work area. She worked at the company for 10 years when she developed wheezing, a cough, shortness of breath and chest tightness and was prescribed Atrovent. She continued to work at this job. Her asthma worsened and she required a greater amount of asthma medication. She smoked a pack of cigarettes a day for eight years from her late teens till her mid-20s.

AA3584. A female in her 40s experienced an exacerbation of her pre-existing asthma in her office job. Exposure to cleaning agents including aerosols, dirt and dust, and burnt food triggered wheezing, a cough, chest tightness and shortness of breath. She was prescribed Advair, Singulair, ProAir and Prednisone, during one of several visits to the emergency department from these workplace exposures. She continued to work in this environment for three years until she was awarded workers' compensation. Since then, her asthma improved and she required less asthma medication. She was a life-long non-smoker.

POA3504. A female evidence custodian at a police warehouse developed work-related asthma in her 50s. She worked in a warehouse that had a history of water leaks and mold. She developed wheezing, a cough, and shortness of breath. She was treated at an emergency department and prescribed a nebulizer with Duo-Neb, Flovent, Singulair and Ventolin. About six months later she was awarded workers' compensation. Since that time her asthma improved and she required less asthma medication. She was a life-long non-smoker.

FARMING/AGRICULTURE

EXPOSURE TO CLEANING PRODUCTS

AA3523. A female in her 40s experienced an exacerbation of her pre-existing asthma in her job at a tree fruit farm. She was exposed to bleach, which was used to clean the fruit. The bleach triggered wheezing, and she sought treatment at an emergency department where she was prescribed Albuterol, Benadryl, Flonase and Prednisone. She was a life-long non-smoker.

EXPOSURE TO PLANT DUST

AA3567. A male in his 50s experienced an exacerbation of his pre-existing childhood asthma while working in a corn field for a large agricultural crop production farm. He experienced wheezing, chest tightness, shortness of breath and a cough. He did not work in the corn fields after this incident. He was a life-long non-smoker.

MISCELLANEOUS SERVICES & INDUSTRIES

EXPOSURE TO CLEANING PRODUCTS

AA3577. A female in her 50s experienced periodic exacerbations of her pre-existing asthma with exposure to certain

cleaning agents. She worked for a housekeeping company cleaning bathrooms at various businesses. A sprayed disinfectant triggered her asthma. She quit this job because the cleaning agents triggered her asthma. Since then, her asthma improved and she required less asthma medication. She smoked an average of five cigarettes a day since her late teens.

AA3524. A female waitress in her late teens experienced an exacerbation of her childhood asthma. She was exposed to cleaning agents including bleach when she cleaned the tables at the restaurant. She quit her job but continued to be exposed to cleaning agents outside of the workplace, including those used in her home. She smoked half a pack of cigarettes a day since her early teens.

AA3564. A female in her 40s experienced an aggravation of her pre-existing asthma while working at a hotel. Her duties included setting up and maintaining the breakfast bar, cleaning the hotel's swimming pool, and cleaning the lobby bathroom. The bleach-based cleaning products caused her to wheeze, cough, have chest tightness, and shortness of breath. She was treated in the emergency department where she was prescribed Advair and Spiriva. On spirometry, her FVC was 79% of predicted, FEV₁ was 53% of predicted, and her FEV₁/FVC was 66% of predicted. Pre- and post-bronchodilation showed a significant $\geq 12\%$ improvement in FEV₁. She continued to work at the hotel; her asthma worsened and she required a greater amount of asthma medication. She smoked a half a pack of cigarettes a day since her late teens.

OA3503. A female lifeguard in her 20s developed work-related asthma about a year after beginning to work at a health club. Part of her duties were to mop the pool deck. She used a product containing quaternary amines for this task. She developed a cough, wheezing, shortness of breath and chest tightness and was prescribed Albuterol and Flovent. Shortly after her diagnosis, she quit this job because of her asthma. Since then her asthma symptoms improved and she no longer required asthma medication. She was a life-long non-smoker.

EXPOSURE TO MISCELLANEOUS CHEMICALS AND DUSTS

OA3526. A female black jack dealer developed work-related asthma in her 60s after working for over 10 years at a casino. She was exposed to ozone that was supplied by an ozone generator at the casino. She experienced a cough and shortness of breath and was prescribed Symbicort and Albuterol. On spirometry, her FVC was 80% of predicted, FEV₁ was 71% of predicted, and her FEV₁/FVC was 89% of predicted. Pre- and post- bronchodilation showed a significant 12% improvement in FEV₁, and her peak flow meter results were consistent with work-related asthma. She continued to work at the casino, and her symptoms and medication use remained the same. She was a life-long non-smoker.

POA3561. A male developed asthma in his 50s after working as a janitor at a movie theater for several years. He experienced a cough, shortness of breath, wheezing and chest tightness when oil-based paint was used in the bathrooms of the theater. He went to the emergency room and was prescribed Prednisone, Brovana, Singulair, Dulera, Methylprednisolone, Spiriva, ProAir and Albuterol. On spirometry, his FVC was 63% of predicted, FEV₁ was 68% of predicted, and his FEV₁/FVC was 108% of predicted. He continued to work at the theater, his asthma remained the same and he required the same amount of asthma medication. Since his diagnosis, he visited the emergency department six times, and was hospitalized 10 times. He smoked a pack of cigarettes a day from his late teens until his early 20s.

RADS3517. A male developed RADS in his 30s while working as a superintendent on a machine repair job at a steel making plant. He had worked for the equipment repair company for five years before the exposures at this particular job caused his asthma. He was exposed to a spill of two five-gallon drums of an unknown chemical. He developed wheezing, a cough and shortness of breath. He was treated in the emergency department and prescribed Albuterol, Singulair, Combivent, Theophylline and Symbicort. On spirometry, his FVC was 83% of predicted, FEV₁ was 34% of predicted, and his FEV₁/FVC was 41% of predicted. Pre- and post-bronchodilation showed a significant $\geq 12\%$ improvement in FEV₁. Several years after the incident, he was awarded workers' compensation. Almost 20 years later, his asthma remained unchanged and he required a greater amount of asthma medication. He had approximately 150 trips to the emergency department and was hospitalized 10 times. He smoked a couple cigarettes a day for 12 years, but quit in his mid-30s.

AA3486. A male in his 20s experienced an exacerbation of his pre-existing asthma while cleaning out moldy grain from a food production plant. He worked for a company that performed industrial cleaning services. The exposure to the moldy grain triggered wheezing, chest tightness, a cough and shortness of breath within 24 hours. After this incident he quit this job because of his lung problems. Since that time, his asthma improved and he no longer required asthma medication. He was able to find a new job as a truck driver. He was a life-long non-smoker.

POA3478. A female developed work-related asthma in her 50s while working for an industrial janitorial service/

mechanical maintenance company; she was assigned as a tool keeper at a nuclear power plant. She worked near an area where cleaning agents were being used, and developed wheezing, chest tightness and shortness of breath. She was treated in an emergency department and prescribed Albuterol, Qvar and Prednisone. She had worked in this occupation for almost 20 years before her asthma developed. Since the exposure to cleaning agents, she stopped working at the power plant and was reassigned to a hospital. Her asthma symptoms improved and she required less asthma medication. She smoked about a half a pack of cigarettes a day from her early 20s to her late 40s.

OA3508. A female hair salon manager in her 30s developed work-related asthma from exposure to hair dyes and bleaches. She did this job for almost 15 years prior to her diagnosis of asthma. The majority of her time was spent doing haircuts and coloring. She developed a cough, chest tightness, shortness of breath and wheezing. She was treated in an emergency department where she was prescribed Dulera and Ventolin. On spirometry, her FVC was 126% of predicted and her FEV₁ was 111% of predicted. She had a positive methacholine challenge test, and her peak flow meter results were consistent with work-related asthma. Since her diagnosis she continued to work at the salon, and her asthma symptoms and asthma medication remained unchanged. She smoked a half a pack of cigarettes a day for almost 15 years from her mid-teens to her late 20s.

OA3509. A female hair salon manager in her 50s developed work-related asthma from exposure to hair dyes and solutions used for perms, as well as hair spray. She did this job for over 10 years before she developed wheezing, a cough, chest tightness and shortness of breath. She was initially prescribed Ventolin. A couple years later, when she was hospitalized twice for her asthma, she was additionally prescribed Symbicort and placed on oxygen. After the hospitalizations, she quit this job because of her work-related asthma. Since then, her asthma improved although she required the same amount of asthma medication. She smoked 15 cigarettes a day for almost 30 years, but quit in her early 50s, about five years before her asthma developed.

POA3468. A female developed work-related asthma in her 30s while working in a correctional facility. She supervised the inmates in the kitchen when they cooked and served meals. After renovations in the kitchen area produced construction dust and paint fume, she developed wheezing, chest tightness and shortness of breath. She was treated in an emergency department and prescribed Singulair, Qvar, Atrovent and Ventolin. On spirometry, her FVC was 79% of predicted, FEV₁ was 78% of predicted, and her FEV₁/FVC was 99% of predicted. Once the renovations were completed, her asthma improved and she required less asthma medication. She was a life-long non-smoker.

AA3505. A female in her 60s experienced an exacerbation of her pre-existing asthma at her job as an inspector at a dry cleaning company. A fire at the facility triggered wheezing and shortness of breath. On spirometry, her FVC was 76% of predicted and her FEV₁ was 74% of predicted. Since that time, she went on disability leave because of her asthma. Her asthma symptoms and asthma medication use remained the same. She smoked a pack of cigarettes a day for over 20 years from her 30s until her early 50s.

CONSTRUCTION

EXPOSURE TO ISOCYANATES

OA3546. A male in his 40s developed work-related asthma from exposure to isocyanates in his job where he sprayed foam insulation. The first month he began doing this job, he experienced shortness of breath. Two years later, he developed chest tightness, and the year following that he developed wheezing. He was prescribed Prednisone, Dulera and Albuterol. On spirometry, his FVC was 91% of predicted, FEV₁ was 84% of predicted, and his FEV₁/FVC was 92% of predicted. Pre- and post-bronchodilation showed a significant $\geq 12\%$ improvement in FEV₁. He described applying the foam in crawl spaces of residential homes. He continued to perform this job; he began wearing a protective suit, a mask with an organic filter, and gloves. His asthma symptoms improved and he no longer required asthma medication. He smoked cigarettes for 30 years but quit when his first asthma symptoms began.

EXPOSURE TO MISCELLANEOUS CHEMICALS AND DUSTS

AA3521. A male in his 20s experienced an exacerbation of his pre-existing asthma while working for a heating and cooling company. He used a chemical to flush out an air conditioner. He experienced chest tightness and shortness of breath, and was treated in the emergency department where he was prescribed Albuterol. He was a life-long non-smoker.