2010
Annual Report on
Carbon Monoxide Poisoning
In Michigan

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2010 ANNUAL REPORT ON CARBON MONOXIDE POISONING IN MICHIGAN

A Joint Report Of

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SUMMARY

This is the second annual report on carbon monoxide (CO) poisoning surveillance in Michigan. This report provides information about the 986 individuals who were unintentionally poisoned by carbon monoxide in Michigan in 2010, including 26 individuals who died from carbon monoxide exposure. It includes a special focus on work-related carbon monoxide poisonings. It is based on data collected as a result of regulations promulgated September 18, 2007 by the Michigan Department of Community Health (MDCH) to address the health hazards of exposure to carbon monoxide. The State's Public Health Code requires health care facilities and health care professionals to report unintentional carbon monoxide poisoning. MDCH regulations also require laboratories to report carboxyhemoglobin test results. Michigan State University's Department of Medicine, Occupational and Environmental Medicine Division (MSU) administers this reporting for the State.

BACKGROUND

One of the leading causes of unintentional poisoning deaths in the United States is carbon monoxide poisoning.[1] CO is an odorless and colorless gas produced by all forms of combustion including running gasoline, diesel, natural gas or propane powered equipment, coal or oil fired boilers, smoking of tobacco products and fires. The Environmental Protection Agency (EPA) allowable environmental exposure to CO in outdoor ambient air is 9 ppm for an 8 hour average.[2] Workplace standards in Michigan require the CO level be kept below 35 ppm averaged over an eight hour day and a 200 ppm ceiling that should never be exceeded in general industry; for the construction industry, the limit is 50 ppm averaged over an 8 hour work day without a standard for a ceiling level.[3,4]

During combustion, incomplete oxygenation of the carbon atom in the substance being burned produces CO. When inhaled, CO binds to hemoglobin in the blood as well as other proteins in the body such as myoglobin. This binding reduces the delivery of oxygen to organs such as the brain and heart and all other body tissues. When hemoglobin combines with CO, it forms a bright red compound called carboxyhemoglobin (COHb), which can be measured in the blood. All individuals have low levels of COHb in their blood, values less than 1.0%, as a consequence of the normal breakdown of red blood cells. Cigarette smokers average 4.0% COHb, with heavier smokers having higher values. Work for eight hours at the allowable Michigan Occupational Safety and Health Administration (MIOSHA) standard for general industry time weighted average (TWA) of 35 ppm will cause a 5.4% COHb blood level and 7.4% COHb blood level for the construction TWA of 50 ppm.[5] Alarms on home detectors for carbon monoxide generally do not sound until levels of carbon monoxide reach levels that would cause COHb levels of 5-7%.[5] Exposures to different sources of carbon monoxide are additive (e.g., the average cigarette smoker working at the MIOSHA limit would be expected to have 9.4% COHb level).[5] COHb has a half-life in the blood of 4 to 6 hours. With administration of oxygen the half life is reduced to approximately an hour or to less than a half hour when treated with hyperbaric oxygen.[5] In individuals with atherosclerosis, levels as low as 3-4% COHb can increase the frequency and severity of angina or claudication, at a 6% level cardiac arrythmias may be induced, and at a 10% level a myocardial infarction may be precipitated.[5] In individuals without atherosclerosis, levels below 30% can cause headaches, nausea and weakness. Above 30% there will be decreased mental alertness and weakness, and, with increasing levels, coma and death.[5]

The Centers for Disease Control and Prevention (CDC) recently summarized data from the National Poison Data System (NPDS).[6] Findings included that most CO poisonings occurred at home. These poisonings most often involved females as well as adults aged 18-44 years. Carbon monoxide poisoning was most frequent among persons living in the Midwestern or Northeastern states between November and February.

Mandated reporting of diagnostic information on carbon monoxide poisoning from environmental or occupational exposures allows MDCH and its local public health partners to identify and initiate follow-up actions to prevent further morbidity and mortality.

METHODS

This report is mainly based on data reported from the Michigan poison control center, hospitals, and death certificates for the period 1/1/2010 to 12/31/2010. The Michigan Poison Control Center reported all calls where carbon monoxide exposure was the suspected exposures. Calls requesting information that did not involve symptoms were not included. Hospitals were required to report patients who had ICD-9 discharge codes of 986, E868.3, E868.8, E868.9, E982.1 and death certificates where the underlying cause of death was ICD-10 code T58. In addition, an industrial hygienist from the Michigan OSHA program identified a case.

The records received were abstracted into a uniform data system that included, for each individual case report, demographic information (age, gender and race), admission date, discharge date, exposure date, COHb test result, cigarette smoking status, report source, source of CO exposure, treatment (including hyperbaric chamber), and, if occupationally exposed, name and address of employer.

A case of carbon monoxide poisoning was defined as an individual who was treated by a health care provider for symptoms related to unintentional carbon monoxide (CO) exposure and for whom a CO exposure diagnosis was coded or whose cause of death was carbon monoxide poisoning. It did not include cases of CO poisoning due to intentional exposure. It should be noted that individuals were included as cases regardless of laboratory confirmation based on the carboxyhemoglobin result. In many cases the COHb result was not available or the blood specimen from the patient was collected too long after exposure to still be elevated.

For individuals who had multiple reports for the same exposure, records were combined and considered as one case. This was done for individuals who had multiple reports from different reporting sources, (e.g. from HDC, PCC, DC, OD…), as well as multiple entries of the same report source (e.g. transfers between hospitals for treatment with hyperbaric oxygen, and multiple hospital visits due to the same exposure). When names were not provided on PCC reports, records were matched by exposure date, hospital where they were treated, carboxyhemoglobin levels, description of exposure, and age (also birth date if available). A minimum of three matching variables were required in order to match the records. However if one of the other variables had conflicting data, they were left as separate records.

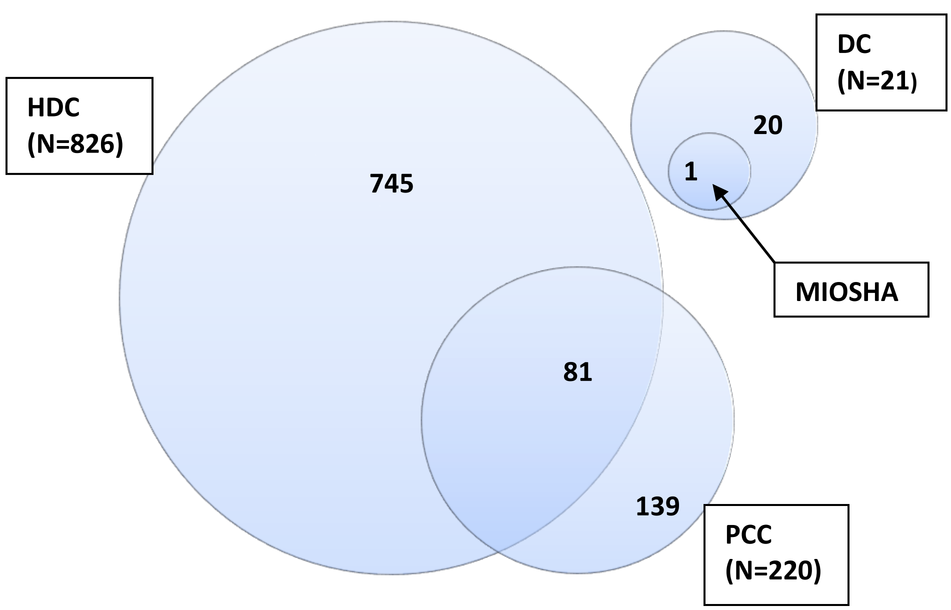
Frequencies and rates of CO poisoning were generated from these data. Denominators used to calculate rates were from the U.S. Census Bureau.[7,8]

Where appropriate, employers of occupationally exposed cases were referred to MIOSHA for follow-up to determine if there was on-going risk of CO exposure. Additional analysis is provided for occupationally exposed cases and results of MIOSHA referrals.

RESULT

A total of 1,113 reports of unintentional carbon monoxide poisoning were received on 986 individuals. One hundred and eighteen of these individuals were poisoned at work.

Figure 1 Overlap of Reporting Sources for 986 CO Poisoning Cases in Michigan, 2010



N's represent the total number of individuals reported by source.
Reporting Source: HDC = Hospital Discharge, DC = Death Certificate, PCC = Poison Control Center, MIOSHA = Michigan OSHA Program.

Seven hundred and forty-five unintentional carbon monoxide poisoning reports were received only from Michigan's 134 hospitals. There were another 139 individuals reported by the PCC only. A smaller number of individuals were identified from death certificates, one of which was also identified by an industrial hygienist for the Michigan OSHA program. The overlap of reporting from all of these sources is diagramed in Figure 1.

Death

There were 26 (2.6%) deaths from unintentional carbon monoxide poisoning. Twenty-one deaths were identified by a death certificate; the other five were reported only by hospital discharge. Fourteen deaths were fire related and 12 were non-fire related. Source of CO was unknown for 4 of the 12 non-fire deaths; three from a vehicle, two from a space heater, one from a furnace, one from an air compressor, and one from a stove.

Gender and Age

Gender was known for 983 individuals, 459 (46.7%) were male, 524 (53.3%) were female (Table 1, Figure 2). Of the 970 individuals where age was known, 183 (18.9%) were 17 years old or younger, 448 (46.2%) were 18 – 44, 234 (24.1%) were 45 – 64, and 105 (10.8%) were 65 or older. Females age 18 – 44 (14.55/100,000) and males age 18 – 44 (11.66/100,000) had the highest incidence rates.

Table 1 Annual Incidence of Unintentional CO Poisoning by Gender and Age, Michigan 2010

	# Male	Michigan Male Population[7]	Male Rate /100,000	# Female	Michigan Female Population	Female Rate /100,000	Unknown Gender	Total
Unknown Age	6			10			0	16
≤ 17 yrs old	91	1,196,646	7.60	90	1,140,326	7.89	2	183
18 - 44 yrs	199	1,706,359	11.66	248	1,704,842	14.55	1	448
45 - 64 yrs	114	1,353,910	8.42	120	1,411,060	8.50	0	234
≥65 yrs	49	589,048	8.32	56	775,383	7.22	0	105
Total	459			524			3	986

Race

Race was known for 480 (48.7%) individuals (Table 2). 359 (74.8%) were Caucasian, 110 (22.9%) were African American, 9 (1.9%) were Hispanic, and two (0.4%) were Native American. African Americans (7.76/100,000) had the highest incidence rate of carbon monoxide poisoning.

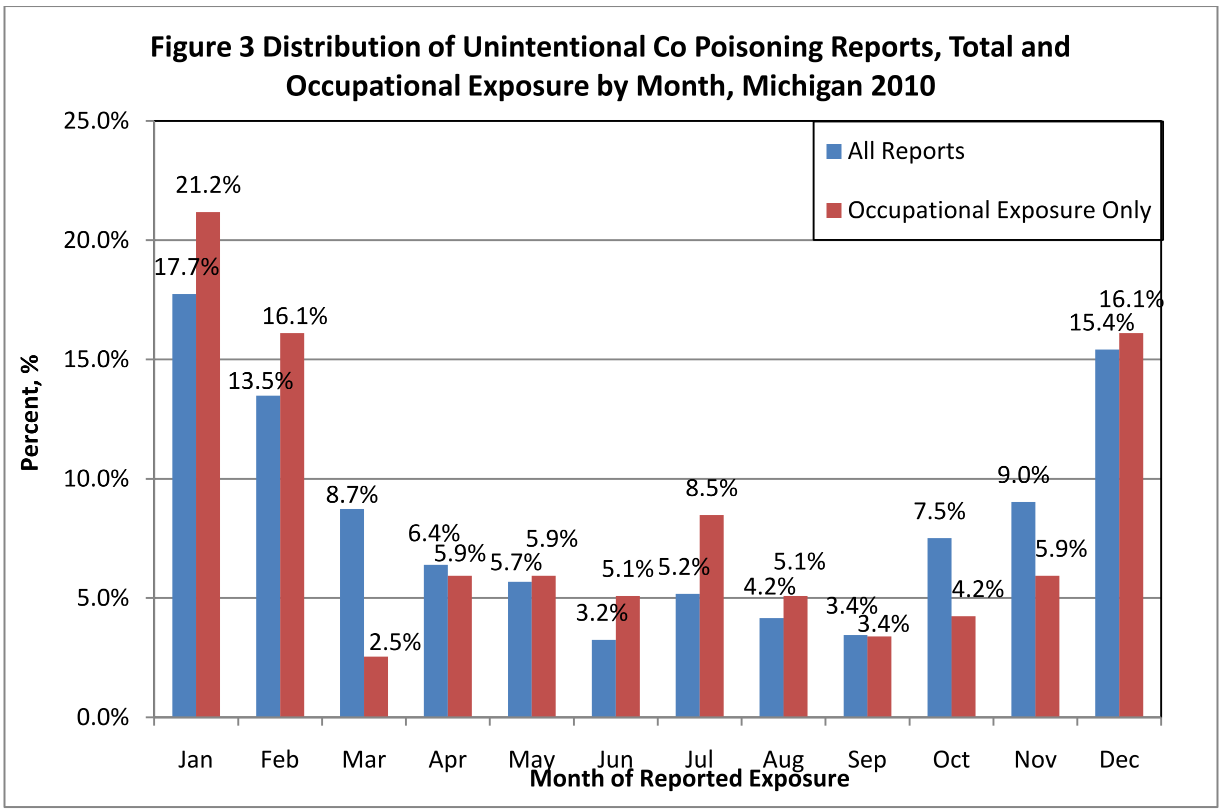
Table 2 Distribution and Incidence Rates of Unintentional CO Poisoning by Race, Michigan 2010

Race	Michigan Population[8]	# Cases	Rate/100,000
White	7,940,400	359	4.521
African American	1,417,247	110	7.762
Asian	244,017	0	0.000
Hispanic	438,551	9	2.052
Native Am	68,523	2	2.919
Multi	203,918	0	0.000

Table 3 Unintentional CO Poisoning Reports by Month, Michigan 2010		
Month	# Reports	Percent (%)
January	175	17.7
February	133	13.5
March	86	8.7
April	63	6.4
May	56	5.7
June	32	3.2
July	51	5.2
August	41	4.2
September	34	3.4
October	74	7.5
November	89	9.0
December	152	15.4
Total	986	100.0

Month of Poisoning

Month of exposure was known for 986 individuals (Table 3 and Figure 3). The most common month for exposure occurred in January, 175 (17.7%), and in the other winter months. The lowest numbers were in the spring and summer months, June being the lowest with 32 individuals (3.2%).



Carboxyhemoglobin Testing

Carboxyhemoglobin level (COHb) was known for 804 (81.5%) of the 986 individuals. The average COHb level for all individuals tested was 10.7%. The range was 0.0% to 74.0% of COHb. Two hundred ninety three (36.6%) individuals had a COHb level greater than 10.0% and 133 (16.2%) individuals had a COHb level greater than 20.0%. Smoking status was known for 652

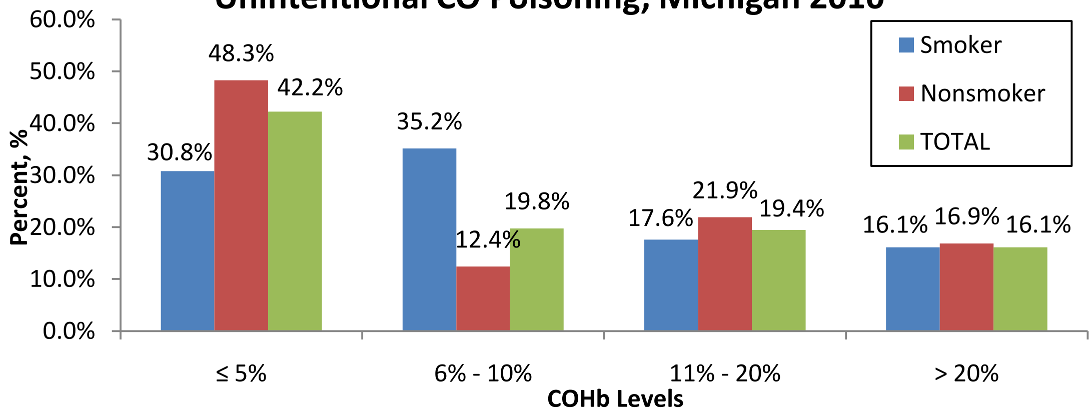
(79.1%) of the 824 individuals tested for COHb, and 702 (71.2%) of all 986 individuals. The distribution of COHb levels by smoking status is shown in Table 4 and Figure 4.

Table 4 COHb Levels by Smoking Status for Unintentional CO Poisoning, Michigan, 2010

	Smoker	Percent (%)	Nonsmoker	Percent (%)	Unknown	TOTAL	Percent (%)
Unknown level	1	0.4	2	0.5	17	20	2.4
≤ 5%	84	30.8	183	48.3	81	348	42.2
6% - 10%	96	35.2	47	12.4	20	163	19.8
11% - 20%	48	17.6	83	21.9	29	160	19.4
> 20%	44	16.1	64	16.9	25	133	16.1
Total	273		379		172	824	
Average COHb	11.16		10.34			10.71	
Median COHb	7.75		6.40			7.00	

***824/986 unintentional exposure (83.6%) individuals were tested for COHb, smoking status was known for 652/824**

Figure 4 COHb Levels by Smoking Status for Unintentional CO Poisoning, Michigan 2010



*824/986 Unintentional CO Exposures were tested for COHb, level was unknown for 20 individuals

Hyperbaric Treatment

Eighty-six (8.7%) individuals were treated with hyperbaric chamber oxygen in 2010. The average COHb level recorded for these individuals was 25.4%. All patients treated with oxygen in an hyperbaric chamber had their COHb measured.

Eighty (93.0%) of the hyperbaric treatments were non-occupational exposures; 22 were from generator exposures, 15 were from a vehicle exposure, 14 were from a furnace or water heater exposure, ten were from a fire, and 19 were from assorted other sources including boats, small engines, a space heater, a wood stove, and a portable grill. There were six occupational exposures that were treated with hyperbaric oxygen. Of the six, five had known exposures; one snow plow worker exposed to the truck's exhaust fumes, a contractor working with a gas-powered saw, an office worker exposed to a faulty furnace, a welder exposed while welding, and an employee from an apple storage warehouse.

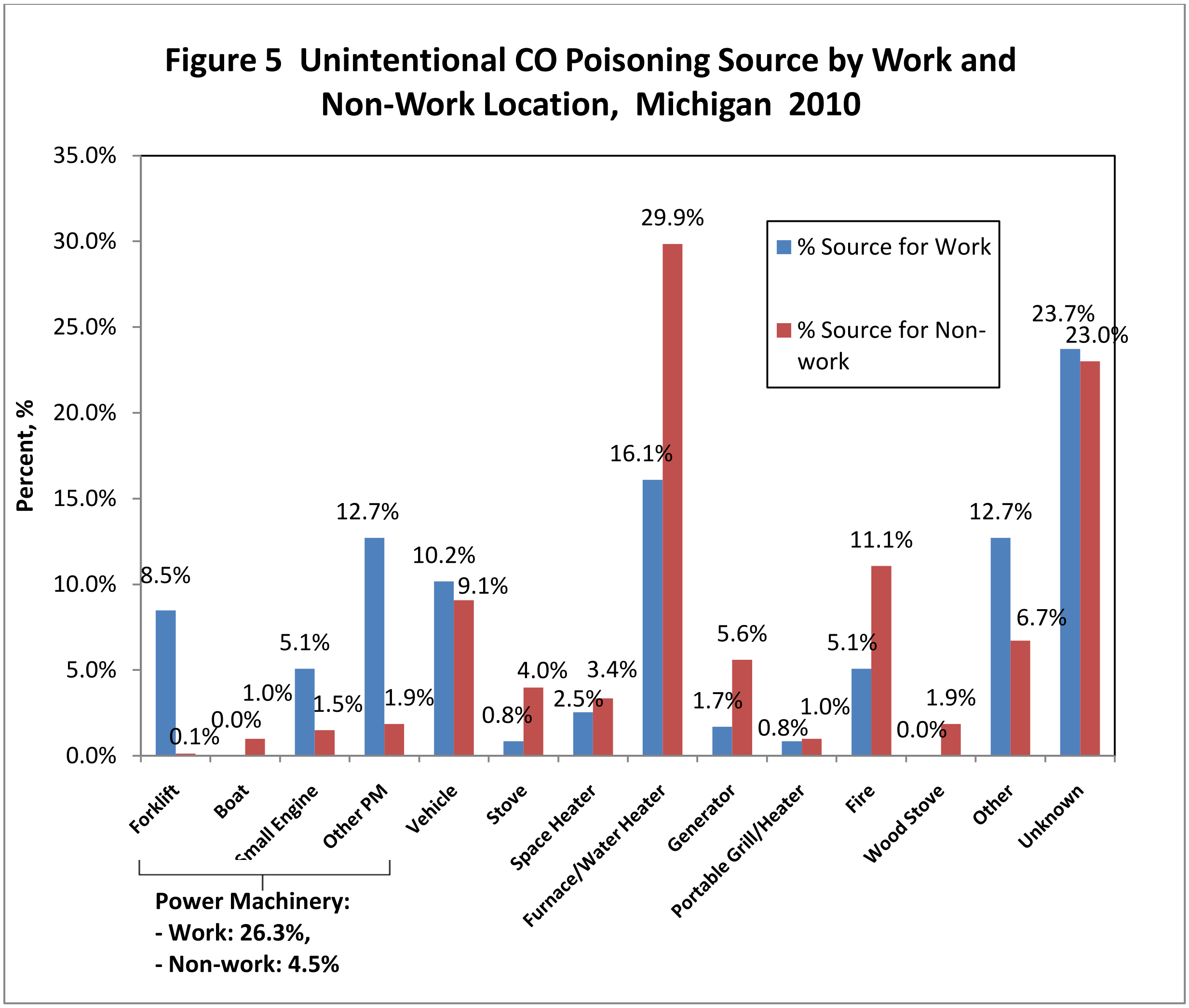
Source and Location of Exposure

Exposure source was known for 712 (72.2%) of the 986 individuals (Table 5, Figure 5). The most common exposure source for non-work exposure was furnace or water heaters (29.9%). There were 28 individuals with work exposures where the source of exposure was unknown. The known source at occupational settings was most commonly power machinery powered by combustion engines (26.3%). Forklifts, concrete saws and power washers were the most frequently identified power machinery listed in occupational exposures. Power machinery at non-work exposures occurred 4.5% of the time and was more varied in type, identified most often as power washers, snow blowers, tractors, and chain saws. The location of exposure was known as either "work" or "non-work" for 922 (93.5%) of the individuals.

Table 5 Unintentional CO Poisoning Source by Work and Non-work Exposure, Michigan 2010

Source	Work		Non-work		Unknown		Total	
	#	%	#	%	#	%	#	%
Power Machinery (PM):*	31	26.3	36	4.5	1	1.6	68	6.9
(Forklift)	**10**	**8.5**	**1**	**0.1**	**0**	**0.0**	**11**	**1.1**
(Boat)	**0**	**0.0**	**8**	**1.0**	**0**	**0.0**	**8**	**0.8**
(Small Engine)	**6**	**5.1**	**12**	**1.5**	**0**	**0.0**	**18**	**1.8**
(Other PM)	**15**	**12.7**	**15**	**1.9**	**1**	**1.6**	**31**	**3.1**
Vehicle	12	10.2	73	9.1	1	1.6	86	8.7
Stove	1	0.8	32	4.0	0	0.0	33	3.3
Space Heater	3	2.5	27	3.4	0	0.0	30	3.0
Furnace/Water Heater	19	16.1	240	29.9	0	0.0	259	26.3
Generator	2	1.7	45	5.6	0	0.0	47	4.8
Portable Grill/Heater	1	0.8	8	1.0	0	0.0	9	0.9
Fire	6	5.1	89	11.1	0	0.0	95	9.6
Wood Stove	0	0.0	15	1.9	0	0.0	15	1.5
Other	15	12.7	54	6.7	1	1.6	70	7.1
Unknown	28	23.7	185	23.0	61	95.3	274	27.8
Total	118	100.0	804	100.0	64	100.0	986	100.0

*** indicates that the number is not included in the totals at the bottom of the table. They are just there to show the totals of the power machinery listed with the right indent.**



Fire

Fire was the source of carbon monoxide exposure for 95 (9.6%) individuals in Michigan. Where location of exposure was known, six (6.3%) were occupational fire exposures. Three individuals exposed to carbon monoxide from occupational fires were fire fighters, one individual worked in manufacturing, one in retail trade, and one in healthcare. Fourteen (14.7%) fire related exposures resulted in death, and none of these deaths were work-related.

Hospitalizations

Of the 986 individuals with reported CO exposure, 123 (12.5%) were hospitalized overnight. The most common source of CO requiring overnight hospitalization included thirty-one (25.2%) from a fire exposure, twenty-three (18.7%) from furnaces or water heaters, fourteen (11.4%) from vehicle exhaust, and ten (8.1%) from a generator. For the 68 individuals where length of stay was known, the average hospitalization was 5.0 days and the median hospitalization was 2 days. The longest hospitalization was for 41 days following a fire related exposure. Forty

(58.8%) stayed two days or less, fifteen (22.1%) stayed 3 to 7 days, five (7.4%) stayed 8 to 14 days, and eight (11.8%) stayed more than two weeks.

Eight (6.5%) of the 123 hospitalizations were due to occupational CO exposure. Of the 8 occupational exposure-related hospitalizations, 3 (37.5%) were from vehicle exhaust, one (12.5%) was from a generator, one (12.5%) from a furnace, one (12.5%) from a forklift, one (12.5%) from the burning of coal, and one where the source of CO was unknown.

ANALYSIS OF OCCUPATIONAL EXPOSURES

Exposure location was known for 922 individuals in 2010 and 118 (12.8%) were identified as work related (Table 5). Gender was known for 117 of the work-related cases; 75 (64.1%) male, 42 (35.9%) female (Table 6). Of the 115 where age was known, 82 (71.3%) were between the age of 18 and 44 and 28 (24.3%) were age 45 to 64. Females age 18 to 44 had the highest incident rate, 14.3 cases per 100,000 (Table 1).

Table 6 Annual Incidence of Unintentional Occupational CO Poisoning by Gender and Age, Michigan 2010

	Male	(%)	Female	(%)	Unknown Gender	Total	(%)
Unknown Age	2	2.7	1	2.4	0	3	2.5
≤ 17 Years Old	1	1.3	0	0.0	0	1	0.8
18 - 44 Years	52	69.3	29	69.0	1	82	69.5
45 - 64 Years	17	22.7	11	26.2	0	28	23.7
≥65 Years	3	4.0	1	2.4	0	4	3.4
Total	75	100.0	42	100.0	1	118	100.0

Race was known for 52 occupationally exposed individuals; 48 (92.3%) were Caucasian and 4 (7.7%) were African American.

Carboxyhemoglobin tests were reported for 96 individuals with occupational exposure. The average COHb level for occupationally exposed individuals tested was 11.4%. Smoking status was known for 75 (78.1%) of the 96 occupationally exposed individuals with COHb levels. The distribution of COHb levels by smoking status for occupationally exposed individuals is shown in Table 7.

Table 7 Unintentional Occupational CO Poisoning by Reported COHb Levels and Smoking Status, Michigan 2010

COHb %	Smoker	Nonsmoker	Unknown	Total
Unknown	0	0	4	4
≤5%	5	26	5	36
6-10%	8	5	6	19
11-20%	10	9	7	26
>20%	4	8	3	15
Total	27	48	25	100

Of the 118 individuals occupationally exposed, month of exposure is shown in Table 8 and Figure 3. The largest percentage of reported exposure occurred in January (21.2%) and the other winter months, the lowest amount of exposures were in the spring and summer months.

NIOSH's National Occupational Research Agenda defines ten industry sector groupings based on the industry classifications of the North American Industry Classification System (NAICS). NORA Sector Codes were assigned for 98 of the 118 work related exposures (Table 9). The largest number of exposures occurred in the Services sector.

Table 8 Unintentional Occupational CO Poisoning Reports by Month, Michigan 2010

Month	# Reports	Percent (%)
January	25	21.2
February	19	16.1
March	3	2.5
April	7	5.9
May	7	5.9
June	6	5.1
July	10	8.5
August	6	5.1
September	4	3.4
October	5	4.2
November	7	5.9
December	19	16.1
Total	118	100.0

Of the 118 individuals occupationally exposed, insurance type was known for 91 employees (77.1%). For 39 of these 91 individuals, Workers' Compensation paid for 39 (42.9%), 30 (33.0%) had private insurance, 16 (17.6%) did not have insurance, and six (6.6%) had Medicare or Medicaid (Table 10, Figure 6).

Table 9 Nora Sector Codes, Occupational CO Poisoning, Michigan 2010

Industry	NAICS Code	# Cases
Agriculture, Forestry, Fishing and Hunting	11	2
Construction	23	5
Health Care and Social Assistance	62, 541940	12
Manufacturing	31-33	20
Mining (except Oil and Gas Extraction)	21	0
Oil and Gas Extraction	211, 213	0
Public Safety	922	5
Services (except Public Safety)	51-56, 61, 71, 72, 81, 92	30
Transportation, Warehousing and Utilities	22, 48, 49	5
Wholesale and Retail Trade	42, 44, 45	19
Unknown		20
Total		98

Thirty-two CO poisonings were reported where multiple employees were affected by the same source at the same facility in nine events. Of the 32, fourteen were exposed due to a leaky furnace at several locations including a condensed milk manufacturer, a fitness center, and a government office. Five employees were exposed due to use of a fork lift on a farm. Four employees were exposed due to oxygen catching fire in a hospital. Three employees were exposed due to a propane powered machine being used to remove asbestos. Another two employees were exposed due to a gas powered trowel in a school basement. The source of exposure was unknown for four employees, two of whom worked in a hospice, and the other two in a fruit and vegetable canning facility.

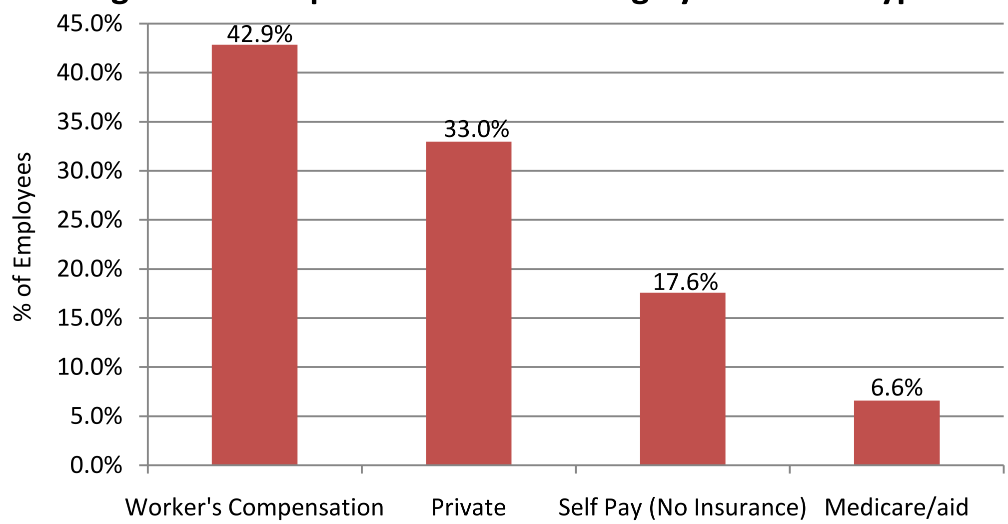
The two highest carboxyhemoglobin levels reported from occupational exposure were in a chauffeur (71.0%) waiting in a garage near a running air compressor, and a farmer (30.9%) working near a fork lift.

Table 10 Occupational CO Poisoning by Insurance Type

Insurance type	n	%
Worker's Compensation	39	42.9
Private	30	33.0
Self Pay (No Insurance)	16	17.6
Medicare/aid	6	6.6
Total	91	100.0

***91/118 (77.1%) occupational CO poisonings had known insurance types.**

Figure 6 Occupational CO Poisoning by Insurance Type



WORK SITE INVESTIGATIONS, 2010

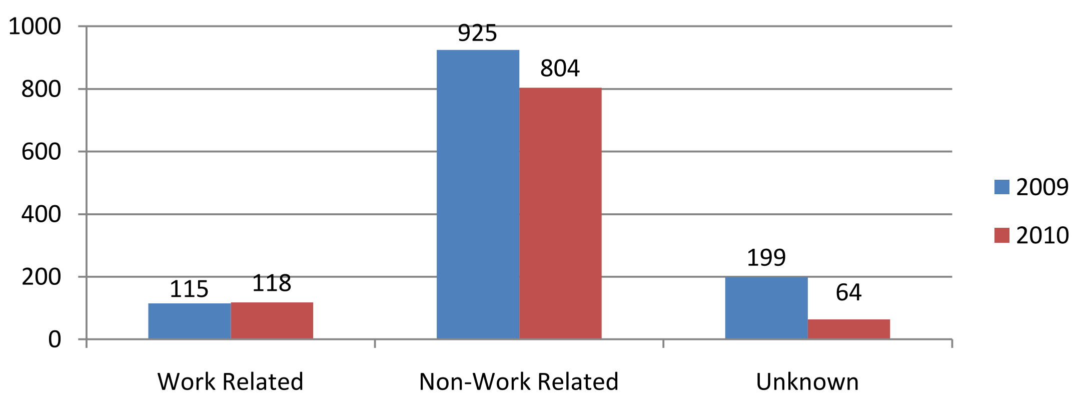
In this second year of the carbon monoxide surveillance system, two cases were referred to MIOSHA, both of which resulted in workplace follow up investigations. In January 2010, MIOSHA inspected a cereal packing company as a result of a 2010 poison control report of five workers who had syncopal episodes due to a faulty boiler. The boiler's make-up louvers did not open when the boiler was running, pulling the combustion products down the stack, including carbon monoxide, into the boiler room. This carbon monoxide leaked into the maintenance shop and employees were exposed to estimated levels of 44 to 187 ppm carbon monoxide for an eight-hour TWA. Two citations were issued at this inspection, one of which was related to air contaminants in confined spaces and the other was related to ineffective ventilation control.

In December 2011, MIOSHA conducted a second inspection at an apple storage warehouse based on a 2010 hospital discharge report. Even though a door was open, after the employee operated a gas powered forklift all morning, the employee began to feel woozy and lightheaded and eventually had a syncopal episode. EMS transported the employee to the hospital. The employee's COHb level was 16.2%, and was treated with hyperbaric oxygen. The inspection did not identify any CO air levels in excess of 35 ppm. However one citation was issued as a result of not communicating the hazards of chemicals in the work area.

DISCUSSION

Carbon monoxide (CO) is one of the leading causes of unintentional poisoning deaths in the United States and 68,316 CO exposures were reported to poison centers in the U.S. during 2000—2009.[7] In Michigan, for the year 2010, reports were received on 986 individuals for unintentional CO poisoning. Twenty-six (2.6%) deaths were recorded; fourteen (53.8%) were fire related. These numbers are decreased from the 1,238 individuals poisoned and 39 deaths in 2009 (Figure 7). All reporting sources had a decrease in number of cases reported. The decrease was also across all age groups, as well as most of the exposures, except for cases involving power machinery and fires. Part of this decrease can be attributed to the new matching method that was introduced in the 2010 annual report. This matching method allowed us to match the cases from the poison control center where no name was provided to cases from other reporting sources. If they matched to any other report, they were considered duplicates, and deleted. In the 2009 annual report, there were 275 unknowns. In the 2010 data, there were originally 118 unknowns; however the matching method brought it down to 47 unknowns, indicating that 71 (60.2%) of the unknowns were duplicates.

Figure 7 Annual Incidence of Unintentional CO Poisoning by Location of Exposure, Michigan 2009 - 2010



Most unintentional CO exposure occurred at home in the months of October to March as a result of furnaces or water heaters. The largest number of individuals, 826 (83.8%), were reported by hospitals. In 2010, Michigan hospitals were required to report 2010 information by April 2011. Changes implemented in 2011 require quarterly reporting by hospitals and health care facilities, thus improving timely response to identify sources of CO poisoning.

Carboxyhemoglobin (COHb) testing was reported for 824 individuals with actual COHb levels reported for 804. COHb reports are indicators of exposure; however levels reported cannot be considered an accurate measure of the true extent of the exposure for several reasons. Results from hospital records are most likely lower than the level an individual would have at the time of exposure due to time elapsed between exposure and medical evaluation, and the administration of oxygen in the ambulance or emergency department (ED) prior to the COHb test. In the general non-smoking population, normal levels of COHb are less than 1%. Approximately half (42.2%) of the COHb measured levels were less than or equal to 5% (Table 4).

Most of Michigan's unintentional carbon monoxide exposures occurred in non-occupational settings. There are no non-occupational indoor air standards for CO in Michigan. For the workplace, the Michigan Occupational Safety and Health Administration (MIOSHA) standard for General Industry is 35 parts per million (ppm) as an 8 hour time-weighted-average (TWA) exposure limit, with a 200 ppm ceiling, and, for construction there is a 50 ppm TWA, with no ceiling limit. An advisory committee of the Michigan Occupational Health Standards Commission has recommended the standard be changed to a 25 ppm 8 hour TWA and a 200 ppm ceiling for both general industry and construction.

Three limitations have been identified with Michigan's CO surveillance system; 1) Information may be missing in the different reporting sources (e.g., source or COHb level). A questionnaire has been developed to contact individuals to obtain missing information but resources are not available to interview the large number of individuals reported with missing data. As surveillance continues and electronic medical records become more universal, we are hopeful that we will receive more complete reports; 2) Hospitals and other sources may not be reporting all cases; some cases are just simply missed. For 2011, in order to see if any more cases of carbon monoxide exposure are not submitted, one large hospital provided laboratory reports of all carboxyhemoglobin results of 10% or greater. Of the seven cases reported from the lab, hospital discharge records were only received on two of the seven, indicating that the other five individuals were not reported through review of hospital discharge codes. 3) Carbon monoxide poisoning, particularly at lower levels of exposure, is a difficult condition to diagnose. In addition, some individuals exposed to CO may not seek medical attention. Thus we presume there are additional cases of unrecognized carbon monoxide poisonings.

Identification of individuals diagnosed with adverse carbon monoxide effects is the first step to initiate preventive interventions. The four most common elevated CO exposures were from furnaces (26.3%), fires (9.6%), vehicles (8.7%), and generators (4.8%). After natural disasters or during prolonged periods of power interruptions, including construction projects, winter storms, and floods, the use of generators is quite common, increasing the potential of excessive CO exposure. Educational materials and campaigns to address this issue have been developed by CDC and MDCH.[9,10] Additional topics for public education include the potential sources of CO exposure, common symptoms associated with CO poisoning, and the hazards associated with CO, especially in the colder months when the frequency of adverse effects is greatest. Prevention strategies include not allowing motor vehicles to idle in enclosed areas, regularly checking and maintaining motor vehicle emissions, ensuring all gas appliances are installed correctly and are located in properly ventilated areas and substituting electric powered forklifts and other equipment for fuel powered equipment during indoor work, both at home and in the work place. In areas that are likely to have CO exposures, installation of a CO detector is recommended at home and work.

Fuel burning heating appliances (i.e. furnaces and water heaters) have become more efficient as a result of the transition from a natural-draft venting system (gravity-driven), to a forced-draft venting system (fan-propelled).[11] Spillage occurs when the products of combustion, flue gas, spill back into a building usually due to a blockage in the flue. Some of these newer appliances are required by ANSI standard ASTM E1998 – 11 to have a spillage prevention mechanism. However there is not a single well-accepted method that is recognized in preventing spillage.[12] One current option is to install a “spill switch” with the fuel-burning heating appliances. When installed correctly, these spill switches detect any blockages in the flue that prevent the products of combustion from exiting a building. Once detected, the spill switch automatically shuts off the fuel supply of the heating system, preventing the build-up of CO.[13] While the older fuel-burning heating systems with natural draft venting do not require a spillage prevention mechanism, their flues are still prone to blockage. This engineering change, along with the addition of these spill switches to older appliances, should decrease the incidence of CO poisonings caused by a faulty furnace/water heater, which was the leading cause of CO poisoning for all cases in 2010.

From the data, it was also evident that a substantial amount of the work-related cases were due to the use of power machinery, whereas in the non-work related cases, power machinery was not as significant. A possible intervention to decrease carbon monoxide exposure could be using automatic shut-off devices with the gas-powered machinery that automatically shut off the machine in use after a dangerous level of carbon monoxide has been detected.[14] This would be useful when using gas-powered machinery and could prevent CO poisoning, especially when these machines are used in closed environments. Effective March 23, 2009, a modification to

Michigan's Uniform Construction Code (Act 230 of 1972) mandated all single-family and multi-family dwellings to have required carbon monoxide detectors installed at the time of initial construction, addition of a bedroom, or other renovation in which a permit is required. The location of these detectors and other specifics are outlined in section 125.1504f of Michigan Compiled Laws (Appendix A). Regulations and ongoing educational programs to encourage the installation of carbon monoxide detectors and spill switches in existing dwellings would address the major source of non-occupational exposure.

Data from future surveillance of CO poisoning will help determine the effectiveness of preventive activity and identify new sources of exposures.

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Appendix A Michigan Uniform Construction Code (Act 230 of 1972) section 125.1504f of Michigan Compiled Laws

STILLE-DEROSSETT-HALE SINGLE STATE CONSTRUCTION CODE ACT (EXCERPT)
Act 230 of 1972

125.1504f Single-family or multifamily dwelling; installation of operational and approved carbon monoxide device; requirements; failure to comply; penalty; liability; definitions; name of section.

Sec. 4f. (1) The director may provide for, at the time of initial construction of a single-family dwelling or a multifamily dwelling, or at the time of renovation of any existing single-family dwelling in which a permit is required, or upon the addition or creation of a bedroom, the installation of at least 1 operational and approved carbon monoxide device within the single-family dwelling or within each unit of the multifamily dwelling. A carbon monoxide device shall be located in the vicinity of the bedrooms, which may include 1 device capable of detecting carbon monoxide near all adjacent bedrooms; in areas within the dwelling adjacent to an attached garage; and in areas adjacent to any fuel-burning appliances.

(2) The carbon monoxide device described in subsection (1) may be battery-powered, plug-in with or without battery backup, wired into the dwelling's AC power line with secondary battery backup, or connected to a system by means of a control panel. If the international residential code is adopted by the director as part of a code adopted after the effective date of the amendatory act that added this section, those requirements apply and shall be followed upon the effective date of the code.

(3) An enforcing agency shall not impose a penalty for the failure of a person to comply with subsection (1) until the effective date of the code that may be adopted after the effective date of the amendatory act that added this section that incorporates that requirement.

(4) A person licensed under article 24 of the occupational code, 1980 PA 299, MCL 339.2401 to 339.2412, who is in compliance with this section or rules promulgated under the code and installs, in accordance with manufacturer's published instructions at the time of installation, a carbon monoxide device shall have no liability, directly or indirectly, to any person with respect to the operation, maintenance, or effectiveness of the carbon monoxide device.

(5) As used in this section:

(a) "Approved" means a carbon monoxide device that is listed as complying with either ANSI/UL 2034 or ANSI/UL 2075 and that is installed in accordance with the manufacturer's instructions.

(b) "Carbon monoxide device" means a device that detects carbon monoxide and alerts occupants via a distinct and audible signal that is either self-contained in the unit or activated via a system connection.

(c) "Operational" means working and in service.

(6) This section shall be known and may be cited as the "Overbeck law".

History: Add. 2008, Act 377, Eff. Mar. 23, 2009.

Popular name: Act 230

Popular name: Uniform Construction Code