2014
Annual Report on
Carbon Monoxide Poisoning
In Michigan

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2014 ANNUAL REPORT ON CARBON MONOXIDE POISONING IN MICHIGAN

A Joint Report Of

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SUMMARY

This is the sixth annual report on carbon monoxide (CO) poisoning surveillance in Michigan. This report provides information about 659 cases of unintentional CO poisoning involving 653 individuals in 616 CO exposure events in Michigan in 2014, including 15 individuals who died from CO exposure. The report is based on data collected as a result of regulations promulgated September 18, 2007, by the Michigan Department of Health and Human Services (MDHHS). The State's public health code requirement for health care facilities to report unintentional CO poisoning was phased out in 2014, due to resource constraints at MDHHS for processing reports, thus hospitals reported cases for only approximately half of the year.

BACKGROUND

Carbon monoxide (CO) is a leading cause of poisoning in the United States.[1] CO exposure results in nearly 450 deaths, more than 2,000 hospitalizations, and more than 50,000 emergency department (ED) visits per year in the United States.[2] CO is a colorless, odorless, tasteless, non-irritant gas that is produced as a result of incomplete combustion of hydrocarbon.[3] Sources of CO can occur both indoors and outdoors, including faulty furnaces, poorly maintained and inadequately ventilated home heating systems and cooking appliances, motor vehicle exhaust, and fuel-powered equipment (e.g., space heaters and generators).[3] The Environmental Protection Agency (EPA) allowable limit for environmental exposure to CO in outdoor ambient air is 9 parts per million (ppm) for an 8-hour average.[3] Workplace standards set by the Michigan Occupational Safety and Health Administration (MIOSHA) for general industry require the CO level be kept below a time weighted average (TWA) of 35 ppm for an 8-hour day and a 200 ppm ceiling that should never be exceeded; for the construction industry, the TWA is 50 ppm averaged over an 8-hour work day without a standard for a ceiling level.[4,5] The National Institute for Occupational Safety and Health (NIOSH) Immediately Dangerous to Life and Health (IDLH) ceiling is 1200 ppm.[6]

When inhaled, CO binds to hemoglobin in the blood as well as other proteins in the body, such as myoglobin, reducing the delivery of oxygen to the brain, heart, and all other body tissues. Hemoglobin combines with CO to form a bright red compound called carboxyhemoglobin (COHb), which can be measured in the blood. Non-smoking individuals generally have less than 1.0% COHb in their blood as a consequence of the normal breakdown of red blood cells. Cigarette smokers have an average 4.0% COHb, with heavier smokers having higher values. Breathing CO at the MIOSHA TWA for general

industry of 35 ppm will cause a 5.4% COHb blood level. Breathing CO at the TWA for construction of 50 ppm will cause a 7.4% COHb blood level.[7] CO home detectors manufactured to meet the requirements of ANSI/UL 2034 are designed to alarm at levels that would result in a COHb level of 10% in adults.[8] Exposure to CO from multiple sources is additive (e.g., the average cigarette smoker working at the MIOSHA general industry TWA would be expected to have 9.4% COHb level).[7] COHb has a half-life in the blood of four to six hours. Oxygen administration reduces the half-life to approximately an hour or less; hyperbaric oxygen treatment will reduce the half-life to less than half an hour.[7] In individuals with atherosclerosis, COHb levels as low as 3–4% can increase the frequency and severity of angina or claudication, 6% can induce cardiac arrhythmias, and 10% may precipitate a myocardial infarction.[7] In individuals without atherosclerosis, COHb levels above 10–20% can cause headaches, nausea, muscle weakness, and decreased mental awareness. COHb levels above 30% can cause increased weakness and confusion. Breathing COHb levels higher than 50% can result in coma and death.[7]

Figure 1: Common used Triad for Diagnosis of Acute Carbon Monoxide Poisoning

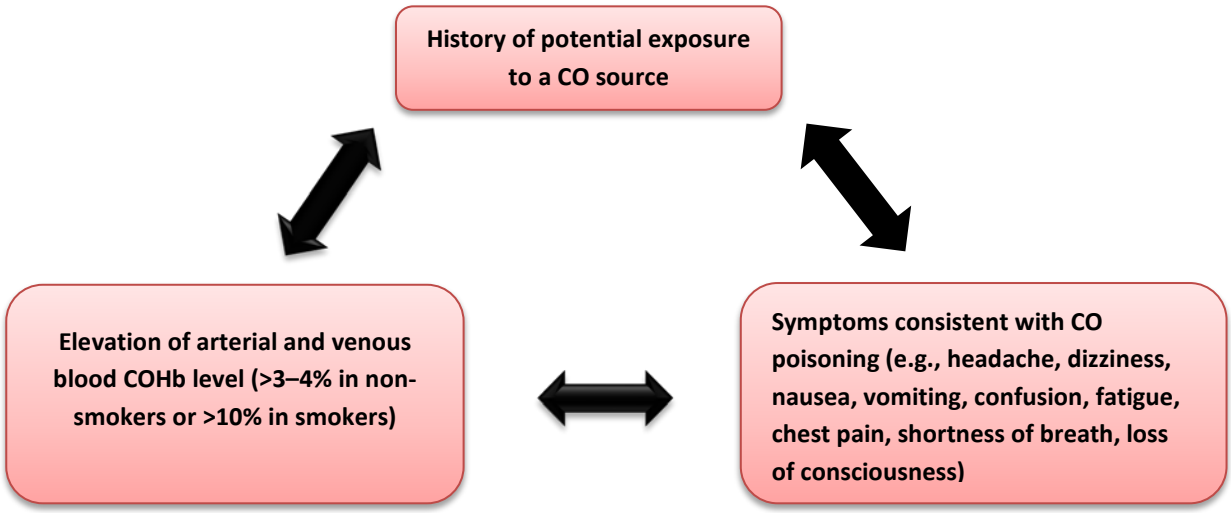


Table 1: Level of Blood CO and Associated Symptoms

% of CO in blood	Symptoms and signs
10–20	Headache, shortness of breath
20–30	Nausea, dizziness, severe headache, difficulty concentrating
30–40	Lethargy, fainting, visual and auditory impairment, chest pain
40–50	Fainting, rapid heart rate, seizure
>50	Coma, convulsion, death

Source: Sullivan, JB Jr; Krieger, GR (eds.). Clinical environmental health and toxic exposure (2nd ed.). Philadelphia: Lippincott, Williams & Wilkins, 2001, p.75.

METHODS

The major data sources for this report were the Michigan Poison Control Center (PCC), Michigan hospitals, and death certificates for the period January 1–December 31, 2014. The PCC reported all calls where the substance was CO, the case had one or more "clinical effects" (symptoms), and the reason for exposure was "unintentional". Hospitals were required to report patients who had any inpatient, outpatient, or ED visit with ICD-9 discharge codes of 986, E868.3, E868.8, E868.9, or E982.1[*] as a discharge diagnosis. Death certificates were obtained where a contributing cause of death was ICD-10 code T58 ("Toxic effects of carbon monoxide accidental [unintentional]").

Hospital medical records and PCC case reports were reviewed to determine whether they met the following surveillance case definition. A confirmed case of CO poisoning was defined as an individual who was treated by a health care provider for symptoms related to unintentional CO exposure in a single event, excluding cigarette smoke. [**] If a person called PCC about CO and/or CO-related symptoms but did not seek medical care, they were excluded. Also excluded were cases in which the physician ruled out CO poisoning in the medical record notes, even though CO poisoning may have been suspected initially and thus assigned a CO ICD code in the discharge diagnosis string. It should be noted that individuals were included as cases regardless of laboratory confirmation based on the COHb result. In many cases the COHb result was not available or the blood specimen from the patient was collected too long after exposure or after treatment with oxygen to still be elevated. All death certificate cases with cause of death code T58 were considered confirmed cases.

Confirmed cases were abstracted into a data system that included, for each individual case report, demographic information (i.e., age, sex, and race), admission date, discharge date, exposure date, COHb test result, cigarette smoking status, report source(s), source of CO exposure (e.g., furnace, forklift), and treatment (including hyperbaric chamber).

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 as well as multiple entries of the same report source (e.g., transfers between hospitals for treatment with hyperbaric oxygen, multiple hospital visits due to the same exposure).

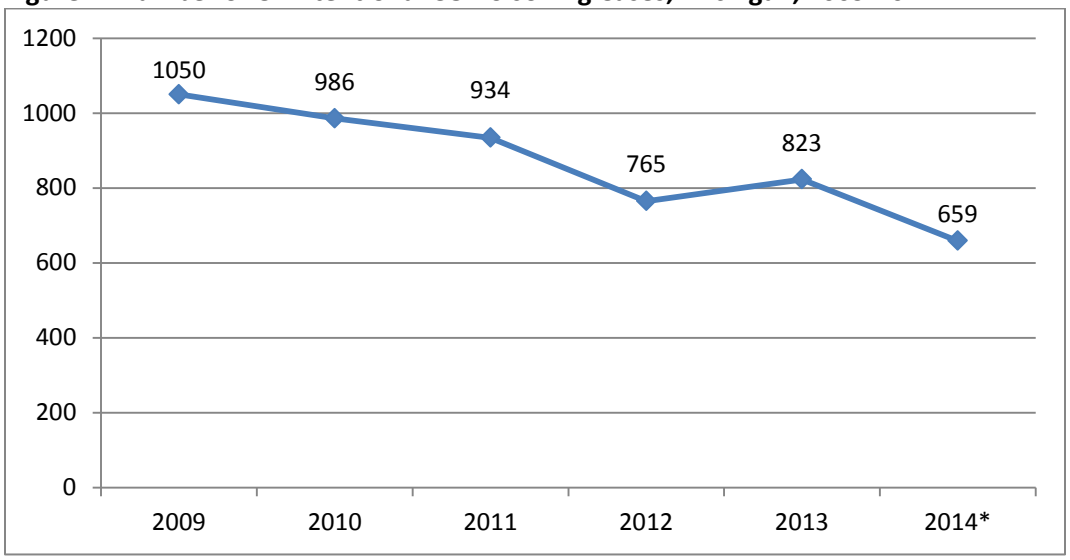
*ICD-9 code definitions: 986 = ""Toxic effects of CO"; E868.3 = "CO from incomplete combustion of other domestic fuels"; E868.8 = "CO from other sources"; E868.9 = "Unspecified CO"; E982.1 ="Poisoning by other CO"
**An individual could be count more than once, as a case, if the individual was involved in more than one unrelated exposure event

Frequencies and rates of CO poisoning were generated from these data. Denominators used to calculate rates were from the US Census Bureau.[9]

RESULTS

A total of 659 reports of unintentional CO poisoning were reported on 653 individuals in 2014. Four individuals were reported with two different exposures, and one individual with three different exposures. Figure 2 shows the number of unintentional carbon monoxide poisoning in Michigan, 2009–2014.

Figure 2: Number of Unintentional CO Poisoning Cases, Michigan, 2009-2014

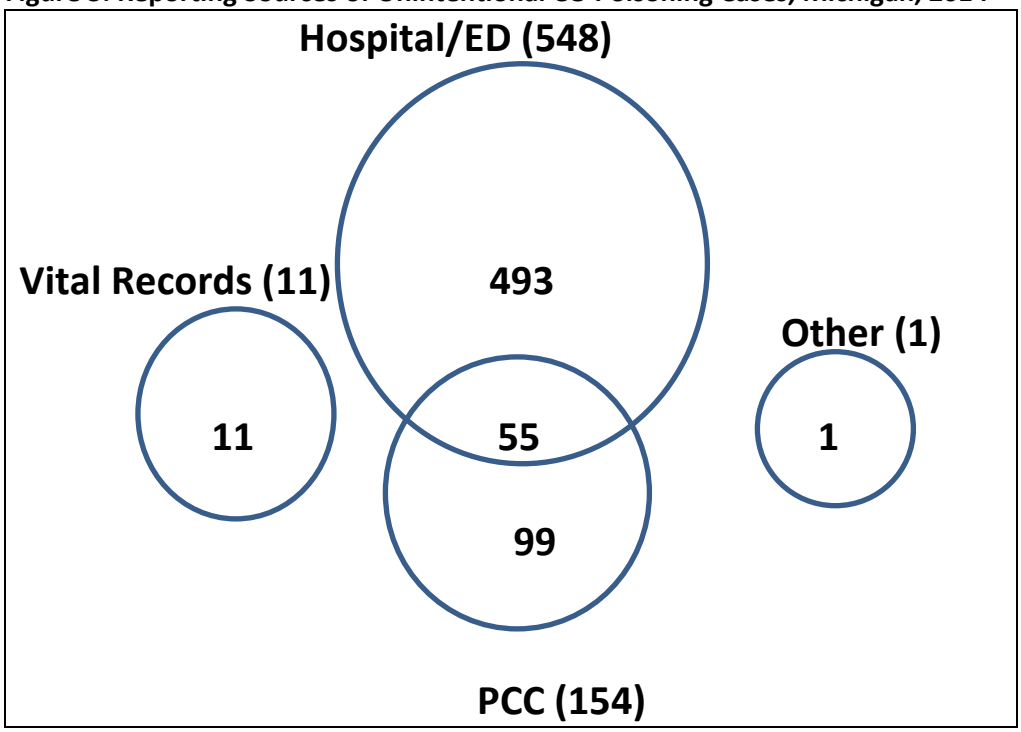


*Hospital reporting for 2014 was incomplete because hospitals were notified that they no longer needed to report CO poisoning cases. Thirty (28%) 138 hospitals reported cases for all quarters of the year, 42 (31%) reported for three quarters of the year, and 56 (41%) only reported for the first two quarters. (See p. 24 for additional discussion).

Source of Reports

Hospital/ED reports identified 548 cases, PCC 154 cases, and vital records 11 cases. Hospital/ED reports matched 55 PCC reports.

Figure 3: Reporting Sources of Unintentional CO Poisoning Cases, Michigan, 2014



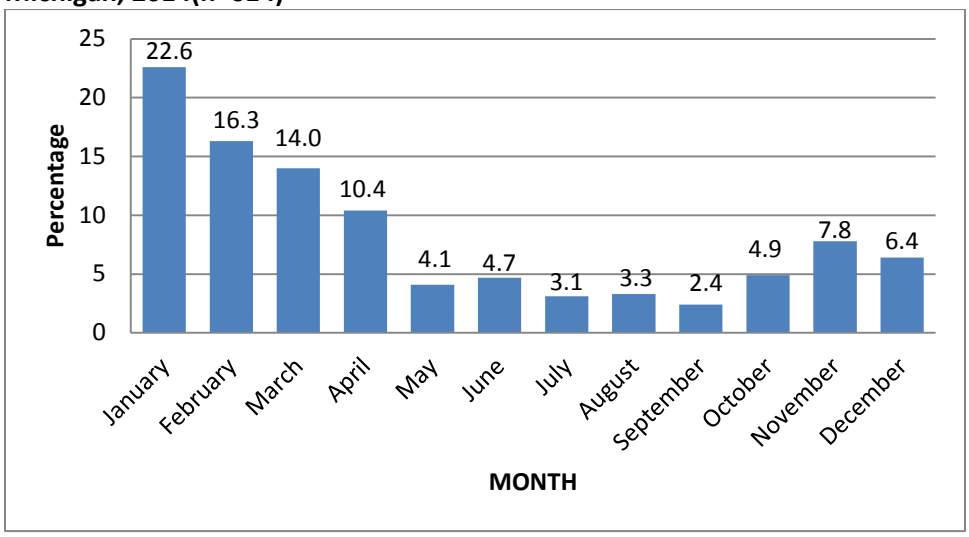
Month of Exposure

Month of exposure was known for 614 (93.0%) cases (Table 2 and Figure 4). January and February were the months with the highest number of exposures, 139 (22.6%) and 100 (16.3), respectively. September was the month with the lowest number of exposures, 15 (2.4%) cases.

Table 2: Unintentional CO Poisoning Cases by Month, Michigan, 2014 (n=614)

Month	No.	%
January	139	22.6
February	100	16.3
March	86	14
April	64	10.4
May	25	4.1
June	29	4.7
July	19	3.1
August	20	3.3
September	15	2.4
October	30	4.9
November	48	7.8
December	39	6.4
Total	**614**	**100**

Figure 4: Percentage of Unintentional CO Poisoning Cases by Month of Exposure, Michigan, 2014(n=614)



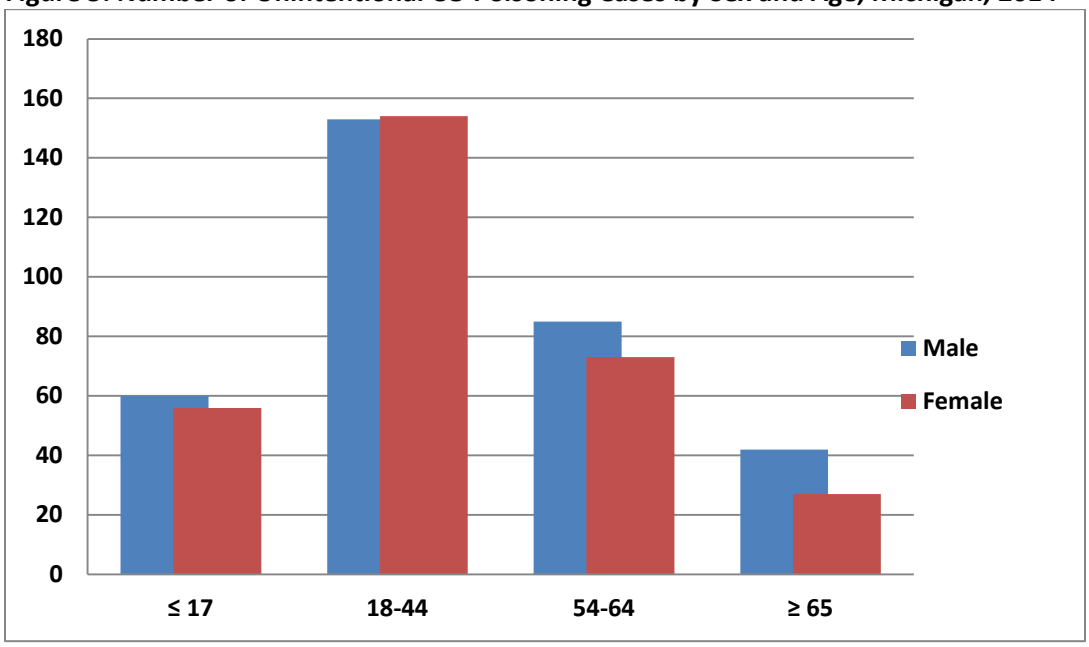
Sex and Age

Sex was known for 652 individuals, of which 342 (52.5%) were male and 310 (47.4%) were female. Of the 650 individuals where both age and sex were known, 116 (17.9%) were 17 years old or younger, 307 (47.0%) were 18–44 years old, 158 (24.2%) were 45–64 years old, and 69 (10.6%) were 65 years old or older (Table 2 and Figure 5).

Table 2: Unintentional CO Poisoning by Sex and Age, Michigan, 2014

Age group (years)	Male		Female		Total	
	No.	%	No.	%	No.	%
≤17	60	17.6	56	18.1	116	17.8
18–44	153	45.0	154	49.7	307	47.2
45–64	85	25.0	73	23.5	158	24.4
≥65	42	12.4	27	8.7	69	10.6
Total	**340**	**100**	**310**	**100**	**650**	**100**

Figure 5: Number of Unintentional CO Poisoning Cases by Sex and Age, Michigan, 2014



Race

Race was known for 349 (53.5%) individuals. Of the cases for which race was known, 238 (68.2%) were Caucasian, 93 (26.6%) were African American, one (0.3%) was Native American, and 17 (4.9%) were other, which included Hispanic. Other race had the highest incidence rate of unintentional CO poisoning (11.6/100,000), followed by African American (6.6/100,000).

Table 3: Number of Unintentional CO Poisoning Cases by Race, Michigan, 2014 (n=350)

Race	Michigan Population	No. Cases	Rate/100,000
Caucasian	7,803,120	238	3.1
African American	1,400,362	93	6.6
Native American	64,611	1	1.6
Other	147,029	17	11.6

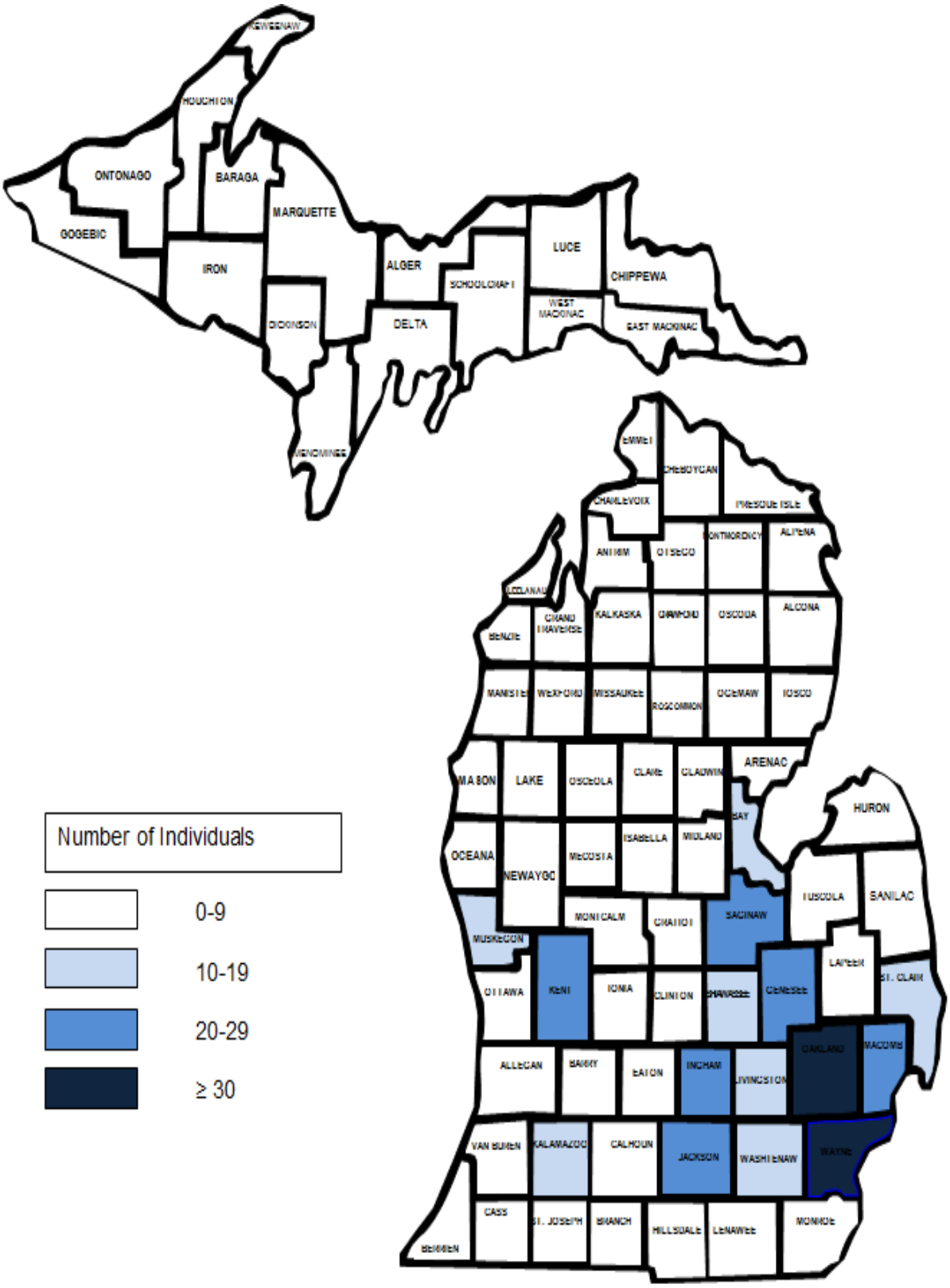
County of Residence

Table 4 and Figure 6 illustrate the number of individuals with unintentional CO poisoning and the corresponding county of residence. County of residence was known for 578 (88.5%) individuals. Eleven (1.7%) of the total number of individuals were classified as out of state. Thirteen counties had no cases, 59 counties had less than ten cases, seven counties had between 11 and 19 cases, six counties had between 20 and 29 cases, and only two counties had more than 30 cases. Wayne County had the highest number of cases; 131 (22.1%).

Table 4: Unintentional CO Poisoning Cases by County of Residence, Michigan 2014

County	No.	%	County	No.	%
Alcona County	3	0.5	Lake County	5	0.9
Alger County	2	0.3	Lapeer County	0	0.0
Allegan County	1	0.2	Leelanau County	1	0.2
Alpena County	2	0.3	Lenawee County	6	1.0
Antrim County	4	0.7	Livingston County	17	2.9
Arenac County	1	0.2	Luce County	0	0.0
Baraga County	0	0.0	Mackinac County	0	0.0
Barry County	1	0.2	Macomb County	25	4.3
Bay County	17	2.9	Manistee County	3	0.5
Benzie County	0	0.0	Marquette County	10	1.7
Berrien County	4	0.7	Mason County	1	0.2
Branch County	2	0.3	Mecosta County	6	1.0
Calhoun County	4	0.7	Menominee County	1	0.2
Cass County	1	0.2	Midland County	2	0.3
Charlevoix County	2	0.3	Missaukee County	1	0.2
Cheboygan County	2	0.3	Monroe County	8	1.4
Chippewa County	2	0.3	Montcalm County	7	1.2
Clare County	1	0.2	Montmorency County	0	0.0
Clinton County	4	0.7	Muskegon County	13	2.2
Crawford County	3	0.5	Newaygo County	3	0.5
Delta County	1	0.2	Oakland County	35	6.1
Dickinson County	2	0.3	Oceana County	6	1.0
Eaton County	4	0.7	Ogemaw County	0	0.0
Emmet County	1	0.2	Ontonagon County	0	0.0
Genesee County	27	4.7	Osceola County	4	0.7
Gladwin County	0	0.0	Oscoda County	1	0.2
Gogebic County	5	0.9	Otsego County	1	0.2
Grand Traverse County	4	0.7	Ottawa County	6	1.0
Gratiot County	1	0.2	Presque Isle County	3	0.5
Hillsdale County	0	0.0	Roscommon County	1	0.2
Houghton County	2	0.3	Saginaw County	26	4.5
Huron County	1	0.2	St. Clair County	13	2.2
Ingham County	23	4.0	St. Joseph County	0	0.0
Ionia County	6	1.0	Sanilac County	1	0.2
Iosco County	5	0.9	Schoolcraft County	0	0.0
Iron County	0	0.0	Shiawassee County	11	1.9
Isabella County	0	0.0	Tuscola County	5	0.9
Jackson County	21	3.6	Van Buren County	5	0.9
Kalamazoo County	12	2.1	Washtenaw County	15	2.6
Kalkaska County	7	1.2	Wayne County	131	22.7
Kent County	24	4.2	Wexford County	3	0.5
Keweenaw County	0	0.0	**Total**	**578**	**100.0**

Figure 6: Unintentional CO Poisoning Cases by County of Residence, Michigan, 2014



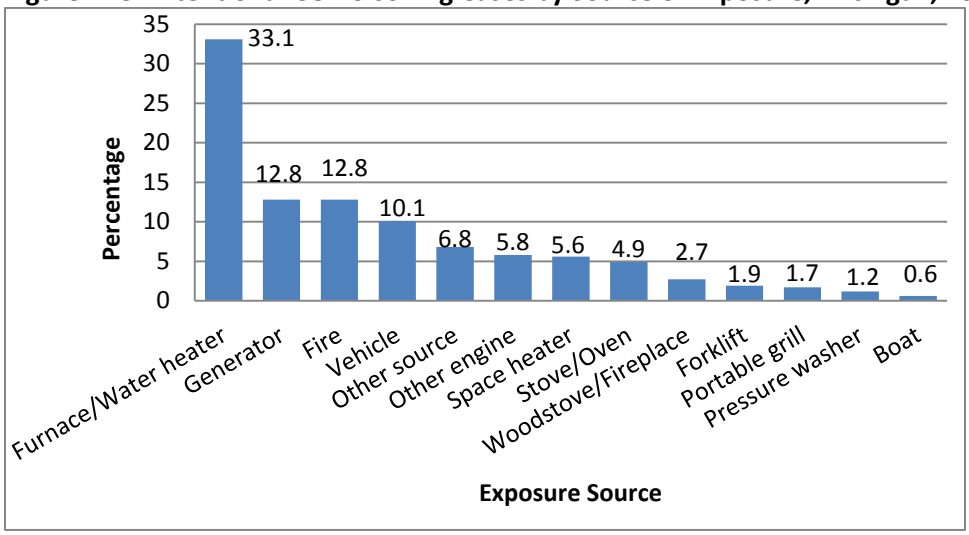
Source of Exposure

Exposure source was known for 483 (73.6%) of the 659 cases (Table 5, Figure 7). The most common source of exposure was furnace/water heater, 160 (33.1%); followed by exposure from a generator and fire, 62 (12.8%) for both sources. There were another 176 (26.7%) cases with CO exposure where the source of exposure was unknown.

Table 5: Sources of Carbon Monoxide Exposure, Michigan, 2014 (n=483)

Source	No.	%
Furnace/water heater	160	33.1
Generator	62	12.8
Fire	62	12.8
Vehicle	49	10.1
Other source	32	6.8
Other engine	28	5.8
Space heater	27	5.6
Stove/oven	24	4.9
Woodstove/fireplace	13	2.7
Forklift	9	1.9
Portable grill	8	1.7
Pressure washer	6	1.2
Boat	3	0.6
Total	**483**	**100**

Figure 7: Unintentional CO Poisoning Cases by Source of Exposure, Michigan, 2014



Fire

Fire was the source of CO exposure for 62 (12.8%) of the 483 cases where a source was known. Seven of the fire exposures were work related. Four (6.5%) of the fire related exposures resulted in death; none of the four deaths were work-related.

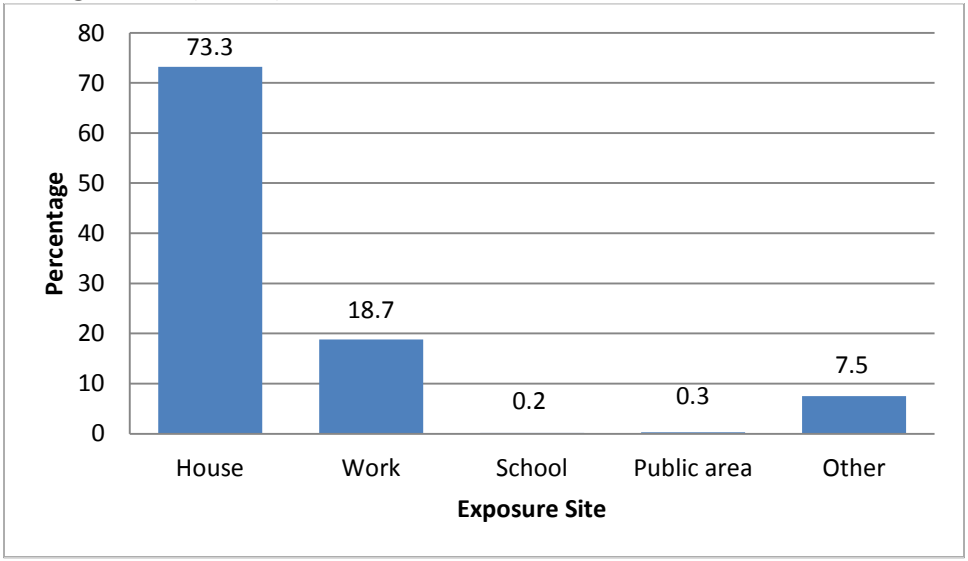
Exposure Site

Exposure sites were known for 627 (95.1%) of the 659 cases. The most common exposure site was house, 460 (73.3%) of the known exposure sites; followed by exposure at work, 117 (18.7%).

Table 6: Number and Percent of Unintentional CO poisoning Cases by Exposure Site (n=627)

Exposure Site	No.	%
House	460	73.3
Work	117	18.7
School	1	0.2
Public area	2	0.3
Other	47	7.5
Total	**627**	**100**

Figure 8: Percentage of Unintentional CO Poisoning Cases by Exposure Site, Michigan, 2014(n=627)



Events with Multiple Cases

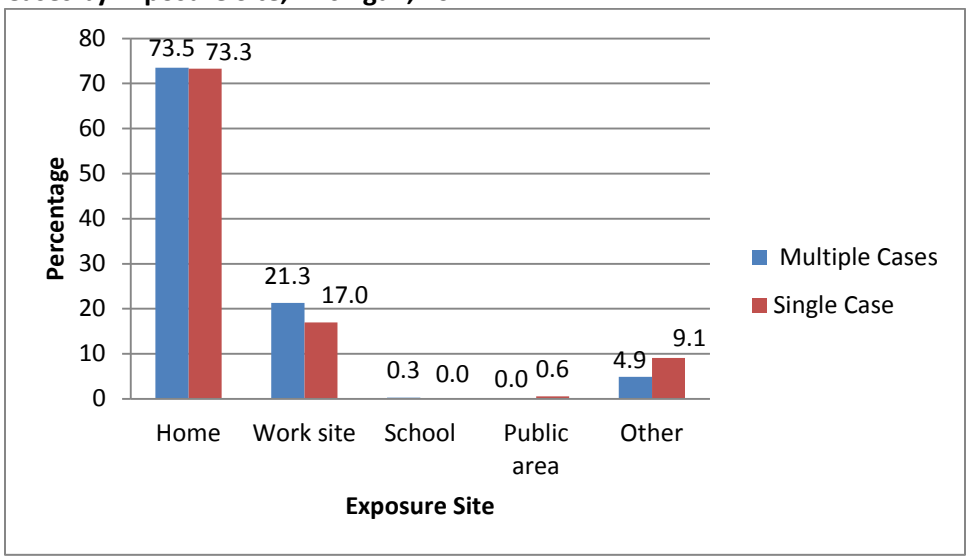
The number of people in each exposure event was known for 648 (98.3%) cases. Of these cases, 293 (45.2%) events involved more than one individual, and 355 (54.8%) events involved only one individual.

Six cases were classified as a multiple cases with unknown exposure site. Twenty six cases were single cases with unknown exposure sites.

Table7: Unintentional CO Poisoning Events by Exposure Site, Multiple and Single Patient, Michigan 2014 (n=616)

Exposure Site	Multiple Cases			
	Yes		No	
	No.	%	No.	%
Home	211	73.5	241	73.3
Work site	61	21.3	56	17
School	1	0.3	0	0
Public area	0	0	2	0.6
Other	14	4.9	30	9.1
Total	**287**	**100**	**329**	**100**

Figure 9: Percentage of Unintentional CO Poisoning Cases with Multiple and Cases by Exposure Site, Michigan, 2014



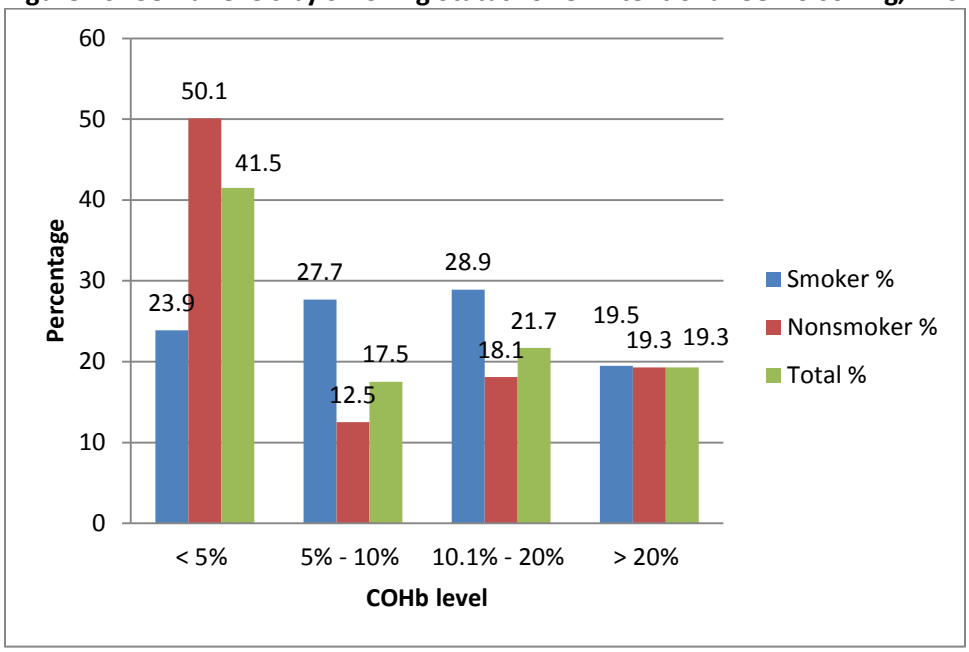
Carboxyhemoglobin (COHb) Testing

COHb was known for 547 (82.9%) of the 659 cases. The average COHb level for all cases tested was 11.0%. The range of COHb was 0.0% to 53%. Two hundred twenty-two (40.6%) cases had a COHb level greater than 10%, and 105 (19.2%) cases had a COHb level greater than 20%. Smoking status was known for 480 (87.8%) of the 547 cases tested for COHb, and 523 (80.0%) of all 653 individuals. The distribution of COHb levels by smoking status is shown in Table 8 and Figure 10.

Table 8: Unintentional CO Poisoning by COHb Levels and Smoking Status, Michigan 2014(n=480)

COHb Levels	Smoker		Nonsmoker		Total	
	No.	%	No.	%	No.	%
<5%	38	23.9	161	50.1	199	**41.5**
5%– 10%	44	27.7	40	12.5	84	**17.5**
10.1%– 20%	46	28.9	58	18.1	104	**21.7**
>20%	31	19.5	62	19.3	93	**19.3**
Total	**159**	**100**	**321**	**100**	**480**	**100**

Figure 10: COHb Levels by Smoking Status for Unintentional CO Poisoning, Michigan, 2014



Treatment Location

There were 625 (94.8%) of the cases with known treatment location. Most of the case 513 (81.9%) received treatment at an ED. Only 111 (17.7%) stayed overnight in a hospital. Fire was the most common CO source for hospitalized patients and accounted for 38 (34.2%) of the hospitalized patients.

Hyperbaric Treatment

Thirty-four (5.2%) cases were known to have been treated with hyperbaric chamber oxygen. All of the 34 cases had their COHb reported. The average COHb level recorded for these individuals was 24.3%. All of the 34 cases of the hyperbaric treatments were non-occupational exposures. Source of exposure was known for 26 (76.5%) of the 34 cases, including four from generator exposures, five from a fire, two from vehicle exposures, nine from furnace or water heater exposures, three from space heaters, one from stove/ovens, and two from other sources. For eight cases the source of exposure was unknown. Of the 34 cases, 20 (58.8%) treated cases were over age 35 years.

CDC recommends: "Consider hyperbaric oxygen therapy (HBO) therapy when the patient has a COHb level of more than 25–30%, there is evidence of cardiac involvement, severe acidosis, transient or prolonged unconsciousness, neurological impairment, abnormal neuropsychiatric testing, or the patient is ≥36 years in age. HBO is also administered at lower COHb (<25%) levels if suggested by clinical condition and/history of exposure."[10] Table 8 shows the hyperbaric treatment status of the 275 cases age 36 and older with known age, hyperbaric status and COHb level stratified by their COHb levels.

Table 8: Hyperbaric Treatment for Cases 36 Years of Age and Older, Michigan, 2014

Received Hyperbaric Treatment	Average COHb	No. Cases			
		Total	COHb < 25%	COHb 25-30%	COHb >30%
Yes	28.7	20	9	0	11
No	10.5	255	225	16	14

Death

There were 15 (2.3%) deaths from unintentional CO poisoning. Twelve deaths occurred at home and three deaths occurred at an “Other location”. Source of CO was known for 11 deaths; four deaths were fire related four were from a generator, two were from propane leak, and one was from a portable grill.

ANALYSIS OF OCCUPATIONAL EXPOSURES

One hundred and seventeen (18.7%) of the total cases with known exposure site (n=627) were identified as having occurred at work. Gender was known for 116 (99.1%) of the work-related cases: 68 (58.6%) were male, 48 (41.4%) were female. Eighty three (71.6%) were between the age of 18 and 44 years old, and 33 (28.4%) were more than 44 years old. (Table 11)

Table 11: Unintentional Occupational CO Poisoning Cases by Age and Gender, Michigan, 2014

Age (years)	Gender					
	Male		Female		Total	
	No.	%	No.	%	No.	%
≤17	0	0.0	0	0.0	0	0.0
18–44	47	69.1	36	75	83	71.6
>44	21	30.9	12	25	33	28.4
Total	68	58.6	48	41.4	116*	100

*One case with unknown gender

Forty-three (70.5%) of the 61 cases with known race were Caucasian, 11 (18.0%) were African American, and 7 (11.5%) were other, which included Hispanic.

COHb tests were reported for 101 cases with occupational exposure. The average COHb level for occupationally exposed individuals tested was 8.6%. Smoking status was known for 92 (91.1%) of the 101 occupationally exposed individuals with COHb levels. The distribution of
COHb levels by smoking status are shown in Table 12.

Table 12: Unintentional Occupational CO Poisoning Cases by COHb Levels and Smoking Status, Michigan 2014

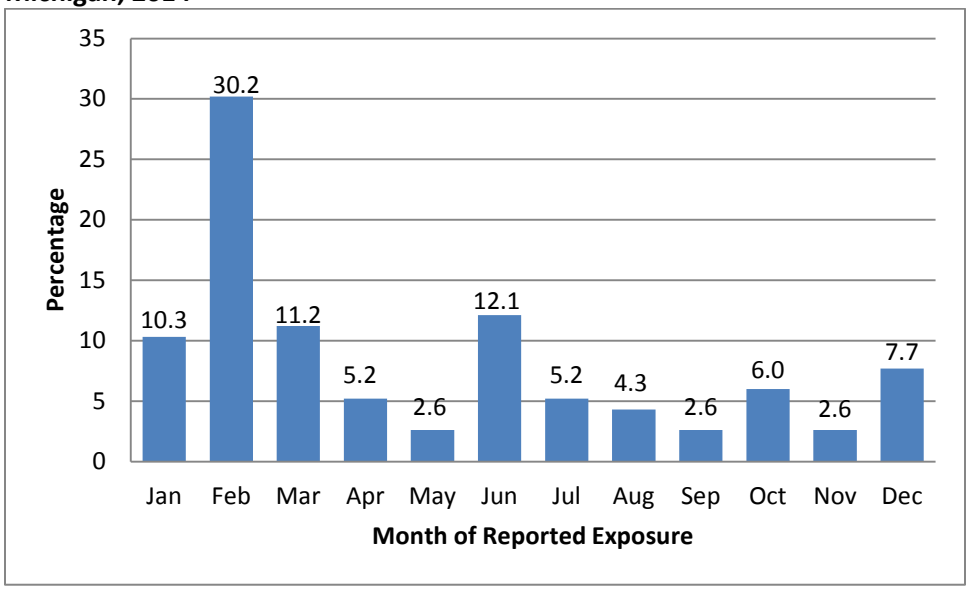
COHB %	Smoker		Nonsmoker		Total	
	No.	%	No.	%	No.	%
<5	8	20.5	34	64.2	42	45.7
5–10	15	38.5	4	7.5	19	20.7
10.1–20	13	33.3	9	17	22	23.9
>20	3	7.7	6	11.3	9	9.7
Total	**39**	**42.4**	**53**	**57.6**	**92**	**100**

Of the 117 occupationally exposed cases, the month of exposure was known for 116 (99.1%). (Table 13 and Figure 11) The largest percentage of cases occurred in February and June (35 [30.2%] and 14 [12.1], respectively).

Table 13: Unintentional Occupational CO Poisoning Cases by Month of Exposure, Michigan, 2014 (n=116)

Month	No. Cases	%
Jan	12	10.3
Feb	35	30.2
Mar	13	11.2
Apr	6	5.2
May	3	2.6
Jun	14	12.1
Jul	6	5.2
Aug	5	4.3
Sep	3	2.6
Oct	7	6
Nov	3	2.6
Dec	9	7.7
Total	**116**	**100**

Figure 11: Percentage of Unintentional CO Poisoning Cases by Month of Exposure, Michigan, 2014

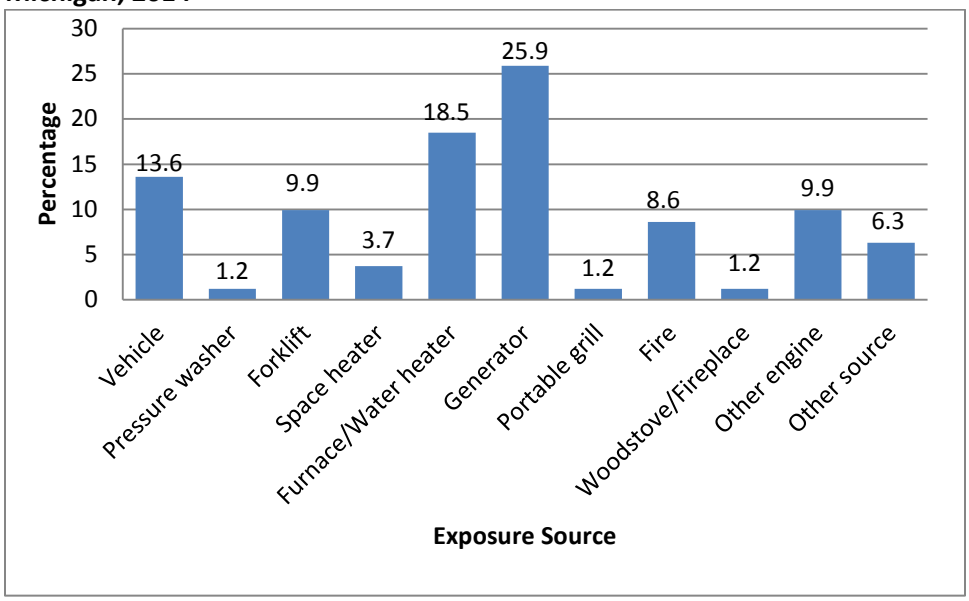


Of the 117 occupationally exposed cases, the source of exposure was known for 81 (69.2%) cases. The most common source of work-related exposure was from generators, 21 (25.9%) cases, followed by furnaces/water heaters, 15 (18.5%) cases (Table 14, Figure 12).

Table 14: Unintentional Occupational CO Poisoning Cases by Source of Exposure, Michigan, 2014

CO Source	No.	%
Vehicle	11	13.6
Pressure washer	1	1.2
Forklift	8	9.9
Space heater	3	3.7
Furnace/water heater	15	18.5
Generator	21	25.9
Portable grill	1	1.2
Fire	7	8.6
Woodstove/fireplace	1	1.2
Other engine	8	9.9
Other source	5	6.3
Total	**81**	**100**

Figure 12: Percentage of Occupational CO Poisoning Cases by Source of Exposure, Michigan, 2014

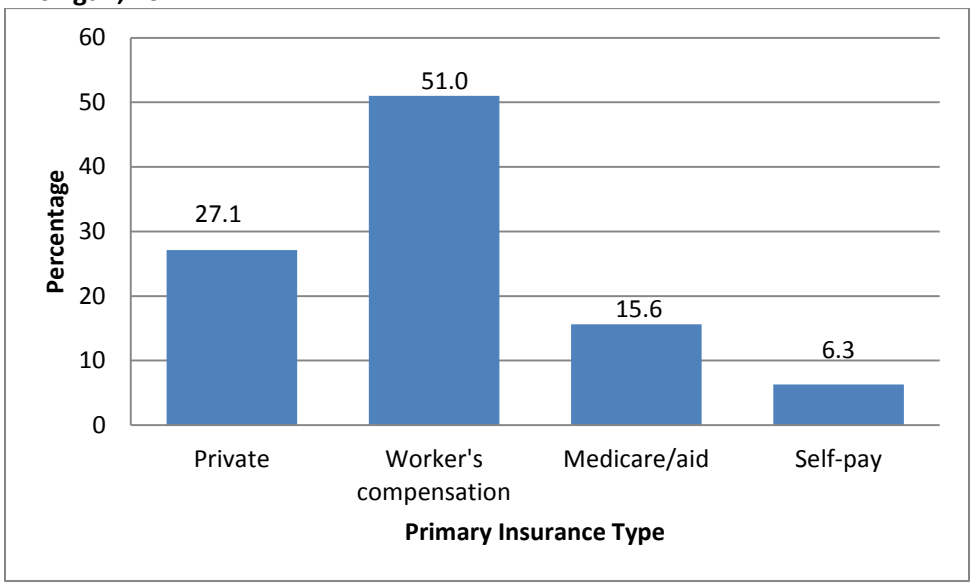


Of the 117 individuals occupationally exposed, insurance type was known for 96 (82.1%) workers. For 49 (51.0%) of these, worker's compensation was the expected payer, 26 (27.1%) had private insurance, and 6 (6.3%) were self-pay or did not have insurance (Table 15, Figure 13).

Table 15: Unintentional Occupational CO Poisoning Cases by Insurance Type, Michigan 2014 (n=96)

Insurance Type	No.	%
Private	26	27.1
Worker's compensation	49	51.0
Medicare/Medicaid	15	15.6
Self-pay	**6**	**6.3**
Total	**96**	**100**

Figure 13: Unintentional Occupational CO Poisoning Cases by Insurance Type, Michigan, 2014



DISCUSSION

The toxicity of CO and its impact on health is well documented. Exposure to CO can come from numerous sources and affect all population groups. Sub-groups at increased risk of adverse health effects from CO exposure are pregnant women and their fetus children, the elderly, and health-impaired individuals.[11] Although most cases of CO poisoning can be successfully treated depending on severity with either removal from exposure, oxygen therapy or hyperbaric oxygen, in some severe cases, long-term negative effects (cardiovascular abnormalities and neurological disturbances) can occur.[11]

In Michigan, for the year 2014, reports were received on 659 cases with confirmed unintentional CO poisoning. Four persons were treated for CO poisoning more than once. The reduced number of cases in 2014 was secondary to reduced hospital/ED reporting requests being sent rather than evidence of a decrease in CO exposure in the state.

Fifteen (2.3%) deaths were reported. Four of were fire related, four were from a generator, two were from a propane leak, one was from a portable grill, and four were from an unknown source. The most common source of CO exposure was a furnace or water heater in 160 (33.1%) cases with 15 (9.3%) cases took place at work.

A major limitation of the data for 2014 was the reduced number of cases compared to previous years, due to reduced hospital/ED reporting rather than evidence of a decrease in CO exposure in the state. This was because partway through the year the hospitals were notified that reporting was no longer required. Despite the usefulness of the data derived from the CO surveillance system, the collection, review and abstraction of CO poisoning medical records from Michigan's 136 hospitals proved to be too labor intensive and the project was phased out. We estimate that up to half the cases of CO poisoning may have been missed. Data compilation and analysis of the 2014 case reports that had been submitted became possible in 2015 with additional support from a public health professional in the CDC's Public Health Associate Program with a limited term assignment to MDHHS. For the future, MDHHS is transitioning to a passive surveillance system using administrative data from hospital discharges and death certificates, which will be posted on a web portal where the public can query the data. This web portal is under development by the MDHHS Michigan Tracking Network (www.michigan.gov/mitracking, which is funded by the CDC's Environmental Public Health Tracking Program

(www.cdc.gov/nceh/tracking). The MI Tracking web portal, which is expected to go live in late 2016, will make a range of environmental health, exposure and hazards data available.

Other limitations with the data presented in this report include: 1) Information may be missing in the different reporting sources (e.g., multiple vs single patient, treatment type). 2) Hospitals and other sources may not be reporting all cases and some cases are just simply missed. 3) The surveillance system does not capture Michigan residents who were treated for CO poisoning in out-of-state hospitals. 4) CO 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. 5) Transfer patient from one hospital to another for hyperbaric treatment resulted in missing information about the length of hospitalization and type of treatment. Thus we presume there are additional cases of unrecognized CO poisoning.

Prevention of exposure to CO and appropriate diagnosis are important to protect the health of the public. The following activities are needed:

- Improved awareness by medical professionals in the recognition of CO poisoning.
- Enhanced education of the general population of the possible harmful effects of CO poisoning after both mild and severe exposure would increase overall awareness.
- Targeted awareness campaigns to inform susceptible groups are particularly important.
- Increased awareness of the importance of the correct installation and maintenance of gas appliances is vital, including adequate ventilation, and on-going maintenance. Awareness of the potential sources of CO in the home is critical.
- Highlighted benefits of installing CO audible alarms as a preventative measure and installation of a CO alarm with furnace/water heater maintenance visits should increase the use of CO monitors.

Interventions

Identification of individuals diagnosed with CO poisoning is the first step to initiate preventive interventions. The four most common sources of CO were from furnaces (160 [33.1%]), generators (62 [12.8%]), and vehicles (49 [10.1%]). 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 for CO exposure. In many cases of CO poisoning, the generator is operated too close to a window, in an attached garage, or even inside the home. Sometimes these

inappropriate placements are done to prevent theft of the generator. These generators are often run under full load which increases the amount of CO produced. A generator operating in the basement of a home can produce a lethal level of CO in 15 minutes.[12] Educational materials and campaigns to address this issue have been developed by CDC (www.cdc.gov/co) and MDHHS (www.michigan.gov/carbononoxide). 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 in both the home and workplace 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 electric powered equipment for fuel powered equipment during indoor work. For the workplace, at the minimum, periodic air monitoring should be conducted to ensure that the Michigan Occupational Safety and Health Administration (MIOSHA) standard for General Industry of 35 parts per million (ppm) as an 8-hour time-weighted-average (TWA) exposure limit, with a 200 ppm ceiling, and, for construction 50 ppm TWA, with no ceiling limit is being met.

Ongoing vigilance is needed by the public to protect itself from CO exposure wherever combustion takes place. Health care providers need to be vigilant in recognizing CO toxicity by considering where a patient's symptoms are occurring and confirmation by measurement of COHb levels.

Carbon Monoxide Detectors

Most of Michigan's unintentional CO exposures occurred in non-occupational settings. There are no non-occupational indoor air standards for CO in Michigan. Installation of CO detectors is recommended in homes that burn natural gas, oil or wood. Effective March 23, 2009, a modification to Michigan's Uniform Construction Code (Act 230 of 1972) mandated that all single-family and multi-family dwellings have CO 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. The CO detectors cited in the Construction Code are required to meet ANSI/UL Standard 2034. Standard 2034 was designed to protect adults by alarming at a CO level which would produce a level of 10% COHb in an adult. For 2014, 547 cases had a COHb level recorded. Of the 547, 283 (51.7%) had a COHb level of less than 10%.

Before Standard 2034 was revised, CO detectors alarmed at lower levels. This created a large number of false alarms in some communities during particular weather patterns or in areas of high vehicle traffic. In order to reduce the number of false alarms, CO detectors meeting Standard 2034 will not alarm at constant level of 30 ppm or less for 30 days. Individuals with atherosclerosis or history of heart disease or stroke may want to consider purchasing a CO detector with a digital readout and a button that can be pressed to give the highest reading recorded. Depending on the CO detector, the level on the readout may be lower than 30 ppm. Background readings in the general environment are less than 4pmm. This type of detector can be used to give an earlier warning of elevated CO in the home.

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Appendix A: Michigan Uniform Construction Code (Act 230 of 1972), Section 125.1504 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