UPDATED AUGUST 8, 2014

2009 ANNUAL REPORT

CARBON MONOXIDE POISONING IN MICHIGAN

Table of Contents

2009 ANNUAL REPORT ON CARBON MONOXIDE POISONING IN MICHIGAN

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from the report dated 4/16/2012*

SUMMARY

This is the first annual report on carbon monoxide (CO) poisoning surveillance in Michigan. This report provides information about the 1,050 individuals who were unintentionally poisoned by carbon monoxide in Michigan in 2009, including 41 deaths. 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.

*This report is revised from a report posted April 16, 2014, based on an update of the data after merging information about individuals reported in multiple data sources and deleting reports that did not meet the case definition.

Carbon Monoxide Standards

- **General Atmosphere 9 ppm[2]**
- **General Industry 35 ppm 8 hour average with 200 ppm ceiling[3]**
- **Construction Industry 50 ppm 8 hour average [4]**

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 arrhythmias 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) (Appendix A)[5]. Findings included that most CO poisonings occurred at home. These poisonings most often involved females, children aged ≤ 17 years and 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 1/1/2009 to 12/31/2009. 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 X47 and T58 was a contributing cause. In addition, industrial hygienists from the Michigan OSHA program, occupational disease reports and a newspaper clipping service identified a few cases.

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 included 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 was collected too long after exposure to still be elevated.

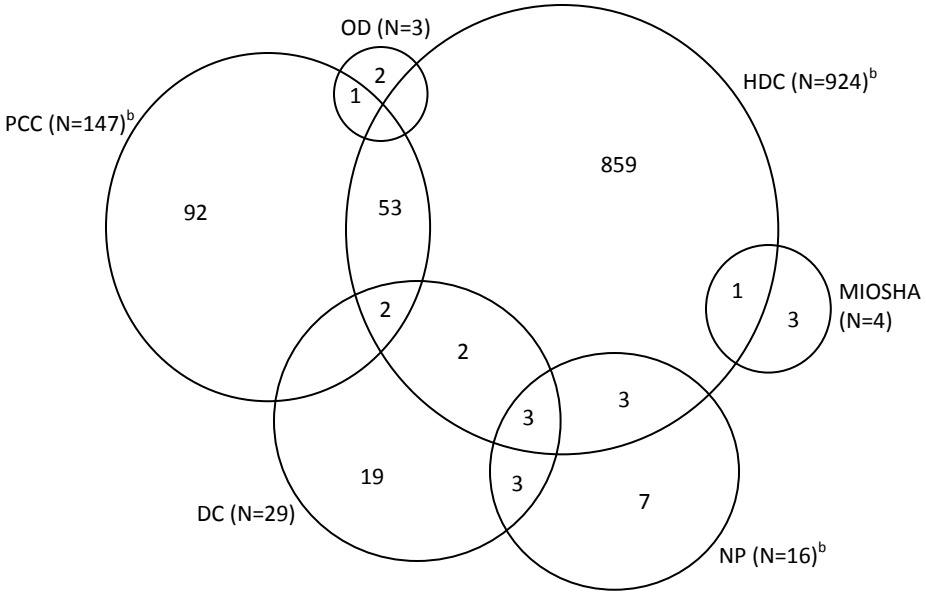
Individuals reported by multiple hospitals and/ or multiple data sources were matched by name and exposure date; matched records were to merged to create one record per confirmed case.

Frequencies and rates of CO poisoning were generated from these data. Denominators for rates are from the U.S. Census Bureau.[7]

Where appropriate, employers of

In individuals with atherosclerosis, carboxyhemoglobin levels as low as 3-4% can increase the frequency and severity of angina or claudication, at a 6% level, cardiac arrhythmias may be induced and at a 10% level a myocardial infarction may be precipitated.[5]

Figure 1 Overlap of Reporting Sources for 1,050 CO Poisoning Cases, Michigan 2009



[a]Ns represent the total number of individuals reported by source.
[b]One individual had overlap reporting of HDC-PCC-NP.
Reporting Source: OD= Occupational Disease Reports, HDC=Hospital Discharge, NP=Newspaper Reports, DC=Death Certificates, PCC= Poison Control Center

occupationally exposed cases were referred to MIOSHA for follow-up to determine if there was on-going risk of CO exposure for occupationally exposed cases and results of MIOSHA referrals.

RESULTS

A total of 1,356 reports of unintentional carbon monoxide poisoning were received. After records review to select cases meeting the case definition and matching for multiple case reports per individual, 1050 individuals remained.

Figure 1 shows the numbers of individuals by data source, illustrating the numbers reported by one source only or multiple sources. Of the 924, individuals identified by a hospital report, 859 (93%) were not identified by any other

Of the 1,050 individuals reported with unintentional CO poisoning in 2009 there were 41 (3.3%) deaths. Twenty-two deaths were fire related and 19 were non-fire related.

Table 1 Number and Incidence of Unintentional CO Poisoning by Gender and Age, Michigan 2009

	Male	Michigan Male Population	Rate/100,000 US Census Data*	Fe-male	Michigan Female Population	Rate/100,000 US Census Data*	Unknown Gender	TOTAL
Unknown Age	5			7			9	21
≤ 17 yrs old	104	1,202 546	8.6	136	1,147,346	11.9	4	244
18 – 44 yrs	193	1,779,448	10.8	255	1,752,662	14.5	1	449
45 – 64 yrs	102	1,349,251	7.6	131	1,398,702	9.4	2	235
≥65 yrs old	52	571,609	9.1	46	768,163	6.0	3	101
TOTAL	456			575			19	1,050

*Total number by age in Michigan; 7/1/2009 Resident Population Estimates, U.S. Census Bureau. [4]

data source. Sixty-two percent of individuals reported from PCC were reported only by the PCC. Smaller numbers of individuals were identified from death certificates, newspaper reports, and occupational disease reports alone or in in combination.

Death

There were 41 (3.9%) deaths from unintentional carbon monoxide poisoning. Twenty-nine deaths were identified by a death certificate; the other twelve were reported only by hospital discharge, of which all but one were fire-related. Twenty-two deaths in total were fire related and 17 were non-fire related.

Table 2 Distribution and Incidence Rates of Unintentional CO Poisoning by Race, Michigan 2009

	Michigan Population*	# Cases	Rate/100,000
WHITE	8,091,776	414	5.1
BLACK	1,413,582	123	8.8
ASIAN	241,597	2	0.8
HISPANIC	385,491	21	5.4
NATIVE AM	62,485	1	1.6
MULTI	155,850	1	0.6

*Total number by race in Michigan; 7/1/2009 Resident Population Estimates, U.S. Census Bureau.[4]

Source of CO was unknown for two of the 17 non-fire deaths; seven were from a generator, five from a vehicle, two from a furnace or water heater, two from a space heater, and one from a charcoal grill.

Gender and Age

Gender was known for 1,031 individuals, 456 (44.2) were male, 575 (55.7%) were female (Table 1). Of the 1,026 individuals where age was known, 244 (23.5%) were 17 years old or younger, 449 (43.8%) were 18 – 44, 235 (22.9%) were 45 – 64 and 98 (9.6%) were 65 or older. Females age 18 – 44 (14.5/100,000) and females younger than 18 (11.9/100,000) had the highest incident rates.

Race

Race was known for 562 (53.5%) individuals (Table 2), 414 (73.7%) were Caucasian, 123 (22.0%) were African American, 21 (3.7%) were Hispanic, two (0.4%) were Asian, one was Native American, and one was multi-racial. African Americans had the highest incidence

rate of carbon monoxide poisoning (8.8/100,000) .

Month of Poisoning

Month of exposure was known for 1,045 individuals (Table 3). The most common month for exposure occurred in January, with 207 (19.8%) individuals, and in the other winter months. The lowest numbers were in the spring and summer months.

Table 3 Unintentional CO Poisoning Reports by Month, Michigan 2009

	# Reports*	(%)
Jan	207	(19.8)
Feb	133	(12.7)
Mar	105	(10.1)
Apr	69	(6.6)
May	43	(4.1)
Jun	55	(5.2)
Jul	39	(3.7)
Aug	37	(3.5)
Sept	36	(3.4)
Oct	110	(10.5)
Nov	88	(8.4)
Dec	123	(11.7)
TOTAL	1,045	(100)

*5 unknown date of exposure/admission

Carboxyhemoglobin Testing

Carboxyhemoglobin level (COHb) was known for 828 (78.9%) of the 1,050 individuals. The average COHb level for all individuals tested was 10.0%. The range was 0.0% to 96.0% of COHb; 277 (33.4%) individuals had a COHb level greater than 10% and 129 (15.6%) individuals had a COHb level greater than 20%. Smoking status was known for 642 (77.5%)) of the 828 individuals tested for COHb, of which 229 (35.7%) were smokers. The average COHb level was about the same between smokers and non-smokers, but a greater proportion of nonsmokers had levels higher than 20% (67 or 16.2%) than smokers (24 or 10.5%)

Hyperbaric Treatment

Sixty five (6.2%) individuals were treated with hyperbaric chamber oxygen in 2009. The average COHb level recorded for these individuals was 25.3%. Only one patient was given hyperbaric chamber oxygen without a COHb level taken. This was a child, age 13, one of four family members exposed to CO by a furnace and generator heating the home. COHb levels of the other three members ranged from 17% to 36%.

Sixty (92.3%) of the hyperbaric treatments were for non-occupational exposures to CO. They included 11 from furnace or water heater exposures, 15 from fire, 17 from vehicle exposure, six from generators, and two from assorted other sources including power washers, cement saws, and a snowmobile. Occupational exposures that were treated with hyperbaric oxygen included two construction exposures to gasoline powered generators, a taxi driver with two separate exposure incidents from vehicle exhaust, one employee from a manufacturing facility, one from a services industry, and one from a food storage facility.

Hospitalizations

Of the 1,050 individuals with reported CO exposure, 115 (11.0%) were hospitalized overnight. The most common source of CO requiring overnight hospitalization included twenty-seven (23.4%) from fire exposure, eighteen (15.6%) from vehicle exhaust, and fifteen (13.0%) from furnaces or water heaters. For the 53 individuals where length of stay was known, the average hospitalization was 7.5 days and the median hospitalization was 2 days. The longest hospitalization was for 53 days following a fire related exposure. Twenty -eight individuals (52.8%) stayed two days or less, thirteen (24.5%) stayed 3 to 7 days, three (5.7%) stayed 7 to 14 days, and nine (17.0%) stayed more than two weeks.

Twelve (10.4%) of the 115 hospitalizations were due to occupational CO exposure. Of the 12 occupational exposure-related hospitalizations, 3 (25%) were exposed from generators, 3 (25%) from vehicle exhaust, 2 (16.7%) from fire, 2 (16.7%) from furnaces, one (8.3%) from heavy equipment and one where the source of CO was unknown.

Source and Location of Exposure

Exposure source was known for 728 (69.3%) of the 1,050 individuals, including 85 (78.7%)of the 108 work-related exposures. (Table 4, Figure 2). The location of exposure was known as either “work” or “non-work” for 931 (88.7%) of the individuals.

The most common exposure source for non-work exposure was furnace or water heaters. For work exposure, commonly the CO was from power machinery powered by combustion engines. Forklifts, concrete saws and power washers were the most frequently identified power machinery listed in occupational exposures. Power machinery at non-work exposures was more varied in type, identified most often as snow blowers, tractors, chain saws and power washers.

Fire: Exposure at work

Fire was the source of carbon monoxide exposure for 92 (8.7%) individuals in Michigan. Where location of exposure was known, twelve (13.0%) were occupational fire exposures. Six individuals exposed to carbon monoxide from occupational fires worked in manufacturing, five employees were police or firefighters, and one individual was employed in food service. Twenty-two (23.9%) fire related exposures resulted in death, and none were work-related.

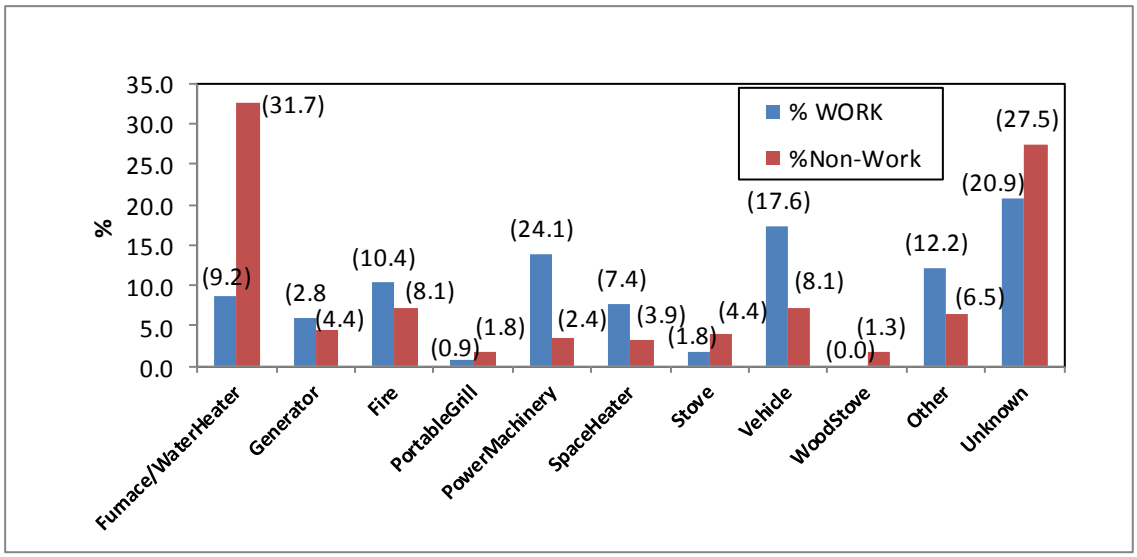
Gender and Race: Exposures at Work

Gender was known for 105 of the 108 work-related cases; 63 (60.0%) male, 42 (40.0%) female (Table 5). Of the 105 where age was known, 65 (62.0%) were between the age of 18 and 44 and 37 (37.0%) were age 45 to 64.

Race was known for 54 occupationally exposed

Of the 115 individuals hospitalized for CO poisoning overnight, the most common source included 27 from fire exposure, 18 from vehicle exhaust and 15 from furnaces or water heaters. Twelve (10.4%) hospitalizations were from a CO exposure at work.

Figure 2 Unintentional CO Poisoning Source by Work and Non-Work Exposure, Michigan 2009



individuals; 44 (81.5%) were Caucasian, 9 (16.7%) were African American, one (1.9%) was Hispanic.

COHB: Exposures at Work

Carboxyhemoglobin tests were reported for 93 individuals with occupational exposure. The average COHb level for occupationally exposed individuals tested was 9.4%. Smoking status was known for 72 (77.4%) of the 93 occupationally exposed individuals with COHb levels. The distribution of COHb levels by smoking status for occupationally exposed individuals is shown in Table 6.

Month of Exposure: Exposures at Work

Of the 108 individuals occupationally exposed, month of exposure is shown in Table 7. The largest percentage of reported exposure occurred in January (22.4%) and the other winter months, the lowest number of exposures were in the spring and summer months.

Industry Site: Exposures at Work

NIOSH's National Occupational Research Agenda defines ten industry sector groupings based on the industry classifications of the

Table 4 Unintentional CO Poisoning Source by Work and Non-Work Exposure, Michigan 2009

	Furnace/ Water Heater		Generator		Fire		Other		Portable Grill		Power Machinery		Space Heater		Stove		Vehicle		Wood Stove		Unknown		Total
	#	(%)	#	(%)	#	(%)	#	(%)	#	(%)	#	(%)	#	(%)	#	(%)	#	(%)	#	(%)	#	(%)	#
Work	10	(9.2)	3	(2.8)	12	(10.4)	14	(1.1)	1	(0.9)	26	(24.1)	8	(7.4)	2	(1.8)	19	(17.6)	0	(0.0)	23	(21.3)	108
Non-work Wor	261	(31.7)	38	(4.4)	67	(8.1)	58	(7.0)	15	(1.8)	23	(2.4)	25	(3.0)	37	(4.4)	67	(8.1)	11	(1.3)	211	(25.6)	823
Unk	4	(3.3)	6	(5.0)	13	(10.9)	0	-	1	(0.8)	2	(1.6)	1	(0.8)	0	-	4	(3.3)	0	-	88	(74.0)	119
Total	275	(26.1)	47	(4.5)	92	(8.7)	72	(6.8)	17	(1.6)	51	(4.8)	34	(3.2)	39	(3.7)	90	(8.6)	11	(1.0)	322	(30.6)	1,050

Table 5 Number and Percent of Unintentional Occupational CO Poisoning by Gender and Age, Michigan 2009

	Male		Female		Unknown Gender	Total	
	Number	Percent (%)	Number	Percent (%)	Number	Number	Percent (%)
≤ 17 yrs old	1	(1.6)	0	(0.0)	0	1	(0.9)
18 - 44 yrs	39	(62.0)	26	(62.0	0	65	(60.1)
45 - 64 yrs	21	(33.3)	16	(38.1)	0	37	(34.3)
≥65 yrs	2	(3.2)	0	(0.0)	0	2	(1.9)
UnknownAge	0	(0.0)	0	(0.0)	3	3	(2.8)
Total	63	(100.0)	42	(100.0)	3	108	(100.0)

North American Industry Classification System (NAICS). NORA Sector Codes were assigned for 97 of the 108 work related exposures (Table 8). The largest number of exposures occurred in the Services sector.

Twelve CO poisonings were reported where multiple employees were affected by the same source at the same facility for a total of 4 events. Three individuals in the banking industry were exposed as the result of a construction project; three individuals in a foster care group home were exposed to a leaky furnace; and a generator at an indoor location was the cause of CO exposure for three cleaning staff. In unrelated incidents, several food service workers were exposed to leaky furnaces or hot water heaters.

Table 6 Unintentional Occupational CO Poisoning by Reported COHb Levels and Smoking Status, Michigan 2009

COHb %	Smoker	Non-Smoker	Unknown	TO-TAL
Unknown		5		5
≤5%	9	27	10	46
6 -10%	8	4	2	14
11-20%	1	12	5	18
>20%	0	6	4	10
TOTAL	18	54	21	93

The highest carboxyhemoglobin levels reported from occupational exposure came from a night auditor (68%) exposed to a hot water heater with combustion problems, and a construction worker (36%) working in a home with two generators running.

Work Site Investigations, 2009

In this first year of the carbon monoxide surveillance system two workplace follow up investigations were conducted. In June 2009, MIOSHA inspected a chemical plant as a result of a 2008 hospital discharge report of a worker cleaning steel vats with methylene chloride. After skin absorption or inhalation methylene chloride is broken down in the body to carbon monoxide. This worker had an elevated carboxyhemoglobin. He lost consciousness from the exposure, was transported by EMS and hospitalized overnight. Eight citations were issued at this inspection, three were related to air contaminants in confined spaces. Employees had not received information and training on the health effects of methylene chloride nor were appropriate gloves or respirators provided to employees.

In December 2009 MIOSHA conducted an

inspection where three food service establishment employees were exposed to carbon monoxide from a leaking furnace/water heater. One employee's carboxyhemoglobin level was measured at 26%. No citations were issued because, at the time of inspection, the hot water heater was in working order and air monitoring performed by the industrial hygienist did not detect any further leakage of CO.

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.[6, full text in Appendix A]

In Michigan, for the year 2009, reports were received on 1,050 individuals for unintentional CO poisoning. Forty-one (3.3%) deaths were recorded; twenty-two (53.7%) were fire related.

Most unintentional CO exposures occurred at home in the months of October to March. Furnaces or water heaters were the most common sources of CO for non-work exposures, and power equipment for exposures at work.

Table 7 Unintentional Occupational CO Poisoning Reports by Month, Michigan 2009

	Number	Percent (%)
January	24	(22.4)
February	13	(12.1)
March	7	(6.5)
April	5	(4.7)
May	4	(3.7)
June	4	(3.7)
July	3	(2.8)
August	2	(1.9)
September	9	(8.4)
October	11	(10.3)
November	13	(12.1)
December	12	(11.2)
TOTAL	107	(99.9)

** 1 unknown date of exposure, occupational

Carboxyhemoglobin (COHb) testing was reported for 849 individuals with actual COHb levels reported for 663. 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

Table 8 NORA SECTOR CODES, Occupational CO Poisoning, Michigan 2009

Industry	NAICS Code	# Cases
Agriculture, Forestry & Fishing	11	1
Construction	23	11
Healthcare & Social Assistance	62	8
Manufacturing	31-33	13
Mining	21	0
Oil and Gas Extraction	211,213,111,213,112	0
Public Safety	922,149,221,600,000	8
Services (except Public Safety)	51-56, 61, 71-72, 81	39
Transportation	48-49 & 22	7
Wholesale and Retail Trade	42 & 44-45	10
TOTAL		97

*13 were unknown Industry Type

medical evaluation, and the administration of oxygen in the ambulance or emergency department (ED) prior to the COHb test. In the general population, normal levels of COHb are less than 1%. Approximately half the COHb measured levels were less than or equal to 5% .

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. 3) Carbon monoxide poisoning, particularly at lower levels of exposure, is a difficult condition to diagnose and so we presume there are additional cases of unrecognized carbon monoxide poisonings.

An advisory committee of the Michigan Occupational Health Standards Commission has recommended the MIOSHA standard be changed to 25 ppm TWA and 200 ppm ceiling for both general industry and construction.

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 (26.1%)), fires (8.7%), vehicles (8.6%), and generators (4.5%). 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.[8,9]

Important 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

Public Educational Topics for CO

- **Potential sources of CO exposure**
- **Common symptoms of CO poisoning**
- **Hazards of CO, especially in colder months where adverse effects are more frequent**

correctly and are located in properly ventilated areas and substituting electric powered forklifts and other 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.

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 construction, addition of a bedroom or other renovation. The location of these detectors and other specifics are outlined in section 125.1504f of Michigan Compiled Laws (Appendix B).

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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http://www.cdc.gov/co/

www.michigan.gov/carbonmonoxide

APPENDICES

APPENDIX A

Centers for Disease Control and Prevention **Morbidity and Mortality Weekly Report (*MMWR*)**
CDC 24/7: Saving Lives, Protecting People, Saving Money Through Prevention.

Carbon Monoxide Exposures --- United States, 2000--2009

Weekly
August 5, 2011 / 60(30);1014-1017

Carbon monoxide (CO) poisoning is a leading cause of unintentional poisoning deaths in the United States (*1*). CO is an odorless, colorless gas that usually remains undetectable until exposure results in injury or death. CO poisoning is preventable; nonetheless, unintentional, non--fire-related CO poisoning is responsible for approximately 15,000 emergency department visits and nearly 500 deaths annually in the United States (*2*). National estimates of CO exposures have been based on secondary data sources, such as hospital administrative records, and are limited to exposures treated within the health-care system. To describe more completely the national burden of CO exposure and risk factors associated with vulnerable populations, CDC used data from the National Poison Data System (NPDS) to characterize reported unintentional, non--fire-related CO exposures, including those that were managed at the site of exposure and were not treated at a health-care facility. Among 68,316 CO exposures reported to poison centers during 2000--2009, a total of 30,798 (45.1%) were managed at the site of exposure with instructions from the poison center by telephone, 36,691 (53.7%) were treated at a health-care facility, and the management site for the remainder was unknown. Although symptoms varied slightly between persons managed on-site and those treated at a health-care facility, most CO exposures occurred at home and most often involved females, children aged ≤17 years, and adults aged 18--44 years. Surveillance and analysis of data from NPDS and secondary sources might provide a more comprehensive description of the burden of CO exposure in the United States and assist in the development of interventions better targeted to high-risk populations.

NPDS is a near real-time, comprehensive poisoning surveillance system that collects data on calls regarding poison exposure placed to any of the U.S. poison centers. NPDS is owned and managed by the American Association of Poison Control Centers. CDC uses NPDS to receive, analyze, and display data from poison center calls. Calls to poison centers come from health-care professionals or persons voluntarily reporting a poison exposure. The information provided by the caller might pertain to themselves or others and is used by the poison center to create a record of the call with details such as the date, poison substance, and symptoms.* If the report concerns someone who was treated at a health-care facility, a poison center staff member will contact the health-care facility during the course of treatment to obtain pertinent clinical information. Details from poison center records are uploaded to NPDS.

NPDS data from 2000--2009 in which CO was identified in the substance data field and the reason for exposure was recorded as "unintentional" were extracted for this report If "fire" or "smoke" were in the substance data field, these exposures were excluded to restrict the analysis to unintentional, non--fire-related CO exposures. The data were then stratified according to management site (i.e., health-care facility or site of exposure) and a descriptive analysis was conducted. Rates were calculated using reports of CO exposures to the poison centers and 2000--2009 U.S. census data (*3,4*). Additionally, the characteristics of persons managed on-site were compared with those of persons managed at a health-care facility.

The 68,316 CO exposures reported to poison centers during 2000--2009 represented 0.29% of all poison exposures reported in NPDS. Compared with all exposures reported to NPDS, the proportion of reported CO exposures steadily declined, from 0.31% in 2006 to 0.24% in 2009. On average, 23.2 CO exposures were reported per 1 million population per year (range: 19.7--25.3) (Figure). The number of persons with reported CO exposures who were transported to a health-care facility ranged from 11.1 to 14.3 per million each year and the number of persons with reported CO exposures who were managed on-site ranged from 8.6 to 14.0 per million each year (Figure). Total reported CO exposures included 34,356 females (23.0 per million) and 30,257 males (20.9 per million). The most commonly exposed age groups were <17 years (25.7 per million) and 18--44 years (19.4 per million) (Table 1).

CO exposures most frequently occurred between November and February (53.5%) and among persons residing in the Midwest (31.2 per million) or the Northeast (36.7 per million). A greater proportion of CO exposures managed on-site occurred in the Northeast (35.5%) (Table 1). The exposure site was reported as "residence" (77.6%) or "workplace" (12.0%) in most cases (Table 1). Clinical symptoms were reported for 68.1% of the total exposures, with headache, nausea, and dizziness most commonly reported (Table 2). However, 83.0% of reported exposures had a medical outcome of "no effect" or "minor effect." During 2000--2009, a total of 235 CO exposure--related deaths were reported to NPDS. Of those persons who died, 65.0% were male and 30.5% were aged 18--44 years. Most persons (68.2%) transported to a health-care facility were aged <45 years and 18.6% experienced confusion, syncope, dyspnea, or chest pain following CO exposure. In contrast, among persons managed on-site, 6.2% experienced confusion, syncope, dyspnea, or chest pain (Table 2).

Reported by

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Editorial Note

NPDS provides national data regarding CO-exposed persons treated at a health-care facility and those who do not seek medical care at a health-care facility. This is the first analysis for which NPDS has been used to examine a 10-year period of reported CO exposures. During 2000--2009, based on reports to NPDS, 30,798 persons were exposed to CO but were not treated at a health-care facility. Those persons would not have been identified through CO exposure data sources that rely on health-care facility records and mortality data. The characteristics of all CO exposures reported in NPDS, including those treated on-site and at a health-care facility, are consistent with previous knowledge of CO exposure (1,2). Women and children are the most commonly exposed, but deaths from CO exposure more often occur among men, and exposures most often occur at home and during winter months. CO exposures in the Northeast more frequently were managed on-site.

From 2006 to 2009, the rate of reported CO exposures steadily declined, and the call proportion declined from 0.31% to 0.24%. Similarly, the proportion of CO exposures among all reported unintentional poison exposures decreased by 0.8% during the period, which might be attributable to an overall reduction in calls to poison centers for any unintentional poisoning. The decrease in CO exposure calls to poison centers also might be a result of factors such as increased use of home CO alarms and improved use and maintenance of portable generators and other CO-emitting devices. Data available through NPDS are limited and insufficient to identify specific factors that might

contribute to the observed decline in CO exposure calls. Poison center case notes could provide useful information to identify sources of exposure such as portable generators and furnaces, which are common in unintentional CO poisonings (5).

The findings in this report are subject to at least three limitations. First, not all CO exposures recorded in NPDS are confirmed with biological testing. Each poison expert managing a call uses their own clinical knowledge to determine whether the reported health effects are attributable to the implicated exposure. In some instances, follow-up calls from a poison center to a health-care facility might identify an elevated carboxyhemoglobin level, but this finding would be indicated in case notes, which are not included in the data poison centers submit to NPDS. Second, additional details regarding the cause of exposure, which would be included in case notes and might be useful in understanding risk-behaviors for public health prevention planning, also are omitted from data submitted to NPDS. Finally, the reported exposures represented in this analysis are an underestimate of all CO exposures. Although >20,000 CO exposure-related emergency department visits are reported annually in the United States, NPDS only captured 36,691 of those over a 10-year period (6). Likewise, the number of deaths is an underestimate; previous literature has reported that approximately 450 CO poisoning deaths occur annually in the United States (2). This underestimate exists partly because NPDS is a passive surveillance system and poison center use can vary by geographic location (7). However, CO exposures recorded by NPDS can be used to supplement data from other CO surveillance systems.

Previously, formal characterization of persons exposed to CO only included those who sought treatment at a health-care facility. This left an information gap that could not be addressed with current surveillance methods using hospital administrative records. NPDS can be used to more accurately depict the burden of CO poisoning and its true health impact and cost to society. Using NPDS data, this report found that the demographics of persons managed on-site for CO exposure and those treated at a health-care facility were similar, and the predominant exposure location (e.g., residence) also was similar. This suggests that current prevention efforts for CO poisoning, such as home installation of CO alarms, also can apply to the population managed on-site. NPDS can be useful in monitoring the impact of such prevention efforts. Additionally, state health departments can partner with local poison centers to obtain additional information from case notes to further characterize populations at-risk, determine the circumstances preceding CO exposure, and help develop local- and state-level approaches to prevent CO exposure.

Acknowledgments

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* Poison center staff members are trained how to judge whether an exposure has occurred. They use specific information provided by the caller in this determination. If the substance causing the poisoning can not be identified with certainty, it would be classified as "unknown." Poison centers use a combination of reported information, including potential CO sources, CO alarms, symptoms, and fire/rescue CO readings in the same environment to classify calls as CO-related.

What is already known on this topic?

National estimates of carbon monoxide (CO) exposures have only included persons who receive medical attention at a health-care facility.

What is added by this report?

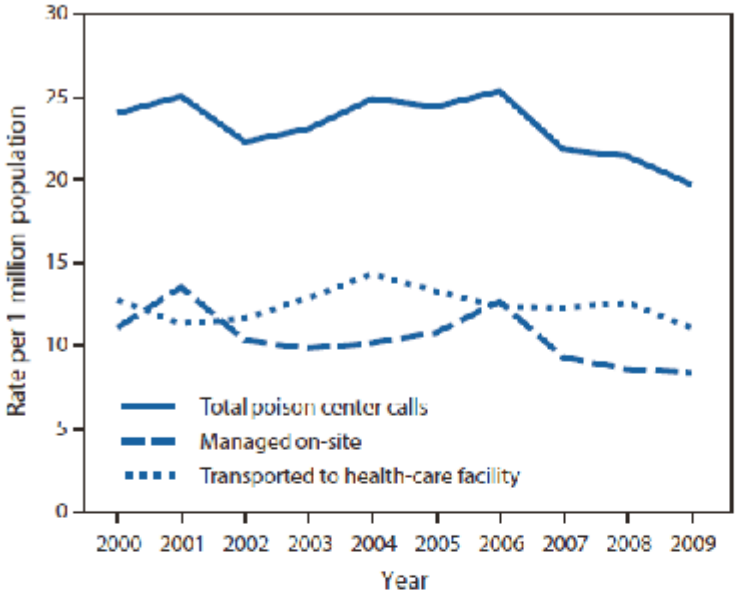
During 2000--2009, a total of 30,798 CO exposures managed outside of a health-care facility were reported in the National Poison Data System (NPDS) that would not have been identified by health-care administrative records. A greater proportion of CO exposures managed on-site were in the Northeast (35.5%), and health effects as a result of CO exposure generally were less severe among persons managed on-site than among those treated at a health-care facility.

What are the implications for public health practice?

NPDS is a useful source of CO-related exposure surveillance data, especially for persons whose CO exposure was not severe enough to require treatment in a health-care facility. State health departments can use this data to detect recent CO exposures and obtain additional information from local poison centers to further characterize populations at-risk, determine the circumstances preceding CO exposure, and better ensure that public health communication and preventive interventions include all potentially affected populations.

FIGURE. Annual rate* of reported carbon monoxide exposures --- National Poison Data System, United States 2000--2009

APPENDIX A



Source: US Census Bureau. Annual estimates of the resident population for the United States, regions, states, and Puerto Rico: April 1, 2000 to July 1, 2009. Washington, DC: US Census Bureau, Population Division; 2010.

* Per 1 million population.

Alternate Text: The figure above shows the annual rate of reported carbon monoxide exposures in the United States during 2000-2009, according to the National Poison Data System. On average, 23.2 CO exposures were reported per 1 million population per year (range: 19.7-25.3).

TABLE 1. Incidence and treatment of reported exposures to unintentional, non--fire-related carbon monoxide --- National Poison Data System, United States, 2000--2009

Variable*	Total (N = 68,316)			Managed on-site* (N = 30,798)			Transported to health-care facility* (N = 36,691)		
	No.	(%)	Rate per 1 million†	No.	(%)	Rate per 1 million†	No.	(%)	Rate per 1 million†
Age (yrs)									
≤17	18,896	(27.7)	25.7	7,367	(23.9)	10.0	11,344	(30.9)	15.4
18--44	23,100	(20.4)	19.4	9,171	(29.8)	8.1	13,673	(37.3)	12.0

45--64	7,806	(11.4)	10.9	2,924	(9.5)	4.1	4,796	(13.1)	6.7
≥65	2,287	(3.4)	6.2	825	(2.7)	2.2	1,431	(3.9)	3.9
Sex									
Female	34,356	(50.3)	23.0	15,631	(50.8)	10.5	18,282	(59.4)	12.2
Male	30,257	(44.3)	20.9	12,934	(42.0)	8.9	16,982	(46.3)	11.7
Region[§]									
Midwest	20,527	(30.1)		9,465	(30.7)		10,840	(29.5)	
Northeast	20,030	(29.3)		10,919	(35.5)		8,966	(24.4)	
West	13,510	(19.8)		4,224	(13.7)		6,984	(19.0)	
South	11,366	(16.6)		4,989	(16.2)		8,243	(22.5)	
Exposure site[§]									
Residence	53,039	(77.6)		24,734	(80.3)		27,569	(75.1)	
Workplace	8,170	(12.0)		2,789	(9.1)		5,273	(14.4)	
Public area	2,593	(3.8)		1,292	(4.2)		1,268	(3.5)	
School	2,016	(3.0)		28	(0.1)		119	(0.3)	
Other	2,498	(4.7)		1,955	(6.3)		2,340	(6.4)	
Outcome									
Death	235	(0.3)		95	(0.3)		106	(0.3)	
Major effect[¶]	1,027	(1.5)		26	(0.1)		995	(2.7)	
Moderate effect**	10,291	(15.1)		1,542	(5.0)		8,630	(23.5)	
Minor effect[††]	34,207	(50.1)		12,430	(40.4)		21,345	(58.2)	

No effect	22,520	(33.0)		16,697	(54.2)		5,595	(15.3)	

* Excludes responses listed as "unknown"; therefore, sums might not total 100%.

† Total population based on U.S. Census Bureau data. Source: Annual estimates of the resident population for the United States by sex, selected age group, and regions: April 1, 2000 to July 1, 2009. Washington, DC: U.S. Census Bureau, Population Division; 2010.

§ Rates could not be calculated.

¶ Exposure symptoms were life-threatening or resulted in significant residual disability or disfigurement.

** Exposure symptoms were pronounced, prolonged, or systemic and usually required some form of treatment.

†† Exposure symptoms were minimally noticeable.

TABLE 2. Symptoms of persons exposed to carbon monoxide, by treatment location --- National Poison Data System, United States, 2000--2009

Symptoms	Total* (N = 68,316)		Managed on-site (N = 30,798)		Treated at health-care facility (N = 36,691)	
	No.	(%)	No.	(%)	No.	(%)
Headache	30,845	(66.3)	9,733	(67.1)	20,773	(66.1)
Nausea	17,653	(38.0)	5,043	(34.8)	12,399	(39.5)
Dizziness/vertigo	13,363	(28.7)	3,732	(25.7)	9,459	(30.1)
Drowsiness/lethargy	8,966	(19.3)	2,864	(19.8)	5,999	(19.1)
Vomiting	7,550	(16.2)	1,601	(11.0)	5,871	(18.7)
Confusion	2,083	(4.5)	319	(2.2)	1,736	(5.5)
Syncope	1,950	(4.2)	105	(0.7)	1,831	(5.8)
Dyspnea	1,538	(3.3)	313	(2.2)	1,209	(3.9)
Chest pain†	1,226	(2.6)	156	(1.1)	1,054	(3.4)
Other	6,548	(14.1)	1,734	(12.0)	4,707	(15.0)

* Symptoms were reported for 68% of all calls during 2000--2009.

† Includes noncardiac chest pain.

Use of trade names and commercial sources is for identification only and does not imply endorsement by the U.S. Department of Health and Human Services.

APPENDIX A

APPENDIX B

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