2023 ANNUAL REPORT ON UNINTENTIONAL CARBON MONOXIDE POISONING IN MICHIGAN

Michigan Department of Health and Human Services
Environmental Health Bureau

March 2025

MDHHS
Michigan Department of Health & Human Services

Table of Contents

Summary and Key Findings

- Among Michigan residents in 2023, there were 481 cases of illness due to unintentional carbon monoxide (CO) poisoning, including 31 deaths (6.5%).
- Women aged 25-44 (6.4 per 100,000 population; 32 cases) and men aged 65 and older (5.8 per 100,000 population; 49 cases) had the highest CO poisoning rates.
- Available data suggests Black Michiganders (3.9 cases per 100,000 population; 57 cases) had significantly higher rates of CO poisoning than white Michiganders (1.7 cases per 100,000; 139 cases). This was true among both males and females and among all age groups other than 5- to 14-year-olds.
- Almost half of all CO poisonings occurred in the coldest months (December, January and February).
- The most common CO sources overall were vehicles (13.9%), furnaces and water heaters (13.5%) and generators (13.1%).
- The most common exposure site was a residential setting (72.6%) while occupational settings accounted for 12.7% of all CO poisoning cases.

Background

Carbon monoxide, or CO, is a colorless, odorless and tasteless gas that is produced any time carbon-based fuel (e.g., gasoline, natural gas, wood) is burned. A few examples of sources that give off CO include furnaces, water heaters, generators, vehicles, charcoal grills, clothes dryers, fireplaces and wood-burning stoves, lawnmowers and lawn equipment, and gas cooking ranges.

CO is dangerous because it prevents the body's tissues and organs from receiving necessary oxygen. When inhaled, the CO molecule outcompetes oxygen to bind to hemoglobin in red blood cells, producing a molecule called carboxyhemoglobin (COHb). This process reduces and inhibits the delivery of oxygen to the rest of the body.[1] Tests can be performed on a person to measure the levels of COHb in their blood and determine if their symptoms are due to CO exposure. Smoking cigarettes produces carbon monoxide and smokers typically have higher levels of COHb in their blood than nonsmokers. Smoking status is taken into consideration when interpreting COHb levels.[1]

CO exposure can lead to illness, known as CO poisoning. CO poisoning symptoms are often nonspecific and include fatigue, headache, dizziness, altered mental status, nausea, vomiting and chest pain.[2] Some of these symptoms are similar to other common illnesses and ailments like the flu or seasickness while boating so people and their health care providers may not realize that their symptoms are due to CO. Severe CO poisoning symptoms can include shortness of breath and loss of consciousness. Death can occur if there is a high concentration of CO in the air. The lack of oxygen in the body caused by CO poisoning can result in long term effects by damaging the brain or heart.[2]

CO poisoning can happen to anyone; however, infants, pregnant women, the elderly and people who have chronic heart disease, anemia or respiratory problems are at higher risk of illness due to CO exposure.[2] CO poisoning is typically treated through oxygen administration or in more serious cases, through hyperbaric oxygen treatment.[2]

It is estimated that each year around 400 Americans die from unintentional, non-fire-related CO poisonings, more than 100,000 people visit the emergency room and more than 14,000 people are hospitalized.[3] Among Michigan residents in 2022, there were 727 emergency department (ED) visits and 108 admissions to the hospital for unintentional CO poisoning (both fire and non-fire related).[4] Medical record reviews conducted by the Michigan Department of Health and Human Services (MDHHS) have identified ED visits that were evaluations for CO exposure but did not have symptoms of CO poisoning. Therefore, it is likely that some of these ED visits represent people being evaluated for CO exposure but not meeting the criteria to be considered CO poisoning. However, these numbers do reflect how often people are using the health care system and emergency services due to concerns about CO exposure in Michigan.

Between 2009 and 2014, annual surveillance reports on cases of unintentional CO poisoning in Michigan had been published as a joint report between Michigan State University (MSU) and MDHHS.[5] In 2023, the Carbon Monoxide Surveillance Program was relaunched by MDHHS to collect enhanced information on illness and death due to unintentional CO poisoning in Michigan. This report details the results of year one of the revived CO surveillance program. This report will be updated annually.

Methods

This surveillance system seeks to identify all cases of illness due to unintentional CO poisoning (including both fire- and non-fire-related sources of CO) that occur in Michigan or among Michigan residents. The Michigan Public Health Code states that when requested, health care facilities, health care professionals and laboratories are required to report non-suicidal, non-medicinal chemical poisonings, including cases of unintentional CO poisoning, to the MDHHS.[6] As the bona fide agent of MDHHS, the MSU Division of Occupational and Environmental Medicine (OEM) requested data from the following sources: Michigan Poison Center (PC) records, inpatient and outpatient medical records from all 172 Michigan hospitals and call-out records from Michigan emergency medical services (EMS). MDHHS obtained death certificates. Criteria were used to identify potential cases of CO poisoning from each of these data sources (Table 1). The data in this report include all cases with an illness onset date between Jan. 1, 2023 and Dec. 31, 2023.

Table 1. Identification criteria for potential CO poisoning case records by data source

Data Source	Identification Criteria
Michigan PC	Substance is recorded as "Carbon monoxide"
Medical records from hospitals (both inpatient and outpatient)	Discharge diagnosis ICD-10-CM code of T58
EMS	Patient care report narrative field contains any of the following: "carbon mon", "CO exposure", "monoxide" or "CO poison"
Death certificates	ICD-10 codes of X47 or Y17 as an underlying cause of death or T58 as a related/contributing cause of death

Information was abstracted from records with an unintentional or undetermined intent, excluding cases of intentional use of CO to cause harm, into a standardized form which was housed in the Michigan Disease Surveillance System (MDSS). Both Michigan and non-Michigan residents were included. When available, the following data were collected for each individual case: demographic information, date of illness onset, lab testing results, symptoms, treatment, smoking status, CO exposure source, environmental readings for CO and CO alarm presence. Potential cases were reviewed and assessed based on available laboratory, clinical, exposure and epidemiologic evidence.

All cases entered into MDSS were reviewed and the Centers for Disease Control and Prevention (CDC) case definition for CO poisoning was applied to each case to determine its status (confirmed, probable, suspect or not a case) (Appendix A).[7] This case definition is a set of uniform criteria used to consistently classify CO poisoning cases across jurisdictions. Case statuses of confirmed, probable and suspect are indicative of the information available on a case and not necessarily of the severity of illness of the individual. Therefore, a confirmed case represents a slightly higher degree of certainty that an individual was a CO poisoning case than a probable or suspect case, and a probable case has a slightly higher degree of certainty than a suspect case. If, upon review, a case entered into MDSS was found to be intentional (e.g., CO poisonings that occurred due to a suicidal or homicidal intent) or if there was not enough information to determine the intent, then that case was classified as "not a case" and excluded from the analysis.

MDSS automatically checks for duplicate cases upon initial entry into the system. Cases were further checked for duplication by comparing first and last name, age, date of birth and date of illness onset using SAS version 9.4 software. New cases were distinguished from existing cases if either of the following occurred:

1. New exposure to CO from a different exposure source.
2. Repeated exposure as defined by having the same exposure source as the previous occurrence but symptoms from the previous occurrence had been resolved prior to the repeat exposure.

Frequencies and rates were calculated using Michigan resident cases defined as confirmed, probable or suspect as the numerator. The denominator used for rates was the Census Bureau's Single-race Population Estimates, accessed through the CDC Wide-ranging Online Data for Epidemiologic Research (WONDER).[8] Population estimates for 2023 were not available at the time of this report, therefore all rates were calculated using 2022 population estimates as the denominator. Unless stated otherwise, rates are age-adjusted via direct method using the 2000 U.S. Standard Population. To protect patient confidentiality, suppression was applied when the count (or numerator) was less than six. In some instances, complementary suppression was applied to prevent back-calculation of suppressed values. All confidence intervals in figures represent 95% confidence intervals. Where confidence intervals do not overlap, a statistically significant difference ($p<0.05$) exists.

Results

Overall

In 2023, there were 490 cases of unintentional CO poisoning reported in Michigan. Nine occurred among non-Michigan residents.

Michigan Residents

The remaining results will focus on Michigan resident cases. Among Michigan residents, there were 481 cases of unintentional CO poisoning (4.5 cases per 100,000 population) in 416 separate CO exposure events, of which 31 (6.5%) resulted in death. Of these cases, 219 (45.5%) were determined to be confirmed cases, while 58 (12.1%) were probable cases and 204 (42.6%) met suspect case criteria (Table 2).

Table 2. CO poisoning cases by case status, Michigan residents, 2023

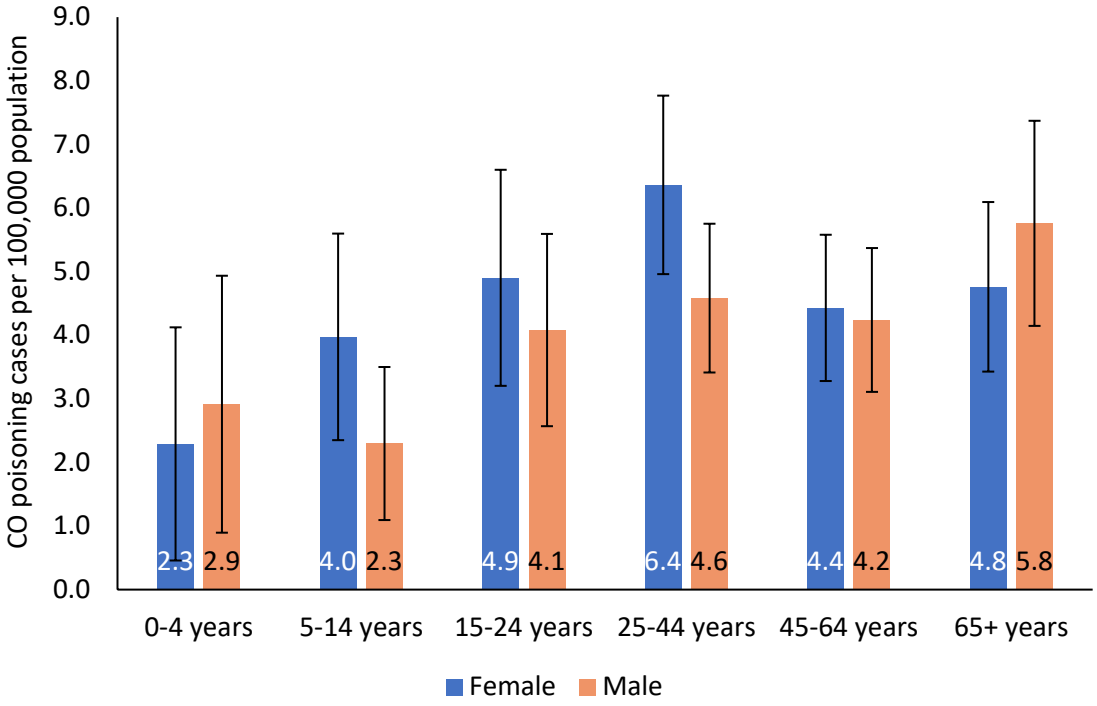
Case Status	Count	Percent
Confirmed	219	45.5%
Probable	58	12.1%
Suspect	204	42.4%
Total	**481**	**100%**

Demographics

The mean age of all cases was 43 years. The age group with the highest rate overall was 25- to 44-year-olds (5.5 cases per 100,000, 138 cases). Among females, the rate of CO poisoning was 5.0 cases per 100,000 (258 cases) while males had a rate of 4.1 cases per 100,000 (220 cases). The highest rates were

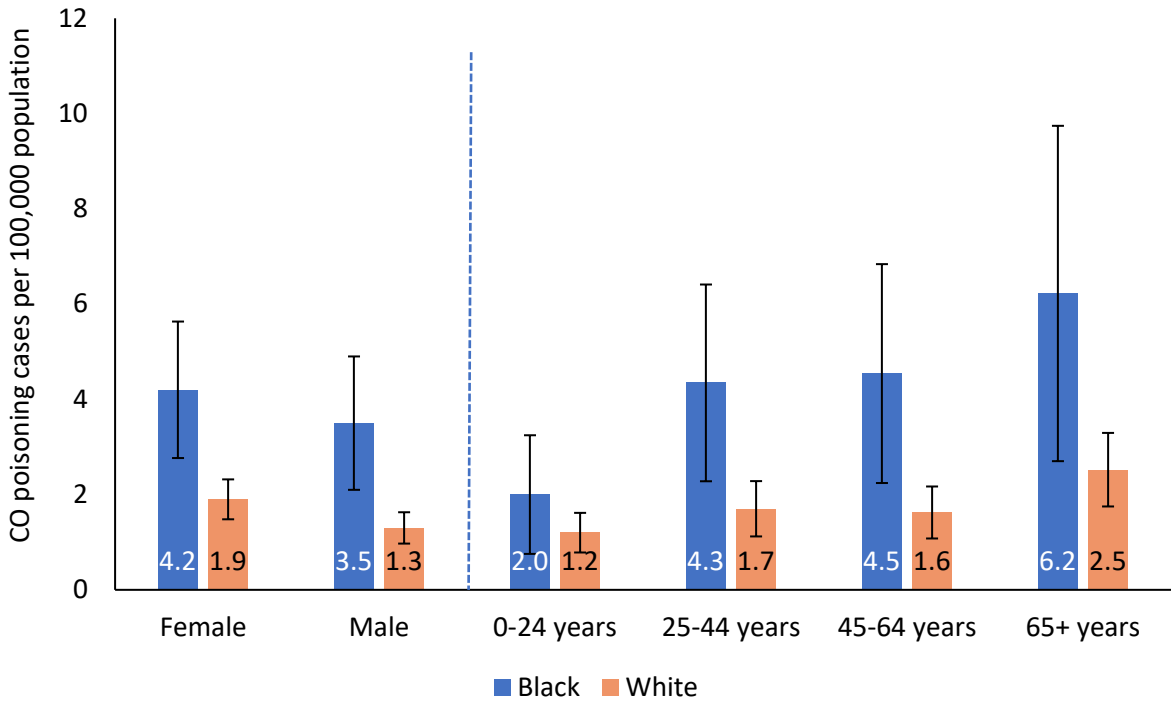
seen among females 25–44 years old (6.4 cases per 100,000; 32 cases) and men 65 years and older (5.8 cases per 100,000; 49 cases) (Figure 1).

Figure 1. Rates and 95% confidence intervals of CO poisoning cases by age group and sex, Michigan residents, 2023



Among the 43.2% of patients with information available on race, Black Michiganders had significantly higher rates (3.9 cases per 100,000; 57 cases) than white Michiganders (1.6 cases per 100,000; 139 cases) overall, and although they had higher rates in all age groups, none of the age group-specific differences were significant. Black males and females both had significantly higher rates than white males and females (Figure 2). It is important to note that race data was not reported for 56.8% of cases; therefore, these rates should be interpreted with caution - see the discussion for additional information. Hispanic ethnicity was not reported for 84.2% of cases so counts and rates by Hispanic ethnicity are not shown here.

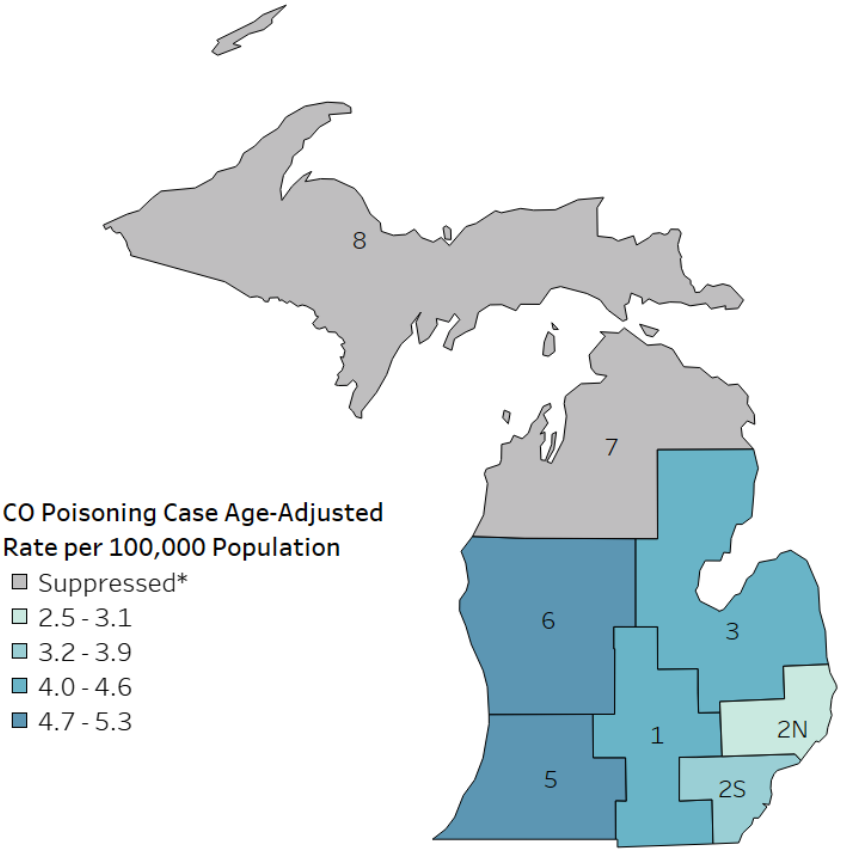
Figure 2. Rates* and 95% confidence intervals of CO poisoning cases by age group and sex for Black and White Michigan residents, 2023



**Rates by sex are age-adjusted while rates by age group are not.*

Additionally, counts by county of residence were frequently less than six, therefore geographic data have been aggregated by the Michigan public health preparedness regions, which categorizes Michigan counties in eight regions. Across the state, the highest rates of CO poisoning were seen in regions five and six, located on the western side of the lower peninsula (Figure 3).

Figure 3. Age-adjusted rate of CO poisoning cases by public health preparedness region, Michigan residents, 2023



**Rates with numerators of less than six have been suppressed. Complementary suppression was applied to prevent back-calculation.*

Table 3. Counts, rates (per 100,000 population), and 95% confidence intervals (CI) of CO poisoning cases by sex, age group, race and public health preparedness region, Michigan residents, 2023**

Demographic Group	CO Poisoning Cases	Rate (95% CI)
Sex[†]		
Female	258	5.0 (4.4–5.6)
Male	220	4.1 (3.6–4.6)
Age Group[§]		
0-4 years	14	2.6 (1.2–4.0)
5-14 years	37	3.1 (2.1–4.1)
15-24 years	60	4.5 (3.3–5.6)
25-44 years	138	5.5 (4.5–6.4)
45-64 years	111	4.3 (3.5–5.1)
65+ years	98	5.2 (4.2–6.2)
Race[¶]		
American Indian or Alaska Native	*	*
Asian or Pacific Islander	*	*
Black	57	3.9 (2.9–4.9)
White	139	1.6 (1.3–1.9)
Other Race	*	*
Public Health Preparedness Region[††]		
1	45	4.0 (2.8–5.2)
2 North	59	2.5 (1.9–3.1)
2 South	94	3.8 (3.0–4.6)
3	45	3.9 (2.8–5.0)
5	53	4.7 (3.4–6.0)
6	85	5.3 (4.2–6.4)
7	*	*
8	*	*

**Suppression of groups with less than six cases. In some cases, complementary suppression was applied to prevent back-calculation.*

***All rates are age-adjusted with the exception of the rates by age group, which are age-specific rates.*

[†]Sex missing for 3 (0.6%) of cases.

[§]Age missing for 23 (4.8%) of cases.

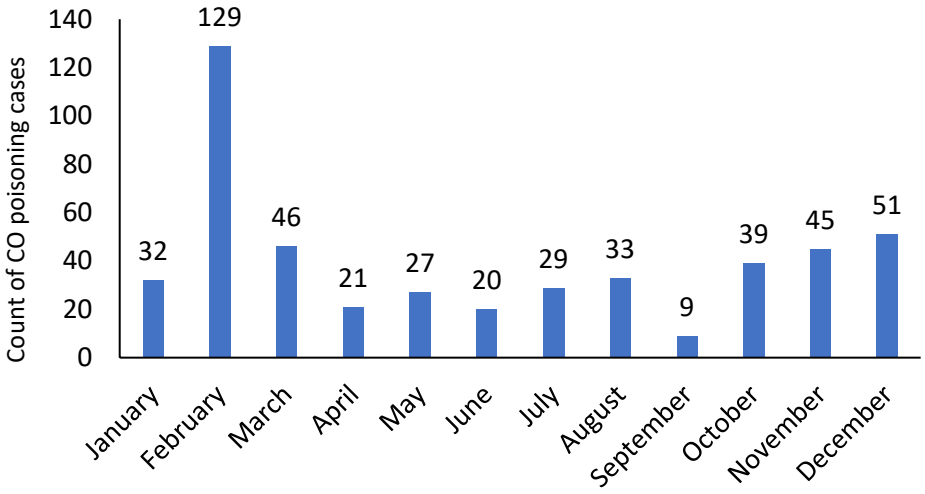
[¶]Race missing for 273 (56.8%) of cases.

[††]Public health preparedness region was determined using the patient's county of residence. County of residence was unavailable for 74 (15.4%) of cases.

Seasonality

Almost half (44.3%) of all CO poisoning cases occurred in the coldest months of the year (December, January and February). In the month of February alone, there were 129 cases of CO poisoning, which represented more than a quarter (26.9%) of all cases identified in 2023 (Figure 4).

Figure 4. Frequency of CO poisoning cases by month of illness onset, Michigan residents, 2023

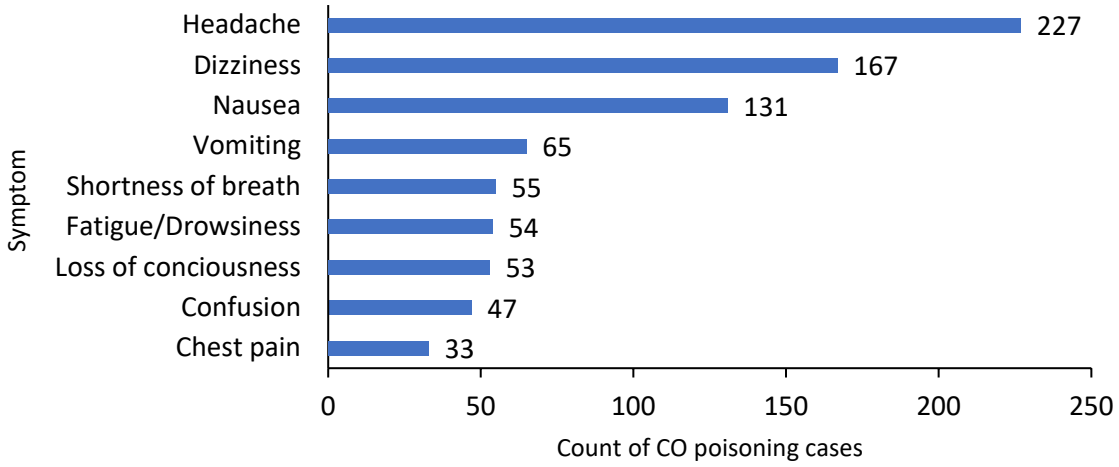


Clinical Data

COHb testing was performed on 51.4% of cases. The average blood COHb result among all tested patients was 14.1%, with a maximum of 66%. Smoking status was known for only 28.4% of cases. Among cases where both smoking status and COHb level were known, the average COHb result for current cigarette smokers (29 cases) was 13.7% whereas the average among current nonsmokers (91 cases) was 12.3% (difference not statistically significant).

The most common symptom was headache, occurring in 227 cases (47.4%), followed by dizziness (167 cases, 34.9%) and nausea (131 cases, 27.3%) (Figure 5). Treatment was received by 245 patients (50.9%) with 243 (50.5%) receiving supplemental oxygen and 10 (2.1%) receiving treatment in a hyperbaric chamber.

Figure 5. Frequency of symptoms among CO poisoning cases, Michigan residents, 2023*



**Symptoms were unknown for (59) 12% of cases.*

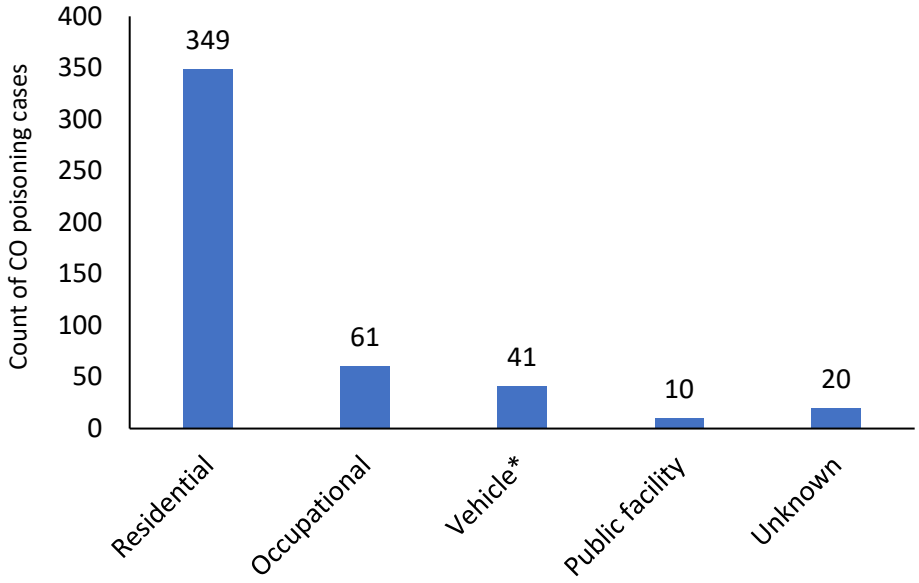
Deaths

Among Michigan residents, there were 31 unintentional CO poisoning deaths in 2023, representing 6.4% of all CO poisoning cases. Two-thirds of cases were male (21) and the mean age at death was 60 years. More than half (58%; n=18) of these deaths occurred in January, February and March. Around half (17, 54.8%) of these deaths were fire related. Among non-fire-related deaths, sources of the CO exposure included generators, portable grills, propane, space heaters and vehicles.

Exposure Information

By far, the most common exposure site was residential, representing 72.1% of all cases. About one in eight cases (12.6%) occurred in an occupational setting. Other exposure sites included vehicles, campers and public facilities, such as hotels, hookah lounges and fast-food restaurants (Figure 6).

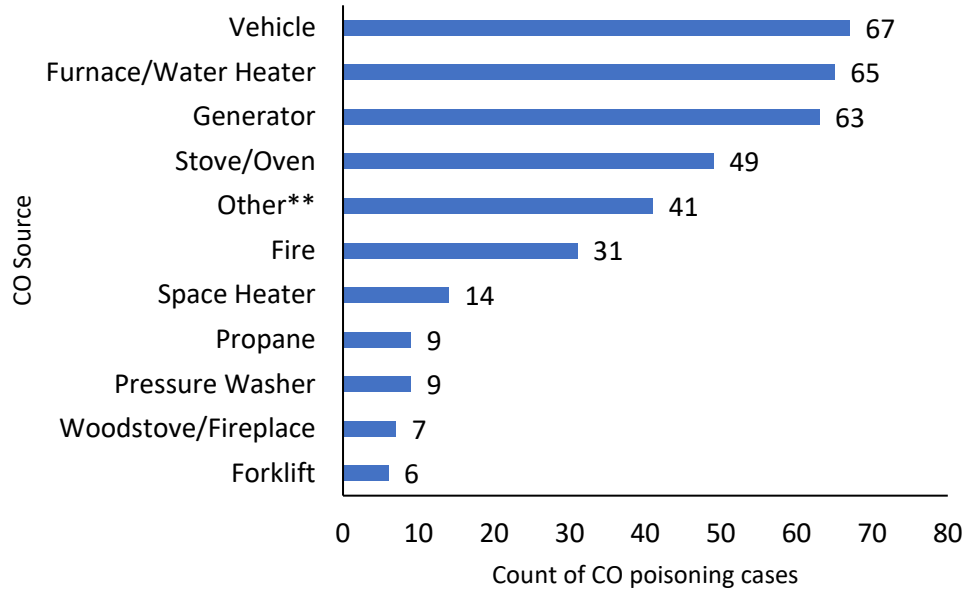
Figure 6. Frequency of CO poisoning cases by exposure site, Michigan residents, 2023



**The "Vehicle" category includes vehicles, such as cars, semi-trucks and campers, that were not located at a home or public facility or associated with an occupation.*

The most common sources of CO were vehicles, furnaces/water heaters and generators. Other common sources of CO included stoves and ovens, fire and space heaters (Figure 7). The most common source of CO exposure among residential settings was furnaces and water heaters (60 cases), followed by generators (54 cases) and stoves and ovens (46 cases). The most common sources of CO exposure among occupational settings were vehicles (10 cases), space heaters (7 cases) and forklifts (6 cases) (Table 4).

Figure 7. Frequency of CO poisoning cases by source of CO, Michigan residents, 2023*



Source was unknown for 120 (25.1%) of cases.
***The "Other" category includes boats, grills, dryers, gas-powered saws, hookah, dryers, burning coals, snow blowers and spray paint guns.*

Table 4. Frequencies and percentages of CO poisoning cases by source of CO for residential and occupational exposure sites, Michigan residents, 2023

	Residential	Occupational
Fire	26 (7.4%)	0
Forklift	0	6 (9.8%)
Furnace/Water Heater	60 (17.2%)	*
Generator	54 (15.5%)	*
Pressure Washer	6 (1.7%)	*
Propane	6 (1.7%)	*
Space Heater	*	7 (11.2%)
Stove/Oven	46 (13.2%)	*
Vehicle	20 (5.7%)	10 (16.4%)
Woodstove/Fireplace	*	0
Other**	30 (8.6%)	*
Unknown	90 (25.8%)	19 (31.1%)
Total	**347**	**61**

Counts less than six have been suppressed. Complementary suppression may have been applied to prevent back-calculation.
***The "Other" category includes boats, grills, dryers, gas-powered saws, hookah, dryers, burning coals, snow blowers and spray paint guns.*

Of the 138 (28.8%) CO poisoning cases that had information available on CO detector presence, 123 cases were known to have a CO detector present during the exposure. The majority of these cases (95.1%; 117 cases) were present in residential settings. The most common CO sources in cases where a CO detector was present were furnaces and water heaters, stoves and ovens and generators, which were the most common sources for all residential CO poisoning cases. Detectors were reported to have alerted due to high CO levels 88% of the time.

Multiple Cases

Often, more than one person would be exposed to the same CO source at the same time, causing multiple cases of illness due to CO poisoning. In 2023, there were 40 CO poisoning incidents that caused multiple cases of CO poisoning. These multi-person exposure events involved 105 people (21.8% of all Michigan resident CO poisoning cases). One of these events had a death associated with it. The average number of people who developed illness in each event was 2.6 people, with a range of two to five people. It is important to note that these numbers only include people who developed illness as a result of their exposure, and therefore may not represent the true number of people who may have been exposed.

Discussion

Despite being preventable, CO poisoning remains a leading cause of non-drug poisonings in Michigan, resulting in 490 cases of CO poisoning in the state in 2023, 481 of which were among Michigan residents. Of these, 31 (6.5%) cases of CO poisoning resulted in death, the majority of which were male and had a mean age of 60 years. When looking at all cases, the mean age was 43 years and women (5.0 per 100,000 population; 258 cases) had a higher rate of CO poisoning than men (4.1 per 100,000 population; 220 cases) (result not statistically significant). When looking at both sex and age group, women aged 25-44 (6.4 per 100,000 population; 32 cases) and men aged 65 years and older (5.8 per 100,000 population; 49 cases) had the highest CO poisoning rates. These findings are consistent with other national studies, which have found that while women often make up the majority of reported CO cases and exposures, men and older adults tend to have more severe outcomes, including death.[9,10] Residents of public health preparedness regions five and six, which are located on the western side of the lower peninsula, had higher rates of CO poisoning than other areas of the state.

Based on the 43.2% of cases where race was known, the data suggests that Black Michiganders had significantly higher rates of CO poisoning than white Michiganders. It is important to note that this finding should be interpreted with caution because of the high degree of missingness of the race field. An analysis of cases with missing race by geography did not find that certain areas of the state were significantly underreporting this variable; therefore, it appears that these data are representative of the state as a whole. These results are consistent with findings from previous Michigan CO poisoning reports as well as national findings, which indicate that Black populations experience a higher burden of CO poisoning when compared to white populations.[5,10–12] Some of these studies have hypothesized that socioeconomic status may play a role in this disparity in CO poisoning rates, however, socioeconomic data was not available for this analysis.[11,12]

The above findings indicate populations within Michigan that may be at higher risk of CO poisoning and who could benefit from increased outreach and education regarding CO poisoning. Based on exposure

information collected by this surveillance system, the following are areas of interest that should be prioritized for CO-related prevention and educational messaging efforts.

CO Prioritization Areas

Proper Use and Maintenance of Gas and Oil Burning Machines

In Michigan, 73% of CO poisonings occurred in residential settings, indicating that this is an area where prevention efforts could be focused. The most common sources of CO poisoning in residential settings were furnaces and water heaters, generators, stoves and ovens. Current national guidelines recommend having furnaces, water heaters and other carbon-based fuel (e.g., gas, oil, coal) burning appliances serviced annually.[3]

Proper vehicle maintenance is also important. Vehicles were the most common source of CO (67 cases). Of these, 34 cases occurred while the person was driving or sitting in a running vehicle in a parking lot. Leaks in the exhaust system were the most commonly reported cause in these cases. Vehicles should have the exhaust system checked every year by a mechanic.[3]

Oftentimes, CO poisonings occurred due to use of a gas or oil burning machine or tool in a poorly ventilated area. Separate examples of this include running a car in an attached garage, using a generator too close to the home during a power outage and using a gas-powered saw in the basement.

CO poisoning cases in occupational settings were also often due to improper use of a tool or machine (such as a forklift, space heater or vehicle) in a poorly ventilated space. In one example of an occupational-related CO exposure, multiple employees were exposed to CO in their workplace after a forklift was used in an enclosed space. The employees experienced nausea, vomiting, chest pain, shortness of breath and headache and were all found to have elevated blood COHb levels. All the employees were treated with supplemental oxygen and recovered from their acute CO poisoning. Substitution of battery or electric powered forklifts and tools eliminates the possibility of CO poisoning both at work and in the home.

Carbon Monoxide Detectors

CO poisoning is entirely preventable with proper use and maintenance of carbon-based fuel burning appliances and machines and use of CO detectors. CO detectors should be installed on all floors and near every sleeping area in a home and should be tested monthly and have the batteries replaced twice a year.[4]

Only 138 (28.8%) CO poisoning cases had information available on CO detector presence. Of these, 123 cases (90% of cases where CO detector presence was known; 25.3% of all cases) reported having a CO detector present at the time of their exposure. When present, the CO detectors alerted for high levels of CO 88% of the time. These data indicate that people may be more likely to report when they did have a CO detector present versus when they did not. However, it is still possible that the number of cases with CO detectors present may be underreported within this surveillance system. These results (25.3% of all cases reporting CO detector use) also align with national findings on CO detector use, where studies of both self-reported and observed CO detector use in the United States have been reported to be between 28% and 33%.[13,14]

In one example of the utility of CO detectors, a homeowner's CO alarm went off around the same time that they began experiencing dizziness. The fire department was called and was able to determine that

the stove was leaking CO, using special CO-detecting meters. After finding the CO source, mitigation measures were taken, such as turning off the gas to the stove, opening windows to air out the home and remeasuring the CO levels later on to ensure it was safe to enter the home again. The homeowner recovered from their CO poisoning symptoms. Use of CO detectors can lead to earlier detection of dangerous levels of CO and prevent more serious illness and death.

Carbon Monoxide Poisoning and Climate Change

CO poisoning during power outages was identified as another area of concern. During power outages, people may turn to other gas-powered appliances for heating or powering their home. There were 16 cases (including two deaths) of CO poisoning due to people heating their living spaces with carbon-based fuel burning appliances, such as ovens and portable, unvented propane heaters, after their power or furnace had gone out. Houses should never be heated with a gas oven.[2]

Generators are another common source of CO during power outages. A large ice storm that occurred in February of 2023 in Michigan led to power outages for over 700,000 Michigan homes and businesses.[15] That same month also saw a much higher number of CO cases out of any month in 2023 (129 cases). It is likely that many of these cases were a result of the power outage as one-third of all CO poisoning cases in February 2023 were caused by a generator (43 cases). In many of these cases, generators were placed inside a home or garage or near to it.

In one example of a power outage-related CO exposure, a family was running a generator in their attached garage after losing power during the ice storm. CO levels built up in the house and multiple people were exposed, leading to symptoms such as vomiting, dizziness and shortness of breath. A fire department reading of CO levels in the home showed over 500 parts per million (ppm), which is well above the current recommended indoor air quality limit set by the EPA (an average of 9 ppm over 8 hours).[1] All people in the household with CO poisoning symptoms were treated with supplemental oxygen and recovered from their acute CO poisoning. Current national guidance states that generators should never be used inside a home or garage and should be located at least 20 feet from the home.[3]

The MDHHS Climate and Health Adaptation Program has identified CO poisoning as one of the top five climate-related health outcomes of most concern for Michigan. As extreme weather events continue to increase, the risk of power outages, and subsequently CO poisonings, will increase.[16] Targeted messaging about safe home heating practices and generator use during these events will be essential in the future.

Limitations

It should be noted that this surveillance system only intends to collect data on events where people experienced illness or died due to unintentional CO exposure. Therefore, the data and counts presented here may not reflect the total number of people that seek health care or utilize emergency services because of CO exposure. The data presented here are not representative of intentional CO poisoning events that may have suicidal or homicidal intent. For example, CO poisonings due to suicide have been found to primarily have motor vehicle exhaust and burning charcoals as the source of CO.[17] Additionally, there were 30 cases (representing 3.8% of all cases reviewed) where reviewers were unable to determine the intent of the CO poisoning. In these instances, the cases were classified as “not a case” and excluded from the analysis.

Additionally, while this surveillance system relies on reporting from a number of sources, additional cases may have occurred that were not captured or identified. If a person did not seek treatment or

assistance for their symptoms, then they would also not be captured in this system. Some CO poisoning cases may have been misdiagnosed due to the nonspecific nature of CO symptoms. Michigan residents who were exposed or sought care out of state would not be captured by this system unless they died as a result of CO poisoning.

Public Health Recommendations

CO poisonings can be prevented by ensuring the public is aware of how to protect themselves from CO exposure risks. As described above, the findings of this analysis suggest that the following CO poisoning prevention topics should be used for CO poisoning prevention education and messaging in Michigan. It is important that these prevention tactics be employed not only in residential settings, but occupational, recreational and public ones as well, where applicable.

Proper use and maintenance of gas and oil burning machines should be promoted. This includes having carbon-based fuel burning appliances, such as furnaces and water heaters, properly vented and serviced annually by a qualified technician. Additionally, machines and tools that use carbon-based fuels should never be used in enclosed or poorly ventilated areas, such as basements or garages, even if the door is open. This applies to vehicles as well, which should never be run in an enclosed space and should have the exhaust system checked by a mechanic annually to ensure there are no leaks.

CO detectors should be more widely used in order to aid in early detection of dangerous CO levels. They should be installed on all floors and near every sleeping area in a home. Detectors should be tested monthly and have their batteries replaced twice a year.

Finally, proper use of carbon-based fuel burning machines during power outages or severe weather events should be emphasized in messaging, especially during the winter months. Messaging can include reminders that living spaces should not be heated with a gas oven and that portable generators should be used appropriately by being placed at least 20 feet from the home - and never inside a home or garage.

Many workplace and household items can produce CO; therefore, the above recommendations do not necessarily encompass all steps that can be taken to reduce CO poisoning risk. Additional information on CO and CO prevention can be found on the MDHHS Carbon Monoxide webpage.

Next Steps

MDHHS will continue to use the best available data to inform people on the risk of CO poisoning and how to prevent it. Health education messaging and materials will be developed based on the findings of this report and distributed for use in CO prevention programming across the state. MDHHS will continue to urge the public to avoid risks of CO exposure by messaging at the appropriate times, including around major power outages and related extreme weather events. The MDHHS CO Poisoning Surveillance Program will continue to conduct unintentional CO poisoning surveillance in the state of Michigan and release updated reports annually to public health partners and the public while working to improve reporting of CO poisoning cases by required reporters. Data for hospitalizations and ED visits due to CO poisoning and/or CO exposure will also be updated annually on the MiTracking data portal (Michigan.gov/mitracking).

References

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Appendix A. CDC CO Poisoning 2019 Case Definition

CSTE Position Statement(s)

- 18-EH-01

Clinical Criteria

Presumptive clinical evidence:

- Loss of consciousness **OR**
- Death

Supportive clinical evidence:

- A person with signs or symptoms consistent with carbon monoxide poisoning, which may include elevated pulse CO-oximetry measurement and/or non-specific symptoms such as nausea, vomiting, confusion, shortness of breath and chest pain.

Laboratory Criteria

Confirmatory laboratory evidence:
A person who does not smoke, or a child (age < 14 years) whose smoking status is unknown, and has a COHb level of ≥ 5.0% as measured in a blood sample.

OR

A person who smokes, or a person (age ≥ 14 years) whose smoking status is unknown, with a COHb level of > 12.0% as measured in a blood sample.

Presumptive laboratory evidence:
A person who smokes, or whose smoking status is unknown (age ≥ 14 years), and has a COHb level of ≥ 9.0% and ≤ 12.0% as measured in a blood sample.

Supportive laboratory evidence:
A person who does not smoke, or a child (age < 14 years) whose smoking status is unknown, and has a COHb level of ≥ 2.5% and < 5.0% as measured in a blood sample.

OR

A person who smokes, or whose smoking status is unknown (age ≥ 14 years), and has a COHb level of ≥ 7.0% and < 9.0% as measured in a blood sample.

Epidemiologic Linkage

A person who was present and exposed in the same CO exposure event as that of a confirmed CO poisoning case.

Criteria to Distinguish a New Case from an Existing Case

A case should be categorized as a new (incident) case when there is either:

- New exposure to CO from different exposure source

OR

- Repeated exposure as defined by having the same exposure source as previous occurrence where the criteria used to designate a case has been resolved prior to repeat exposure

A case is categorized as a prevalent case when there are multiple reports for the same person for the same episode, such as when there are multiple COHb lab test results or when a patient receives multiple hyperbaric treatments following a single poisoning event.

Exposure

Confirmatory exposure evidence:*
A person who had an exposure to an elevated level of CO based on a dedicated or multi-gas meter/instrument (e.g., fire department notation) for a known duration that is consistent with CO poisoning.

Possible exposure evidence:*

- A person who was in a location where a CO detector's alarm sounded,
  OR
- A person who had onset of CO-related symptoms associated physically and temporally with a CO-emitting source (e.g., gasoline-powered generator, power washer, malfunctioning furnace, fire)

*Note: Exposure evidence that is provided by the patient is sufficient for meeting exposure evidence criteria.

Case Classification

Suspected

- A person with supportive laboratory evidence **OR**
- A person with supportive clinical criteria **AND** possible exposure evidence

Probable

- A person with presumptive laboratory evidence* **OR**
- A person with presumptive clinical evidence **AND** possible exposure evidence, **OR**
- A person with presumptive or supportive clinical evidence **AND** epidemiologic linkage

*Other plausible clinical explanations should be considered, including chronic obstructive lung disease and hemolysis.

Confirmed

- A person with confirmatory laboratory evidence* **OR**

- A person with presumptive or supportive clinical evidence **AND** with confirmatory exposure evidence

* Other plausible clinical explanations should be considered, including chronic obstructive lung disease and hemolysis.

MDHHS-Pub-2043 (11-24)