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thesis entitled

Carbon Monoxide Poisoning Cases Treated in an Emergency Department or Hospitalized in Michigan for 1997 and 1998

presented by

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has been accepted towards fulfillment
of the requirements for the

Master of Science degree in Epidemiology

Major Professor's Signature

7/26/04

Date

CARBON MONOXIDE POISONING CASES TREATED IN AN EMERGENCY DEPARTMENT OR HOSPITALIZED IN MICHIGAN FOR 1997 AND 1998

By

Noreen Shoushan Hughes

A THESIS

Submitted to
Michigan State University
in partial fulfillment of the requirements
for the degree of

MASTER OF SCIENCE

Department of Epidemiology

2004

ABSTRACT

Carbon Monoxide Poisoning Cases Treated in an Emergency Department or Hospitalized in Michigan for 1997 and 1998

By

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Among all deaths due to poisonings, carbon monoxide (CO) intoxication is the leading cause. This report describes hospital encounters for CO poisonings, including twenty one deaths, from 1997 and 1998.

Michigan hospitals provided face sheets and discharge summaries of hospitalized and emergency department (ED) visits for CO poisonings. Cases were divided into three categories; suicide attempts, unintentional poisoning, and work related poisoning. Frequency tables were generated to describe and compare the characteristics of the three groups, including demographic characteristics; source of exposure; carboxyhemoglobin level; insurance payer; and time of year.

There were 847 cases of CO poisoning reported from all Michigan hospitals and EDs. Another 312 cases were estimated to have been diagnosed and to have required treatment in the emergency department but were not reported. Most cases were male, aged 22-44 years and occurred in the winter months. The estimated annual incidence rate of CO poisoning treated in the hospital or emergency department was 11.66 per 100,000 individuals.

This information could be used by health care professionals to increase awareness of the potential sources of exposure to CO and the dangers of CO poisoning, in order to prevent future cases of CO poisoning.

Acknowledgements

I would like to take the time to thank the following people for helping me complete this work. First, I would like to acknowledge my advisor Dr. Ken Rosenman who made this project possible and who guided me through this with numerous suggestions and critiques. Thank you for always turning things back to me so quickly and having the time to answer my questions.

Next, I would like to thank my other committee members Dr. Joseph Gardiner and Dr. Corrine Miller for all of the time, advice and knowledge they have given me throughout this project.

I would also like to acknowledge the staff in Dr. Rosenman's office, especially Mary Jo Reily for listening to me and encouraging me through this process.

Finally, I would like to acknowledge the faculty and staff in the Epidemiology department, especially Lora McAdams for your patience and guidance through all of the obstacles faced when completing this thesis.

There are many other family members and friends who supported me through this without whom I would not have gotten this far. Thanks to all of you for your support and encouragement.

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Abbreviations

CI- Confidence Interval

CO- Carbon Monoxide

COHb- Carboxyhemoglobin

ED- Emergency Department

OR- Odds Ratio

Sui- Suicide attempt group

Unint- Unintentional group

Literature Review

Introduction

Carbon Monoxide (CO) is a colorless, odorless gas that is lighter than air, with a density of 1.145 Kg/m^3. It is produced as a by-product of combustion of fossil fuels and is ubiquitous in industrialized society (Weaver, 1999). Among all deaths due to poisonings, CO intoxication is the leading cause (www.cdc.gov). An individual's carboxyhemoglobin (COHb) level is an indicator of exposure to CO; the greater an individual's exposure to CO, the more likely that individuals COHb level will be elevated. Certain high risk groups including, fetuses, infants and those with chronic heart disease, anemia or respiratory problems are more susceptible to adverse effects from exposure to CO (www.cdc.gov).

According to the Centers for Disease Control and Prevention (CDC), cases of CO poisoning are grossly underreported or misdiagnosed. While the exact number of intoxications is unknown, the CDC reports that each year, more than 500 Americans die from unintentional carbon monoxide poisoning, and more than 2,000 individuals commit suicide by intentional poisoning. Unintentional exposures due to CO include faulty furnaces/stoves, motor vehicles (exhaust), gasoline-powered engines and fire (www.cdc.gov).

Urban environments have higher ambient concentrations of CO from auto emissions. Non-smoking city dwellers have been found to have carboxyhemoglobin (COHb) levels in the 1-2% range in comparison to rural levels of 0-1 % (Hardy et al, 1994). CO is also associated with cigarette smoking. Smokers often have COHb levels much higher than non-smokers. Smokers

could have COHb levels as high as 7-9% depending on the number of cigarettes that are consumed (Varon et al., 1997).

This study will look at cases of CO poisoning in Michigan who were treated in an emergency department (ED) or hospitalized during the years 1997 and 1998. The aims of this study were to describe the overall characteristics of cases of CO poisoning as well as with the subgroups of: intentional CO poisoning, unintentional CO poisoning, and work related CO poisoning. The final aim was to estimate the total number of CO poisoning cases that occurred in Michigan in 1997 and 1998 that required hospitalization or ED treatment.

Pathophysiology

Carbon monoxide compromises the ability of blood to transport oxygen (O_2) from the lungs to the tissues. When carbon monoxide is inhaled, it is readily absorbed across the alveolar-capillary membranes in the lungs, where it tightly binds to hemoglobin; the result of this is carboxyhemoglobin (COHb). CO also binds to myoglobin. The affinity of CO to hemoglobin is about 240 times greater than that of oxygen (Struttmann et al., 1998). The uptake of CO is dependent on the concentration of CO and O_2 in the inspired gas, the rate of ventilation, and the duration of exposure to CO (Roughton et al., 1944 and Forbes et al., 1945). COHb is not a permanent bond. It has a 5 hour half life and will reverse itself once the individual has been removed from the CO exposure.

Signs/Symptoms

The features of acute carbon monoxide poisoning are more striking than those resulting from chronic exposure. A history of potential CO exposure is the most reliable indicator of poisoning. Symptoms can manifest quickly but are non specific, including headache, dizziness, weakness, nausea, visual disturbances and confusion (Dolan, 1985). While the signs and symptoms vary from patient to patient, symptom severity and carboxyhemoglobin levels depend on the concentration of CO in the environment, the duration of CO exposure, the level of activity and the interval between exposure and clinical assessment (Struttman et al., 1998).

Although measuring COHb levels is considered useful for determining the severity of exposure, there is debate regarding reliability based on a dose response relationship, researchers have demonstrated that it is difficult to determine an individuals actual COHb level of exposure to CO based on COHb levels (Olson, 1984, Ilano et al., 1990, Martindale, 1989). With COHb levels less than 10%, the patient is usually asymptomatic. Carboxyhemoglobin levels of 20% are associated with symptoms of headache, dizziness, confusion and nausea. Levels above 40% may manifest as comas and seizures due to cerebral edema. Above 60%, death is likely.

As many as 50% of those who recover consciousness and survive acute CO poisoning may experience varying degrees of more subtle, but disabling, neuropsychiatriac sequelae (Gorman et al., 1991, Choi, 1983, Smith, 1973).

Neurological problems may develop weeks after recovery from the acute episode of CO poisoning (Merideth & Vale, 1988).

A study conducted in Connecticut used its poison control center phone logs to identify people with unintentional CO poisoning in residential settings. It was conducted from November 1993 to March 1994 (MMWR, 1995). Interviews identified 51 persons having CO poisoning from exposure in a residential setting (MMWR, 1995). The most common symptoms in these 51 cases were headache, dizziness, nausea, drowsiness and dry mouth. Only 22 of the patients consulted a physician.

Seasonal Variation

Deaths from unintentional carbon monoxide poisoning in the US occur most often during the cold months in the Northern and Midwestern states (Cobb & Eitzel, 1991, Baron et al., 1989 a & b).

Cobb and Eitzel studied deaths due to CO poisoning from 1979-1988 in the United States. The fatal and non-fatal cases followed a strong seasonal pattern, with the highest total number of cases in January and lowest total reported in July. The study was conducted across the United States.

A study in Michigan from 1987-89, reported there were 103 deaths related to unintentional CO poisoning, excluding deaths involving fire (MMWR, 1992). Overall, 78% of the cases occurred from September-April. Seasonal variation has not been found in states with warmer climates. For example, during a 16 year period, from 1980 to 1995, in New Mexico, there were 136 deaths due

to unintentional CO inhalation. Only 45 (33%) of those occurred during November, December, and January (Yoon et al., 1998).

Sources of Poisoning

Generally, when carbon monoxide poisoning occurs at home the most common source of exposure is from a malfunctioning heating system. The Connecticut and Colorado studies cited the most common domestic, non-fire source of poisoning as gas heating systems and faulty furnaces; this accounted for 32 and 44 percent of non-fatal, residential cases, respectively (MMWR, 1995, Cook et al., 1995). Fire is also a source of CO poisoning at home. Many times when fire is a cause of poisoning the result is fatal.

Automobile exhaust is the most common source of CO poisoning when it occurs outside of the home, such as in an attached or detached garage, shed or barn. This was the case for the unintentional domestic fatal cases in Michigan and the non fatal cases in Colorado accounting for 67 and 24 percent of CO cases respectively. (MMWR, 1992, Cook et al., 1995)

Other common sources of carbon monoxide exposure are gas powered engines, pool heaters, smoke from all types of fire, tobacco smoke and paint removers that contain methylene chloride.

Of the 11,547 deaths due to CO poisoning from 1979 to 1988 in the United States reported by Cobb and Eitzel, 6,552 were associated with motor vehicles. Stationary autos accounted for 5,452 cases. Other sources were ships

and aircrafts. Non vehicular sources accounted for 4,995 of the total and 2,302 of the deaths were not specified (Cobb & Eitzel, 1991).

Temporal Trends

In the early 1970's approximately 3,800 people died annually from accidental and intentional carbon monoxide poisoning in the United States (Raub et al., 2000). A 1982 report identified 4,800 CO related deaths per year in the United States from smoke inhalation (MMWR, 1982). A 1988 report identified 1,100 deaths in the United States from unintentional CO poisoning, with an additional 2,500 intentional deaths (Cobb & Eitzel, 1991).

A report from 1998 estimated there were 3800 or more deaths per year due to accidental or intentional CO exposure to faulty indoor heaters or auto exhaust (Struttmann et al 1998). Non-lethal CO poisoning is more common than fatal CO poisoning (Weaver et al, 1999).

Cobb and Eitzel found that from 1979 to 1988, the total number of deaths due to unintentional CO exposure was 11,547. There were 25,326 intentional suicides from CO poisoning during this period. Overall, unintentional CO related deaths decreased from 1513 in 1979 to 878 in 1988, with an average decrease of about 63 deaths per year (Cobb & Eitzel, 1991). The decline is speculated to result, at least in part, from improved safety of heating and cooking appliances, transportation related emissions controls and increased public awareness (Raub et al., 2000).

According to the Annual Reports of the American Association of Poison Control Centers, from 1995 to 2000 the average number of poisoning from CO exposures (intentional and unintentional) reported was 18,999 per year (Watson et al., 2003). The highest year was in 1996 with 22,154 and the lowest year was in 1999 with only 17,006 poisonings from CO exposures.

From 1992-1996 unintentional CO poisonings caused 148 fatalities in the workplace in the United States. The service sector accounted for the largest part, 25% (Janicak, 1998).

The Bureau of Labor Statistics (BLS) estimates that there were 867 non-fatal CO poisonings requiring time away from work and 32 fatal poisonings in private industry in the United States in 1992 (NIOSH Alert).

Geographic Distribution

In a study by Cobb and Eitzel, during the period from 1979-1988, the highest age adjusted death rates were found in the cold, high altitude states; Alaska (2.72/100,000), Wyoming (1.65/100,000), and Montana (1.25/100,000). The lowest death rate was in Hawaii (0.05/100,000), followed by California, Connecticut and Maryland each with 0.25/100,000. Michigan had the 19th highest death rate for CO among the 50 states with .67/100,000.

Age and Gender Distribution

The majority of individuals with CO morbidity or mortality are males with an age range of 30-45 years (MMWR 1992, Yoon et al., 1998, MMWR. 1995, Scheerer et al., 2002, Cobb & Eitzel, 1991).

A study conducted in Michigan found that of the 103 deaths, 83 (81%) were males (MMWR, 1992). The average age was not reported. However, the motor vehicle related deaths among this group in Michigan occurred most often among persons aged 25-44 years (MMWR, 1992).

A study conducted in New Mexico found that of the136 CO related deaths, 100 (74%) were male. The overall median age was 39 (Yoon et al., 1998).

In the Connecticut phone survey of 51 unintentional poisonings the median age was 32. Eighty three percent of the cases were aged 20-49 (MMWR, 1995). No information about gender was reported.

Cobb and Eitzel also found a similar age and gender distribution for CO poisoning. Of the 11,547 unintentional CO-related deaths from 1979-1988, 8,546 (74%) were male. No significant age category was associated with a majority of these deaths. Of the 25,326 intentional deaths that occurred, 71% were males and those aged 35-44 years accounted for the greatest number of deaths.

In contrast to the previous studies mentioned, a study conducted in Kentucky found 53% of the cases to be female. The age findings were consistent with an overall mean age of 31 years (Scheerer et al., 2002).

Treatment

The treatment for CO poisoning is to remove the patient from the exposure and provide them with oxygen which reduces the half life of COHb (Gorman et al., 2003). Successful removal of CO from the blood does not ensure an uneventful recovery with no further clinical signs or symptoms. Complete recovery is obtained more often if supplemental oxygen is given within 6 hours following exposure (Raub et al., 2000)

An alternative treatment is the use of a hyperbaric chamber. In Michigan there are 4 hyperbaric chambers sites: Detroit, Grand Rapids, Kalamazoo and Marquette.

Incidence

The incidence of carbon monoxide poisoning is likely to be underestimated. There are several reasons for this involving both health care providers and patients. Not all patients with symptoms of CO poisoning seek treatment especially if they have mild symptoms. Since the signs and symptoms can be fairly nonspecific CO exposure may not be recognized as the underlying reason for the individual's symptoms. Physicians and patients may attribute these symptoms to alternate causes (Hampson, 1998). It is estimated that one third of all CO poisonings go undiagnosed (Varon et al., 1997).

Schaplowsky et al. (1974) estimated that more than 10,000 people per year in the US required medical attention or missed at least one day of work in the early 1970's because of sub-lethal exposures to CO. Studies among

emergency department (ED) patients indicate that CO poisoning might explain 5-19% of patients presenting with complaints of headaches (Heckerling, 1987, Heckerling et al., 1987).

It is estimated that annually over 40,000 ED visits are due to acute CO poisoning in the United States (Hampson, 1998). In the Pacific Northwest (Washington, Idaho and Montana), in 1994, 1,325 of 2,505,528 ED visits were CO related. The ED rates for evaluation of CO poisoning was 13.6/100,000 in Washington, 22.4/100,000 in Idaho and 40.4/100,000 in Montana (Hampson, 1998).

The National Electronic Injury Surveillance System (NEISS) tracks ED visits related to consumer products in a representative sample of hospitals in the United States. NEISS estimated an average of 10,200 people were treated annually for CO poisoning from 1995-97 (excluding fires, intentional injuries and motor vehicle causes). In 1995, alone, NEISS estimated that 5900 people were treated in EDs for CO poisoning associated with the use of household appliances (National Information Injury Clearinghouse). This estimate does not include cases due to occupation, fire or motor vehicles.

Prevention

Prevention of carbon monoxide poisoning can be achieved by avoiding or limiting exposure to CO. High concentrations of CO can form when automobiles are allowed to idle in garages. Properly maintained automobile exhaust systems and tail pipes, as well as fireplaces and flues will also limit exposures. The use of

fuel burning equipment including gasoline powered tools in properly ventilated areas will also reduce CO exposures. Further, the proper installation and maintenance of gas appliances will decrease the likelihood of CO exposures. A secondary method to prevent CO poisonings is the use of carbon monoxide alarms. Most alarms are designed like smoke alarms and can be simply plugged into an outlet.

A Similar Study

There is one study in the medical literature that used a similar methodology to that used in this paper. Researchers looked at hospital discharge data for 1998-99 (including some ED data) in Kentucky for individuals with an International Classification of Disease (ICD-9) diagnosis code of 986: *toxic effect of carbon monoxide*. Hospitals were mandated by Kentucky law to use the Federal Uniform Billing 92 standards to submit data. Two hundred and sixty seven records from 35 hospitals were identified from the hospital discharge data set to have a diagnosis code of 986 (Scheerer et al., 2002). Submission was required of all hospitals. However, there was a varying level of compliance. In 1998, 66% of all expected discharges were reported. In 1999, compliance improved to 75%. Twenty five of the records were from two hospitals that declined to participate, two were duplicates, three did not have the correct hospital listed, four were not included because they were follow-up visits and not initial visits, and 28 records could not be abstracted because they were either stored in an off site location, could not be located the identification number was

not correct. The final data set used in analysis consisted of 205 records from 33 hospitals.

The mean age of the Kentucky patients was 31 years and females accounted for 53% of the cases. Fifty seven cases involved children less than 18 years of age. Similar to previous studies (MMWR 1992, MMWR, 1995, Yoon et al., 1998), most poisonings (46%) occurred in December, January and February.

The mean initial carboxyhemoglobin (COHb) level was 11.7%. Oxygen was administered to 64% of patients upon arrival to the hospital. Only 18% or 38 cases (16 females) were hospitalized while 69% were treated on an outpatient basis. The mean age of those hospitalized was 49 years.

In 99 cases (48%), private insurance paid for the visit. Workers' Compensation (WC) paid for 23 (11%) of the cases, Medicaid/care paid for 60 (29%) of the cases and 37 (18%) were self paid. Sixteen cases (8%) of the cases had no payer listed.

One hundred and sixteen cases (56%) occurred in a residential setting, 21 (10%) at school, 17 (8%) in a residential garage (13 caused by motor vehicle), 13 (6%) at a worksite, 4 (2%) at a campsite/tent or storage shed and 2 each (1%) occurred in a boat, a field, a green house and a dental office. There were 15 (7%) cases with an unknown location of exposure.

Thirteen (6%) of the cases were listed as suicide attempt but none were fatal. Nine (69%) of the suicide attempts were male, 4 (31%) were female and the mean age was 34 years. Eleven (85%) of these incidents involved automobile exhaust poisoning.

Methods

For the years 1997 and 1998, all 170 Michigan hospitals were requested to provide the hospital discharge or emergency department (ED) summaries and face sheets for both hospitalized patients and patients treated in the ED where the primary or any of the secondary diagnostic codes was carbon monoxide (CO) poisoning (ICD 986) from a work place. The requirement for hospitals to report these medical records was part of the Michigan Public Health Code as amended in 1978 (Article 368, part 56, PA 1978) requiring physicians, hospitals, clinics and employers to report known or suspected cases of occupational illness. The State of Michigan contracted with Michigan State University to administer this reporting law. This study was approved by the Michigan State University Human Subjects Review Board.

Many hospitals found it easier to report all cases with ICD code 986 than to determine which cases were work-related. On receipt of the medical records, at Michigan State University, information was abstracted from the hospital records by three different staff, from 1999 to 2003, using a uniform data abstract sheet. Hospital reports were submitted to the State in many forms ranging from a single insurance face sheet to a complete hospital discharge report. Information obtained included demographic information (age, gender and race), home address, admit date, discharge date, COHb test and value, cigarette smoking information, name of hospital, and source of exposure.

Cases were grouped into the following injury types: suicide attempt, unintentional exposure, unintentional work related exposure and unknown

exposure. Categories were assigned based on available medical record information including location of the exposure, the type of insurance used to pay for the visit, and if the records noted if exposure was intentional.

The cases were divided into four age categories; under 20 years of age, 20-44 years, 45-64 years and 65 years and older.

COHb levels were grouped into three categories. "Low" represented COHb readings of 0-19%, "moderate" represented results 20-39%, and "high" was assigned to results 40% and greater.

Residential zip codes were used to identify the county of residence. Each county was classified as metropolitan or non metropolitan based on the Standard Metropolitan Statistical Areas (SMSA) designations developed by the U.S. Office of Management and Budget.

In order to determine the completeness of the medical records provided by the hospitals, a computerized list of all hospital discharges for the years 1997 and 1998 was purchased from the Michigan Health and Hospital Association (MHA). The list is a complete database of all hospitalizations at all Michigan hospitals for a given year. Cases that were identified on the MHA list but were not reported from the hospitals were then added to the data set to ensure completeness of CO related hospitalizations. Patients seen only in an ED were not collected in the MHA data set, because the MHA only collects information on hospitalized patients.

There is no systematic collection of all ED visits in the state of Michigan nor is there any way to ensure that hospitals reported all ED visits. An estimate of

the true number of hospitalized and ED treated CO poisonings per year was developed based on two assumptions. The first is that the number of reports received from hospitals is complete based on the data from the MHA. The second assumption is that hospitals reporting only hospitalized cases did not search in their ED records for CO cases. The estimate was obtained by calculating the ratio of ED cases per hospitalized cases for those hospitals that submitted data containing both hospital and ED data, and ED data only. This ratio was applied to hospitals not reporting any ED cases to estimate the number of unreported ED cases.

Maps were generated to show the distribution of cases throughout the state of Michigan. Incidence rates were calculated using 2000 census data. Incidence rates were only calculated if there were at least 5 cases located in the county.

Count data were generated to describe and compare the characteristics of those that had intentional CO poisoning (suicide attempt), unintentional CO poisoning, work related CO poisoning and unknown exposure type. Parameters that were compared were demographics (age, gender, county of residence and race), source of exposure, COHb level, insurance provider and time of year. Chi-square (X^2) values were calculated for each frequency table to determine if there were differences in the characteristics by injury type. A X^2 value was considered significant if the two sided p value was $\leq .05$. If the X^2 was significant, further testing was done to determine what differences between groups were significant.

To test for significant differences between the injury types when the outcome was categorical, a logistic regression using a generalized logit model was used. This method was used because the outcomes have no nominal order and a comparison of the groups taken two at a time could be performed. An odds ratio (OR) was calculated for these comparisons. Significant OR's were reported. The OR was considered significant if the 95% confidence interval did not include 1.00.

To test for significant differences between the injury types with a continuous outcome, ANOVA was used. This analysis was done using SAS statistical software.

Results

Eight hundred forty seven cases were identified from the 170 hospitals in Michigan during the 1997-1998 time period. Sixty-three of the hospitals reported no cases and 107 hospitals reported 847 identified cases. In 1997 there were 435 total reports; 234 ED visits, 197 hospitalizations and 4 unknown. For 1998, there were 412 total reports, with 287 ED visits and 125 hospitalizations.

Gender, Race & Age

Table 1A shows the distribution of gender, race and age of the cases.

There was an equal distribution of males (189) and females (192) for the unintentional cases. The majority of the 156 work related cases were male (63%). Of the suicide attempts, males accounted for the most with 86 (72%) and females for 34 (28%).

Table 1B shows the significant differences between men and women. Men were 2.56 (95% CI: 1.65-4.01) times more likely than women to have CO toxicity from a suicide attempt versus an unintentional exposure. Men were also 1.71 (95% CI: 1.17-2.51) times more likely than women to have work related versus unintentional exposure.

The majority of cases of all types of injury were white. In the unintentional group, whites accounted for 213 (76%), and African Americans accounted for 62 (22%). Whites accounted for 77 (73%) of the work related cases, while African Americans accounted for 26 (24%). In the attempted suicide group, whites

accounted for 95 (97%) of the cases, African Americans accounted for 2 (2%) and 1 (1%) was classified as other.

Table 1B shows the significant differences between races. Whites were 13.09 (95% CI: 3.31-58.82) times more likely than African Americans to have CO toxicity from suicide attempts versus unintentional injury. Whites were 16.04 (95% CI: 3.69-69.7) times more likely than African Americans to have a suicide attempt versus work exposure.

The ages ranged from less than 1 to 97 with a mean of 40.5 years. The age was not known for 11 of the 847 patients. The majority of the 120 suicide attempts were aged 20-44 years (55%). Those aged 45-64 years accounted for 33 (28%) of the cases. There were 11 (9%) cases in the youngest group and 10 (8%) in the oldest group.

Half of the unintentional cases were aged 20-44. Those aged 45-64 years accounted for 93 (25%) of the cases. The youngest, aged 0-19 years, accounted for 55 (15%) of the cases and the oldest group, those over 65, accounted for the smallest percentage, with 41 cases (11%).

The majority of the 153 work related cases were aged 20-44 (67%). Those aged 45-64 accounted for 33 (22%) of the cases. Five (3%) of the cases were from the youngest group and 13 (8%) accounted for the oldest group.

Table 1B shows the significant difference between age groups. The youngest group (0-19) was 3.4 (95% CI: 1.13-10.2) times more likely than those aged 20-44 years old to attempt suicide versus a work related injury.

Cigarette smoking

Table 2 illustrates the distribution of the cigarette smoking among the four types of injury groups. The majority, 37 of the 47 suicide cases, were smokers (79%) and 10 (21%) never smoked. The majority, 113 of the 183 unintentional cases were current smokers (62%). Five (3%) were non-smokers and 65 (35%) never smoked. Of the work related cases 48 (70%) were smokers, 2 (3%) were non-smokers and 19 (28%) never smoked. Although the X^2 for the overall table was significant, there were no significant differences between injury groups.

Vital status

Table 3 shows the vital status of the cases. Almost all of the cases were alive in each group. Of the unintentional cases, 368 (98%) were alive. In the work related group, 150 (97%) were alive. Of those that tried to commit suicide 117 (98%) were alive.

Exposure

Table 4A illustrates the source of exposure to CO. There were three main sources of exposure to CO; furnace/stove, car/truck, and other. The "other" exposure category included fire, smoke inhalation, forklifts, other equipment and charcoal grills. The main exposure of the unintentional cases was from furnace/stove emission representing 123 (44%) of the 279 cases.

In the work category, 40 (45%) of the exposures were from other sources. Twenty two (25%) were from furnace/stoves. In the suicide attempt category, 102

(93%) were exposed to CO from car/truck exposures and 6 (5%) of the cases were exposed to CO from furnace/stoves.

Table 4B shows the significant associations for source of exposure. Furnace/stove sources were 45.46 (95% CI: 18.66-110.73) times more likely than car/truck exposures to be the source of exposure for unintentional versus suicide attempts, 3.16 (95% CI: 1.63-6.13) times more likely than car/truck exposures to be the source of exposure for unintentional types of injury versus work related injuries, and 14.39 (95% CI: 5.29-39.1) times more likely than car/truck exposures to be the source of exposure for work related injuries versus suicide attempts.

Furnace/stove sources were 2.03 (95% CI: 1.14-3.64) times more likely than other exposures to be the source of exposure for unintentional versus work related injuries and 5.46 (95% CI: 1.01-29.4) times more likely than other exposures to be the source of exposure for suicide attempts versus work related injuries.

Car/truck sources were 121.94 (95% CI: 28.86-515.71) times more likely than other exposures to be the source of exposure for suicide attempts versus unintentional injuries and 78.44 (95% CI: 17.79-346) times more likely than other exposures to be the source of CO exposure for suicide attempts versus work related injuries.

Insurance

Table 5 illustrates the distribution of the insurance type. Private insurance paid for the majority (57%) of the 328 unintentional injuries. Medicare/aid paid for 95 (29%) of the cases and 45 (14%) cases had no insurance.

Workers' compensation paid for the majority (49%) of the 135 work related injuries. Private insurance paid for 49 (36%), Medicare/aid paid for 13 (10%) and 7 (5%) had no insurance.

Private insurance paid for the majority (60%) of the 96 suicide attempts.

Length of stay at the hospital

The number of days spent in the hospital ranged from less than one day to 98 days. The median value of time spent in the hospital was less than one day. The majority of all injury types spent less than one day in the hospital. Table 6 shows this distribution.

Of the 381 unintentional poisonings, 274 (72%) stayed for less than one day. One hundred-twenty six (81%) of the 156 work related injuries stayed less than one day and 17 (11%) stayed for one day.

Thirty-six (30%) of the 120 suicide attempts stayed in the hospital for less than one day. Twenty-six (22%) stayed for one day, 25 (20%) stayed for four or more days.

Cases that attempted suicide spent significantly more time in the hospital than other injury types. Table 6B shows the significant differences in length of stay between the injury groups.

Type of Visit

Table 7A illustrates the distribution of the type of visit. The majority of non-work and work exposures were ED visits with 282 (74%) and 127 (81%), respectively. The majority of suicide attempts were hospitalized (76%).

Table 7B shows the significant associations between the types of visit. ED visits were 13.74 (95% CI: 7.69-24.57) times more likely than hospitalizations for work related injuries versus suicide attempts and 8.94 (95% CI: 5.5-14.4) times more likely than hospitalizations for unintentional injuries versus suicide attempts.

CarboxyHemoglobin Tests

COHb levels were tested in 544 (64%) of the injuries. However, the actual level of COHb was available in the medical records for only 387 of the cases. Of the 387 known COHb levels, the average level was 12.13%. Table 8A shows the distribution of measured COHb levels by injury type.

Table 8B shows the level of severity of COHb levels. The majority (79%) of all injury types had low levels ($\leq$19%) of COHb. There were twelve injuries that had high levels (>40%).

Table 8C shows the average COHb level stratified by cigarette smoking status. Overall, those who attempted suicide had a higher average COHb level (16.48%) than the other groups. The group with the lowest COHb level was the work related injuries with an average level of 9.4%. There were no significant associations of COHb level between smoking status and injury type.

Season

Table 9A illustrates the seasonality of the carbon monoxide poisoning cases. There were 279 (33%) poisonings that occurred during the winter months (December, January and February). There were 250 (29%) cases in the fall. In the spring there were 209 (25%) cases and in the summer there were only 109 (13%) cases.

The highest percentage of cases over all types of injury occurred in the winter. Suicide attempts were more evenly distributed throughout all seasons than other injury types.

Table 9B shows the significant differences between injury type and seasonality. Work related poisonings were 1.99 (95% CI: 1.14-3.48) times more likely to occur in the winter than spring poisonings compared to unintentional injuries and 2.35 (95% CI: 1.17-4.71) times more likely to occur in the winter than spring poisonings for work related injuries versus suicide injuries. Unintentional poisonings were 2.88 (95% CI: 1.56-5.44) times more likely to occur in the winter than summer poisonings compared to suicide attempts. Unintentional poisonings were 2.44 (95% CI: 1.28-4.67) times more likely to occur in the spring than summer poisonings compared to suicide attempts and 3.31 (95% CI: 1.66-6.60) times more likely in the spring than summer poisonings compared to work related injuries. Suicide attempts were 2.53 (95% CI: 1.24-5.47) times more likely to occur in the spring than fall poisonings compared to work related injuries. Suicide attempts were 2.87 (95% CI: 1.5-5.47) times more likely to occur in the summer than fall poisonings compared to unintentional injuries.

Approximation of Missed Emergency Department Visits

Fifty-eight of the 107 reporting hospitals reported ED cases with or without a hospitalization. The remaining 49 hospitals reported hospitalizations only. The median ratio of ED visits to hospitalizations was 2.17. This value was applied to the 49 hospitals reporting hospitalized cases and not reporting any ED cases. The estimated number of unreported ED visits was 312.

Geographic Distribution

Michigan has twenty-six counties that are metropolitan. Table 10 shows the distribution of residence of the cases according to their metropolitan status. All metropolitan counties, except Cass, had at least one case. There was no statistical significance between injury type and place of residence.

Cases of carbon monoxide were distributed across the state. There was at least one case in 65 of the 83 counties. The county with the highest number of suicides was Oakland County (22 cases). The county with the highest number of non-work related cases was Genesee County (58 cases). The county with the highest number of work related cases was Wayne County (19 cases). Figure 1 shows the number of cases located in each county and Table 11 lists the number of cases per county; Figures 2-4 list the number of cases per county according to the injury type. Figures 5-8 show the incidence rate per county overall and according to injury type.

The calculated incidence rate for all cases of CO poisoning treated in a hospital or ED is 8.52 poisonings per 100,000. The incidence rate increased to

11.66 poisonings per 100,000 individuals when the 312 estimated ED cases that were not reported were included. The following county incidence rates do not include the 312 estimated ED cases. The county with the highest number of cases was Wayne with 152 cases. The county with the highest incidence rate was Huron County (52.7 per 100,000). The county with the lowest incidence rate was Washtenaw County (0.62 per 100,000).

The county with the highest incidence rate for suicide attempts was Calhoun County (5.09 per 100,000). The county with the highest incidence rate for unintentional injury was Branch County (30.52 per 100,000). The county with the highest incidence rate for work related injury was Monroe County (4.10 per 100,000).

Discussion

From 1997-1998, 847 cases of carbon monoxide (CO) poisoning were identified through hospital or emergency department reports. These reports were submitted to the State of Michigan in compliance with the State's occupational disease reporting law. The reports are likely an underestimate of the total number of individuals with CO poisoning. Since CO is colorless, odorless, and nonirritating, its presence is not easily detected and neither patients presenting with non-specific symptoms nor the health care providers evaluating them may be aware that an exposure occurred.

It was estimated that there were 312 additional ED visits that were not reported. There was complete reporting of inpatient hospital visits for these years. However, the extent of underreporting of ED visits even among those hospitals that reported at least one ED visit is unknown.

The results from this study tend to agree with previously reviewed studies. In Michigan, most of the cases of CO poisoning from 1997 and 1998 were male with an average age of 41 years, which is similar to the demographic characteristics reported in four previous studies (MMWR 1992, Yoon et al 1998, MMWR 1995, Cobb and Eitzel, 1991).

The most common sources of exposure to CO, such as motor vehicles and heating sources were similar to other studies (Scheerer et al, MMWR, 1995, Cook et al., MMWR, 1992). In Michigan there were significant differences of CO source between the types of injury. Unintentional injuries were 46 times more likely to occur by furnace compared to suicide attempts. For suicide attempts,

motor vehicles were the most likely source of CO exposure. Unintentional injuries were 3 times as likely to be from a furnace when compared to injuries caused at work. These findings could be used to develop outreach materials to increase awareness of some of the main source of CO exposures at home and at work.

Theoretically, the death rate due to CO poisoning should be greater in the cold, high altitude states. The elevated death rate in colder states could be due to the greater need to use heating equipment that is improperly maintained or defective, and idling motor vehicles with exhaust pipes blocked by snow. This in fact is the case.

In accord with previous studies, the greatest percentage of the Michigan cases occurred in the winter months (Scheerer et al., 1999, MMWR, 1992, Yoon et al., 1998). There were a significantly higher number of injuries in the winter when compared to spring and summer. In the winter people would have a greater exposure to furnaces or heaters and could be in enclosed garages or sheds with motor vehicles.

The longer length of stay found among suicide attempts compared to other injury types could be due to hospitalization for psychiatric evaluation since COHb levels were not appreciably greater in individuals who attempted to commit suicide compared to any other group.

Carboxyhemoglobin levels reported in this study are most likely conservative because the cases were removed from the CO exposure for varying periods of time before the COHb test was administered. Additionally, if oxygen was administered prior to the COHb test this would also lower an individual's

level. Background levels of COHb can range from 0-9% depending on smoking status. As reported, most of the COHb levels mentioned in this study were less than 20%.

The injury group with the highest average COHb level was the suicide attempt group. This is not unexpected considering the CO poisoning was intentional. The group with the lowest average COHb level was the work group. There maybe active monitoring of CO in some workplaces. Additionally, workers may either notice an individual with symptoms or experience symptoms themselves and therefore be more likely seek medical attention.

Workers' compensation paid for just under half of the work related cases. Theoretically workers' compensation should cover nearly all (except for the self employed) of the work related cases. If the illness is work related, private insurance companies or the workers themselves should not have to pay for the hospital bills. In the Kentucky study, workers' compensation paid for only 23 (11.2%) of the 205 total cases, though there was no mention of how many cases were work related. In the current study, workers' compensation paid for 66 (8%) of the total cases.

There were other similarities between the Kentucky study and the Michigan study. Similar to the Kentucky study, the average COHb level in Michigan was near 12% and in both studies private insurance paid for the majority of the injuries. However, there were some differences in the findings from Michigan and Kentucky. Only 6% of the cases in Kentucky were listed as suicide attempts while in Michigan 14% were listed as suicide attempts. One

reason for this difference could be due to more suicide deaths never making it to a hospital in Kentucky. In addition, the overall incidence of CO poisoning in the Kentucky study was 5.07 persons per 100,000, while in the current study in Michigan the incidence rate of CO poisonings was 11.66 per 100,000. This could be due to Michigan's northern climate with a greater potential for cold weather related exposures. The average age in the two studies also differed with the average age of the Michigan cases of 41 compared to 31 in the cases of Kentucky.

Incidents of CO poisoning can be prevented through increased public health awareness and implementation of prevention strategies. Health care professionals and public health professionals need to educate the public about potential sources of CO exposure, common symptoms associated with CO poisoning, as well as the hazards associated with CO toxicity. Prevention strategies include: not allowing motor vehicles to idle in enclosed areas; regularly checking and maintaining motor vehicle emissions; and ensuring all gas appliances are installed correctly and are located in properly ventilated areas. In areas that are likely to have CO exposures, installation of a CO detector is recommended at home and work. Most CO detectors can be simply plugged into a wall outlet and are relatively inexpensive.

Limitations

This study only analyzed hospitalizations and ED visits. Individuals who went to clinics, private doctors or those who did not make it to the hospital would not have been included in this study. It is possible that the demographic characteristics and risk factors of those who did not have a hospital visit represent something other than what this study found. Missed cases would probably be less severe and would not require the type of medical attention received at a hospital or ED. Although we were able to confirm hospitalized cases through a secondary data source (MHA), there was no way to confirm ED visits. There is no organization that collects ED visits in Michigan and therefore it is probable that there were some ED visits at the 62 hospitals that did not report any cases (hospitalizations or ED visits). Nineteen (32%) of the 59 hospitals reporting ED visits reported only ED visits. There was an attempt to estimate how many cases were missed but the estimation was based only on the reported cases. If hospitals under reported CO cases that were treated in an ED then our estimation procedure would not fully capture all the cases that actually occurred.

Another source of missing cases could be from a lack of or misclassification of ICD codes and E codes. It is impossible to speculate who or what these unknowns represent. It is likely that there was no bias in the missing or unknown data collected from the hospitals because the unknown or missing information would likely be distributed across hospitals and injury type categories.

The data have many missing values because the different hospitals provided different types of medical records. Hospitals reported in different ways and reported with different forms, some handwritten, others typed. Data collection at each hospital was also different; some health care providers were more thorough than others in recording details. Records varied in the amount of information written about the patient, the incident, and the treatment. For instance, to obtain more accurate COHb levels, time between exposure and test should be recorded and reported by the hospital along with any record of oxygen that was administered to the patient. This information was rarely available in the medical records to be abstracted.

The work related cases and incidence rates by county might be inaccurate. Because the data was collected for place of residence and not place of work, the true distributions of Figures 4 and 8 may be shifted. The distribution would depend on how close to home these individuals work

A review of death certificates would be necessary to study deaths due to CO poisoning, instead of reviewing hospital discharge data, where only 3% of cases died.

Conclusions

Carbon monoxide poisoning affected an estimated 11.66 per 100,000 people hospitalized or treated in an emergency department in Michigan in 1997 and 1998. This number is likely to be a conservative estimate because even with the addition of the 312 estimated ED cases the estimate may not include all ED cases and does not include individuals not treated in an ED and those that were not hospitalized. Unintentional poisonings were mainly due to faulty heating sources while suicide attempts were primarily due to motor vehicle exposures. Most of the cases were unintentional exposures with an average COHB level of 12.06 %. Males aged 20-44 were most likely to be exposed in all injury categories. Cases were more likely to occur in the winter.

Health care professionals are encouraged to educate the public about the dangers of CO poisoning. In doing this, unintentional exposures could be prevented. The best way to avoid CO exposure is to prevent CO exhaust by routinely inspecting all home heating sources and by preventing motor vehicles from idling in closed areas. As an additional safeguard, a CO detector should be installed in areas where there is a potential for CO to form.

This study demonstrated that hospital discharge and ED data are useful tools to understand the epidemiology of CO poisonings. Efforts to make ED data available similar to hospitalization data would be useful for public health programs.

Tables and Figures

Table 1A.-Demographic Characteristics of Cases of CO poisoning Treated in an ED or Hospitalized in Michigan for 1997 and 1998

	Suicide		Unintentional		Work Related		Unknown		Total	
Gender	#	%	#	%	#	%	#	%	#	%
Male	86	(71.7)	189	(49.6)	98	(62.8)	110	(57.9)	483	(57.0)
Female	34	(28.3)	192	(50.4)	58	(37.2)	80	(42.1)	364	(43.0)
Total	**120**	**100**	**381**	**100**	**156**	**100**	**190**	**100**	**847**	**100**

X^2 =21.25 p=<.0001

Race*

White	95	(97.0)	213	(75.5)	77	(73.3)	103	(79.8)	488	(79.5)
African American	2	(2.0)	62	(22.0)	26	(24.8)	25	(19.4)	115	(18.7)
Other	1	(1.0)	7	(2.5)	2	(1.9)	1	(0.8)	11	(1.8)
Total	**98**	**100**	**282**	**100**	**105**	**100**	**129**	**100**	**614**	**100**

X^2 =36.70 p<.0001

*Race is unknown for 22 suicide attempts, 99 unintentional cases, 51 work related cases and 61 unknown cases

Age Group **

0-19	11	(9.2)	55	(14.7)	5	(3.3)	14	(7.4)	85	(10.2)
20-44	66	(55.0)	186	(49.6)	102	(66.7)	93	(49.5)	447	(53.5)
45-64	33	(27.5)	93	(24.8)	33	(21.6)	53	(28.2)	212	(25.4)
65+	10	(8.3)	41	(10.9)	13	(8.5)	28	(14.9)	92	(11.0)
Total	**120**	**100**	**375**	**100**	**153**	**100**	**188**	**100**	**836**	**100**

X^2 =30.56 p<.0023

** Age is not known for 6 unintentional cases, 3 work related cases and 2 unknown cases

Table 1B.- Significant Associations between Demographic Characteristics of Cases of CO Poisoning Treated in an ED or Hospitalized in Michigan for 1997 and 1998

Gender	Injury Type	OR	95% CI
Male Vs Female	Sui Vs Unint	2.56	1.65-4.01
Male Vs Female	Work Vs Unint	1.71	1.17-2.51

Race	Injury Type	OR	95% CI
White Vs A. American	Sui Vs Unint	13.09	3.31-58.82
White Vs A. American	Sui Vs Work	16.04	3.69-69.7

Age	Injury Type	OR	95% CI
0-19 Vs 20-44	Sui Vs Work	3.40	1.13-10.2
0-19 Vs 65+	Unt Vs Work	3	1.15-10.52

Table 2.- Smoking Status of Cases of CO Poisoning Treated in an ED or Hospitalized in Michigan for 1997 and 1998

Smoking Tobacco*	Suicide		Unintentional		Work Related		Unknown		Total	
	#	%	#	%	#	%	#	%	#	%
Current	37	(78.7)	113	(61.7)	48	(69.6)	29	(87.9)	227	(68.4)
Ex-smoker	0	(0.0)	5	(2.7)	2	(2.9)	0	(0.0)	7	(2.1)
Never smoked	10	(21.3)	65	(35.5)	19	(27.5)	4	(12.1)	98	(29.5)
Total	**47**	**100**	**183**	**100**	**69**	**100**	**33**	**100**	**332**	**100**

X^2 =62.49 p<.0001

*Smoking Status is unknown for 73 suicide attempts, 198 unintentional cases, 87 work related cases and 157 unknown cases

Table 3.- Vital Status of Cases of CO Poisoning Treated in an ED or Hospitalized in Michigan for 1997 and 1998

Vital Status*	Suicide		Unintentional		Work Related		Unknown		Total	
	#	%	#	%	#	%	#	%	#	%
Alive	117	(98.3)	368	(97.9)	150	(97.4)	159	(95.8)	794	(97.4)
Deceased	2	(1.7)	8	(2.1)	4	(2.6)	7	(4.2)	21	(2.6)
Total	**119**	**100**	**376**	**100**	**154**	**100**	**166**	**100**	**815**	**100**

$X^2 = 55.19$ $p < .0001$

*Vital status is unknown for 1 suicide attempt, 5 unintentional cases, 2 work related cases and 24 unknown cases

Table 4A.- Distribution of Source of Exposure for Cases of CO Poisoning Treated in an ED or Hospitalized in Michigan for 1997 and 1998

Exposure*	Suicide		Unintentional		Work Related		Unknown		Total	
	#	%	#	%	#	%	#	%	#	%
Furnace/Stove	6	(5.5)	123	(44.1)	22	(25.0)	10	(24.4)	161	(31.1)
Car/Truck	102	(92.7)	46	(16.5)	26	(29.5)	7	(17.1)	181	(34.9)
Other	2	(1.8)	110	(39.4)	40	(45.5)	24	(58.5)	176	(34.0)
Total	110	100	279	100	88	100	41	100	518	100

X^2 =502.29 p<.0001

*Source of exposure is unknown for 10 suicide attempts, 102 unintentional cases, 68 work related cases and 149 unknown cases

Table 4B.- Significant Associations between the Different of Sources of Exposure for Cases of CO Poisoning Treated in an ED or Hospitalized in Michigan for 1997 and 1998

Source of Exposure	Injury Type	OR	95% CI
Furnace Vs Car	Unint Vs Sui	45.46	18.66-110.73
Furnace Vs Car	Unint Vs Work	3.16	1.63-6.13
Furnace Vs Car	Work Vs Sui	14.39	5.29-39.1
Furnace Vs Other	Unint Vs Work	2.03	1.14-3.64
Furnace Vs Other	Sui Vs Work	5.46	1.01-29.4
Car Vs Other	Sui Vs Unint	121.94	28.86-515.71
Car Vs Other	Sui Vs Work	78.44	17.79-346

Table 5.- Distribution of Insurance Providers for Cases of CO Poisoning Treated in Michigan or Hospitalized in Michigan for 1997 and 1998

Insurance	Suicide		Unintentional		Work Related		Unknown		Total	
	#	%	#	%	#	%	#	%	#	%
Private	58	(60.4)	188	(57.3)	49	(36.3)	83	(56.5)	378	(53.5)
Worker's Compensation	0	(0.0)	0	(0.0)	66	(48.9)	0	(0.0)	66	(9.3)
Medicare/Aid	22	(22.9)	95	(29.0)	13	(9.6)	50	(34.0)	180	(25.5)
No Insurance	16	(16.7)	45	(13.7)	7	(5.2)	14	(9.5)	82	(11.6)
Total	96	100	328	100	135	100	147	100	706	100

$X^2 = 311.57$ $p < .0001$

Insurance is unknown for 24 suicide attempts, 53 unintentional cases, 23 work related cases and 41 unknown cases

Table 6A.- Distribution of Length of Stay for Cases of CO Poisoning Treated in an ED or Hospitalized in Michigan for 1997 and 1998

Length of Stay (Days)	Suicide		Unintentional		Work Related		Unknown		Total	
	#	%	#	%	#	%	#	%	#	%
<1	36	(30.0)	274	(71.9)	126	(80.8)	95	(50.0)	531	(62.7)
1	26	(21.7)	49	(12.9)	17	(10.9)	35	(18.4)	127	(15.0)
2	18	(15.0)	14	(3.7)	1	(0.6)	18	(9.5)	51	(6.0)
3	15	(12.5)	10	(2.6)	1	(0.6)	8	(4.2)	34	(4.0)
≥4	25	(20.8)	34	(8.9)	11	(7.1)	34	(17.9)	104	(12.3)
Total	120	100	381	100	156	100	190	100	847	100

X^2=124.2 p<.0001

Table 6B.- Significant differences of Length of Stay for Cases of CO Poisoning Treated in an ED or Hospitalized in Michigan for 1997 and 1998

Length of Stay	Injury Type	OR	95% CI
<1 Vs 1	Unint Vs Sui	4.03	2.24-7.30
<1 Vs 1	Work Vs Sui	5.65	2.77-11.49
<1 Vs 2	Unint Vs Sui	9.8	4.48-21.28
<1 Vs 2	Work Vs Sui	66.67	8.62-500
<1 Vs 3	Unint Vs Sui	11.36	4.76-27.03
<1 Vs 3	Work Vs Sui	55.56	7.09-500
<1 Vs 4	Unint Vs Sui	5.59	3.0-10.40
<1 Vs 4	Work Vs Sui	8.4	3.77-18.52
1 Vs 2	Unint Vs Sui	2.42	1.04-5.64
1 Vs 3	Unint Vs Sui	2.83	1.12-7.17

Table 7A.- Type of Visit for Cases of CO Poisoning Treated in an ED or Hospitalized in Michigan for 1997 and 1998

Type of Visit*	Suicide		Unintentional		Work Related		Unknown		Total	
	#	%	#	%	#	%	#	%	#	%
ED only	29	(24.2)	282	(74.0)	127	(81.4)	83	(44.6)	521	(61.8)
Hospitalization	91	(75.8)	99	(26.0)	29	(18.6)	103	(55.4)	322	(38.2)
Total	120	100	381	100	156	100	186	100	843	100

X^2 =158.83 p<.0001

*Type of Visit is unknown for 4 unknown cases

Table 7B.- Significant Associations of Visit Type of CO Poisoning Treated in an ED or Hospitalized in Michigan for 1997 and 1998

Visit	Injury Type	OR	95% CI
ED Vs Hospitalization	Work Vs Sui	13.74	7.69-24.57
ED Vs Hospitalization	Unint Vs Sui	8.94	5.5-14.4

Table 8A.- Test for Carboxyhemoglobin in Cases of CO Poisoning Treated in an ED or Hospitalized in Michigan for 1997 and 1998

CoHB Tested*	Suicide		Unintentional		Work Related		Unknown		Total	
	#	%	#	%	#	%	#	%	#	%
No	12	(18.8)	59	(19.3)	25	(20.7)	9	(17.0)	105	(19.3)
Yes	52	(81.3)	247	(80.7)	96	(79.3)	44	(83.0)	439	(80.7)
Total	64	100	306	100	121	100	53	100	544	100

X^2 =170.62 p<.0001

*It is unknown if COHb was tested in 56 suicide attempts, 75 unintentional cases, 35 work related cases and 137 unknown cases

Table 8B.- Carboxyhemoglobin levels for cases of CO Poisoning Treated in an ED or Hospitalized in Michigan for 1997 and 1998

CoHB Level*	Suicide		Unintentional		Work Related		Unknown		Total	
	#	%	#	%	#	%	#	%	#	%
Low (0-19%)	35	(76.1)	168	(78.5)	76	(84.4)	28	(75.7)	307	(79.3)
Moderate (20-39%)	6	(13.0)	43	(20.1)	13	(14.4)	6	(16.2)	68	(17.6)
High (≥40%)	5	(10.9)	3	(1.4)	1	(1.1)	3	(8.1)	12	(3.1)
Total	46	100	214	100	90	100	37	100	387	100

X^2 =96.37 p<.0001

*COHb level is unknown for 23 suicide attempts, 92 unintentional cases, 31 work related cases and 16 unknown cases

Table 8C.-Average Carboxyhemoglobin levels for cases of CO Poisoning by Smoking Status Treated in an ED or Hospitalized in Michigan in 1997 and 1998

Smoking Status	Suicide	Unintentional	Work Related	Unknown
	Average Carboxyhemoglobin levels			
Current Smoker	13.8	13.05	9.27	11.85
Non/Ex Smoker	15	11.02	7.5	9.33
Unknown	18.74	11.7	10.36	13.79
All	16.48	12.06	9.4	12.69

p=.066

Table 9A.- Seasonality of Cases of CO Poisoning Treated in an ED or Hospitalized in Michigan for 1997 and 1998

Season	Suicide		Unintentional		Work Related		Unknown		Total	
	#	%	#	%	#	%	#	%	#	%
Winter	33	(27.5)	128	(33.6)	55	(35.3)	63	(33.2)	279	(32.9)
Spring	31	(25.8)	102	(26.8)	22	(14.1)	54	(28.4)	209	(24.7)
Summer	26	(21.7)	35	(9.2)	25	(16.0)	23	(12.1)	109	(12.9)
Fall	30	(25.0)	116	(30.4)	54	(34.6)	50	(26.3)	250	(29.5)
Total	120	100	381	100	156	100	190	100	847	100

$X^2 = 25.78$ $p < .0022$

Table 9B.- Significant Differences between the Seasonality of Cases of CO Poisoning Treated in an ED or Hospitalized in Michigan for 1997 and 1998

Season	Injury Type	OR	95% CI
Winter Vs Spring	Work Vs Unint	1.99	1.14-3.48
Winter Vs Spring	Work Vs Sui	2.35	1.17-4.71
Winter Vs Summer	Unint Vs Sui	2.88	1.56-5.44
Spring Vs Summer	Unint Vs Sui	2.44	1.28-4.67
Spring Vs Summer	Unint Vs Work	3.31	1.66-6.60
Spring Vs Fall	Sui Vs Work	2.53	1.25-5.47
Summer Vs Fall	Sui Vs Unint	2.87	1.50-5.47

Table 10.- Distribution of Cases treated in an ED or Hospitalized with CO Poisoning According to Location in Michigan in 1997 and 1998

	Suicide		Unintentional		Work Related		Unknown		Total	
Location*	#	%	#	%	#	%	#	%	#	%
Metropolitan	99	(84.6)	296	(80.2)	125	(82.2)	142	(77.6)	662	(80.6)
Non Metropolitan	18	(15.4)	73	(19.8)	27	(17.8)	41	(22.4)	159	(19.4)
Total	**117**	**100**	**369**	**100**	**152**	**100**	**183**	**100**	**821**	**100**

$X^2 = 3.08$ p=0.799

*Zip code was not known for 3 suicide attempts,12 unintetnional injuries, 4 work related injuries and 7 unknown injuries

Table 11.- Distribution of CO poisonings by County**

County	Frequency	Percent
Alcona	0	0.00
Alger	2	0.24
Allegan	10	1.22
Alpena	2	0.24
Antrim	0	0.00
Arenac	4	0.49
Baraga	0	0.00
Barry	2	0.24
Bay	6	0.73
Benzie	0	0.00
Berrien	10	1.22
Branch	22	2.68
Calhoun	34	4.14
Cass	0	0.00
Charlevoix	2	0.24
Cheboygan	7	0.85
Chippewa	5	0.61
Clare	2	0.24
Clinton	1	0.12
Crawford	2	0.24
Delta	1	0.12
Dickinson	3	0.37
Eaton	6	0.73
Emmet	8	0.97
Genesee	88	10.72
Gladwin	0	0.00
Gogebic	0	0.00
Grand Traverse	5	0.61
Gratiot	3	0.37
Hillsdale	3	0.37
Houghton	1	0.12
Huron	19	2.31
Ingham	23	2.80

Table 11.- Distribution of CO poisonings by County (Continued)

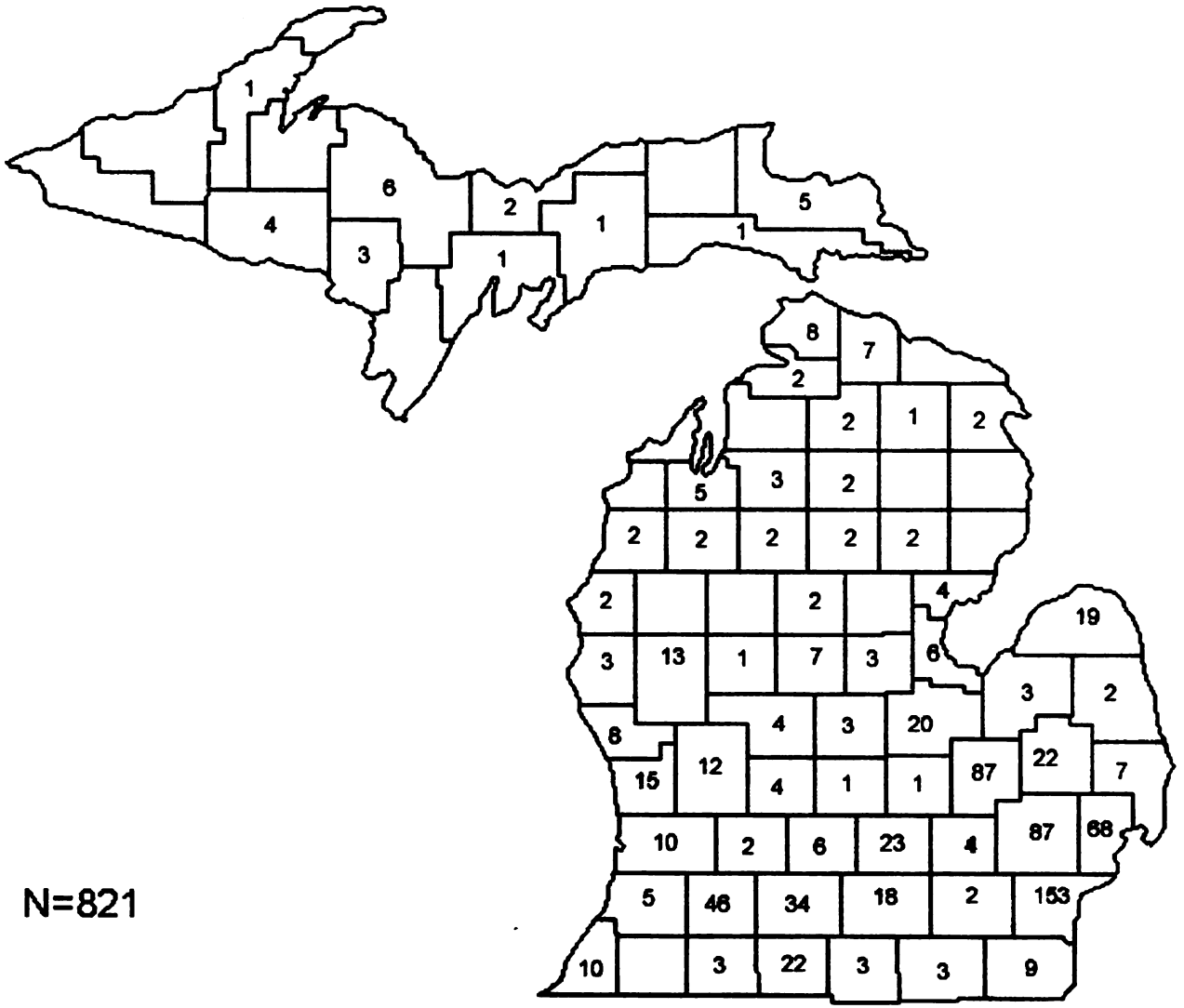
County	Frequency	Percent
Ionia	4	0.49
Iosco	0	0.00
Iron	4	0.49
Isabella	7	0.85
Jackson	18	2.19
Kalamazoo	46	5.60
Kalkaska	3	0.37
Kent	12	1.46
Keweenaw	0	0.00
Lake	0	0.00
Lapeer	22	2.68
Leelanau	0	0.00
Lenawee	3	0.37
Livingston	4	0.49
Luce	0	0.00
Mackinac	1	0.12
Macomb	68	8.28
Manistee	2	0.24
Marquette	6	0.73
Mason	2	0.24
Mecosta	1	0.12
Menominee	0	0.00
Midland	3	0.37
Missaukee	0	0.00
Monroe	9	1.10
Montcalm	4	0.49
Montmorency	1	0.12
Muskegon	8	0.97
Newaygo	13	1.58
Oakland	87	10.60
Oceana	3	0.37
Ogemaw	2	0.24
Ontonagon	0	0.00
Osceola	0	0.00

Table 11.- Distribution of CO poisonings by County (Continued)

Oscoda	0	0.00
Ostego	2	0.24
Ottawa	15	1.83
Presque Isle	0	0.00
Roscommon	2	0.24
Saginaw	20	2.44
Sanilac	2	0.24
Schoolcraft	1	0.12
Shiawassee	1	0.12
St. Clair	7	0.85
St. Joseph	3	0.37
Tuscola	3	0.37
Van Buren	5	0.61
Washtenaw	2	0.24
Wayne	152	18.51
Wexford	2	0.24
Total	821	100.00

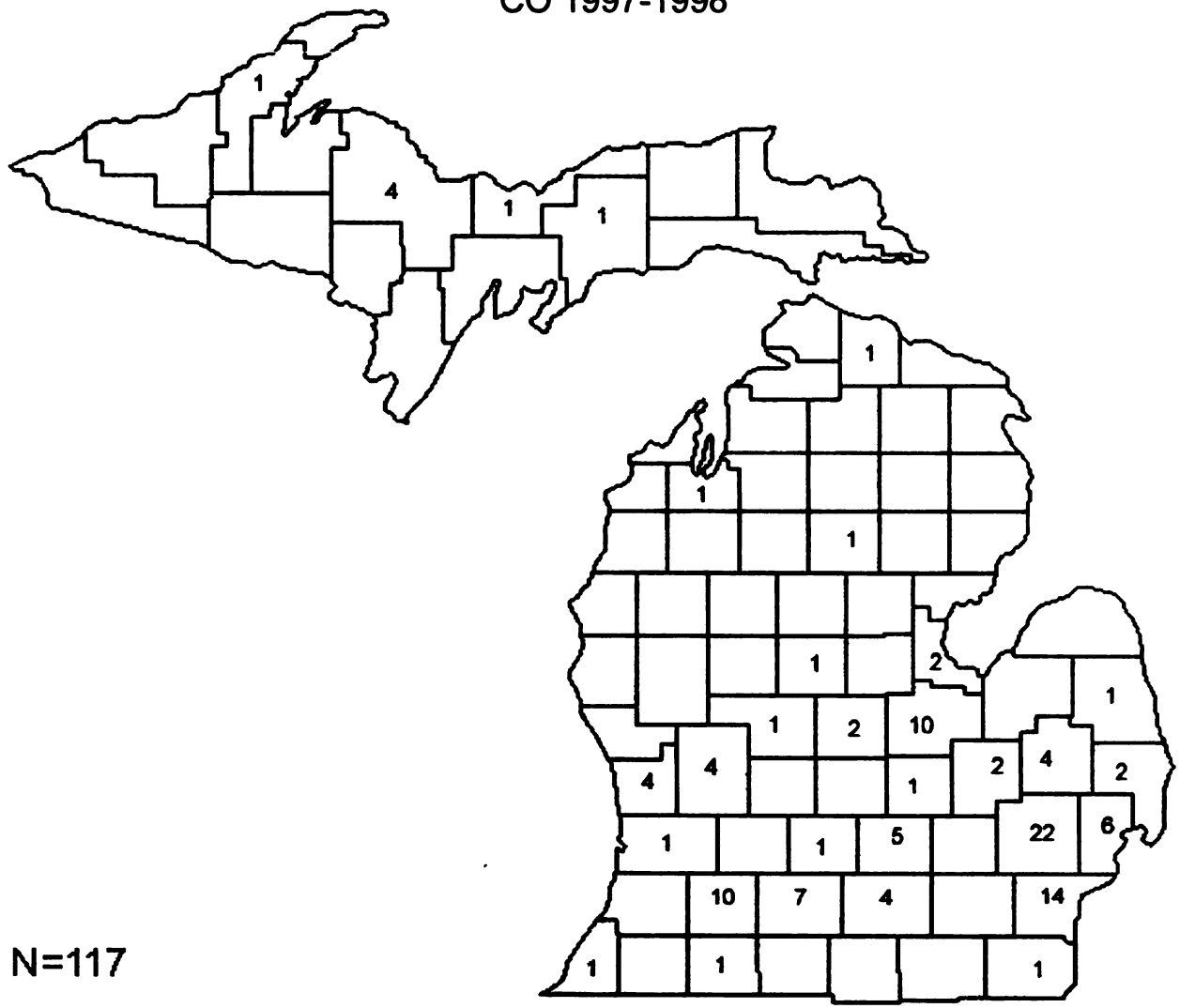
**There are 20 unknown values
** 6 people lived outside of the State

Figure 1.- Number of CO Poisonings 1997-1998



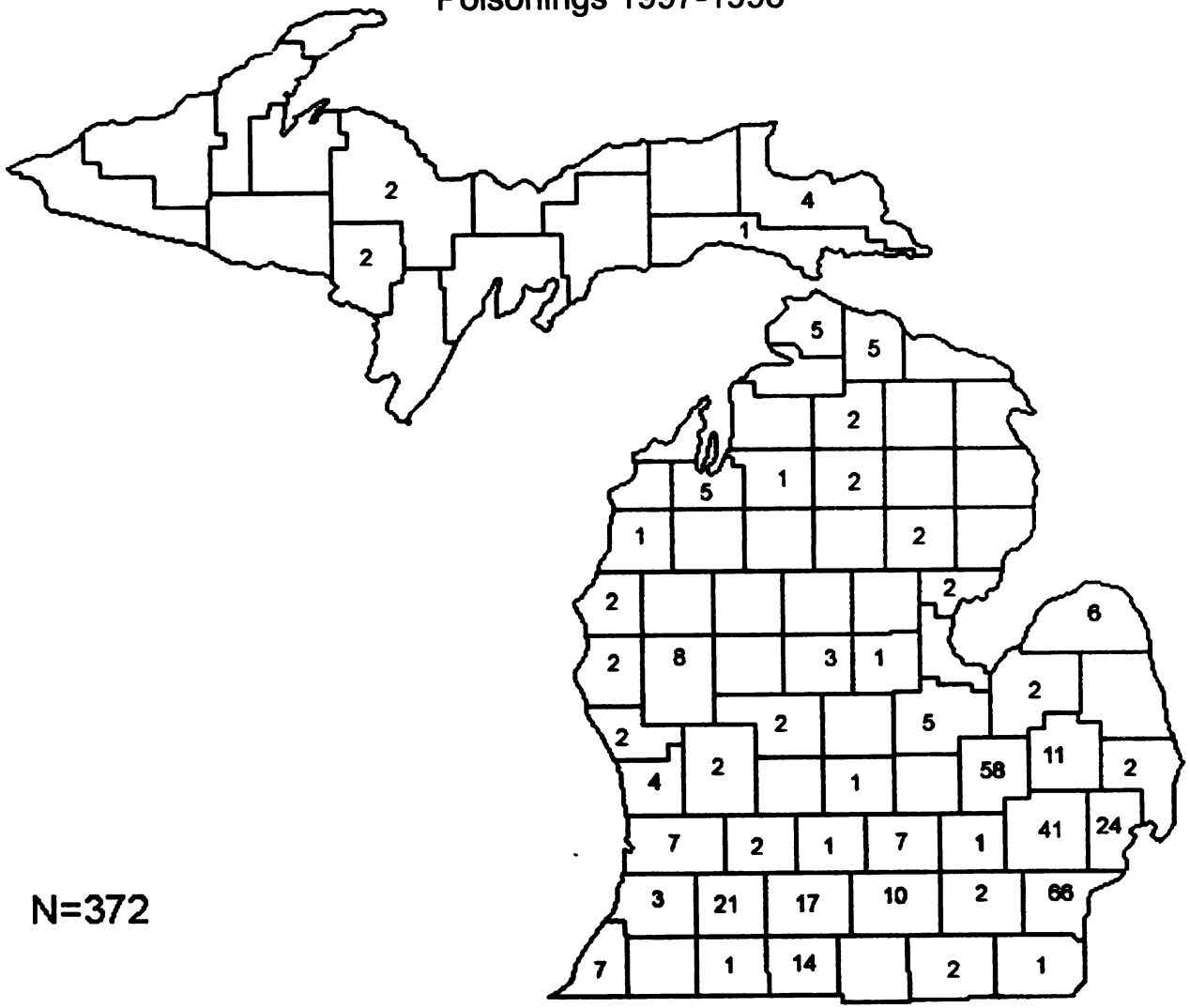
N=821

Figure 2.- Number of Suicide Attempts using
CO 1997-1998



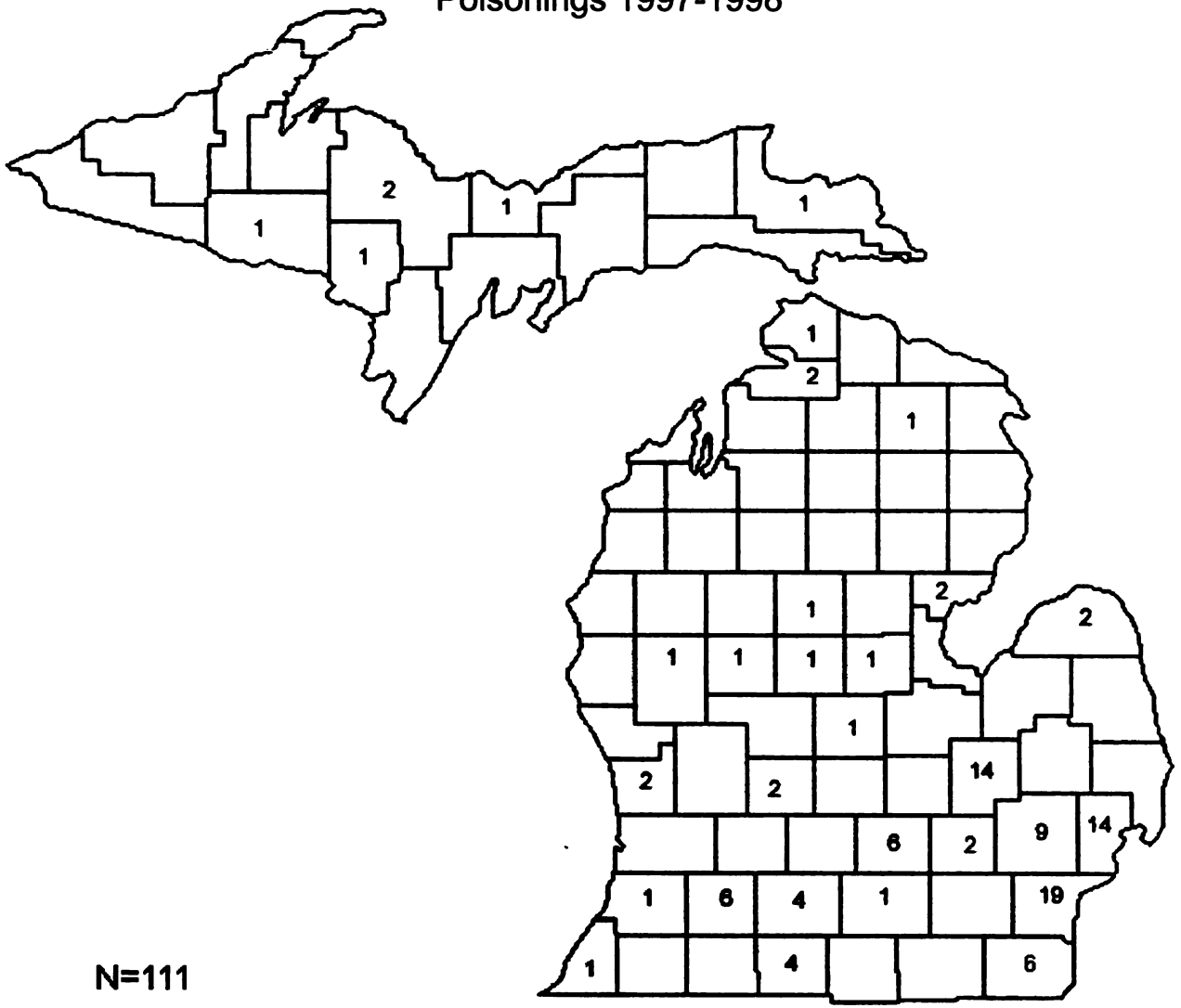
N=117

Figure 3.- Number of Non-Work Related CO Poisonings 1997-1998



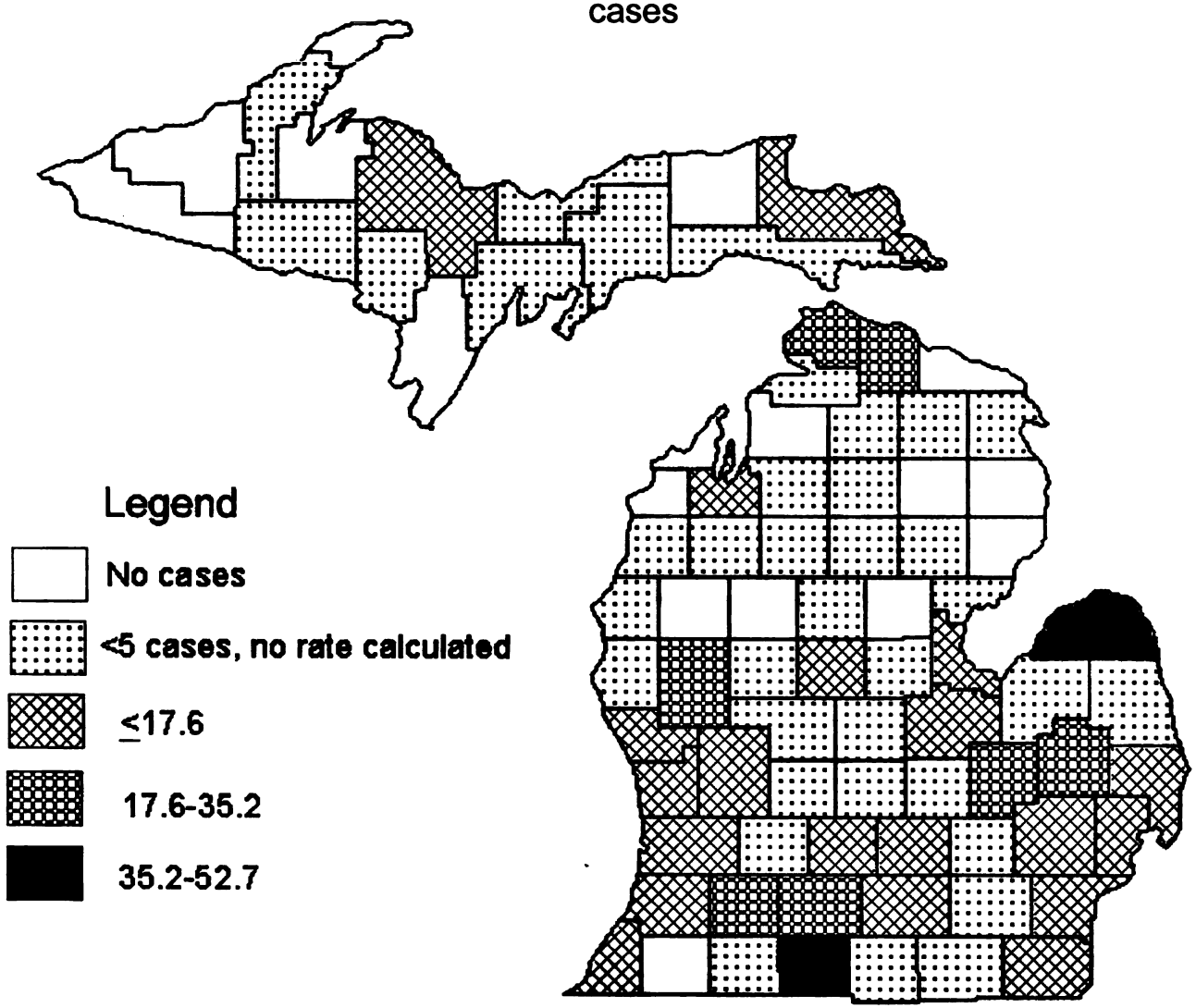
N=372

Figure 4.- Number of Work Related CO Poisonings 1997-1998



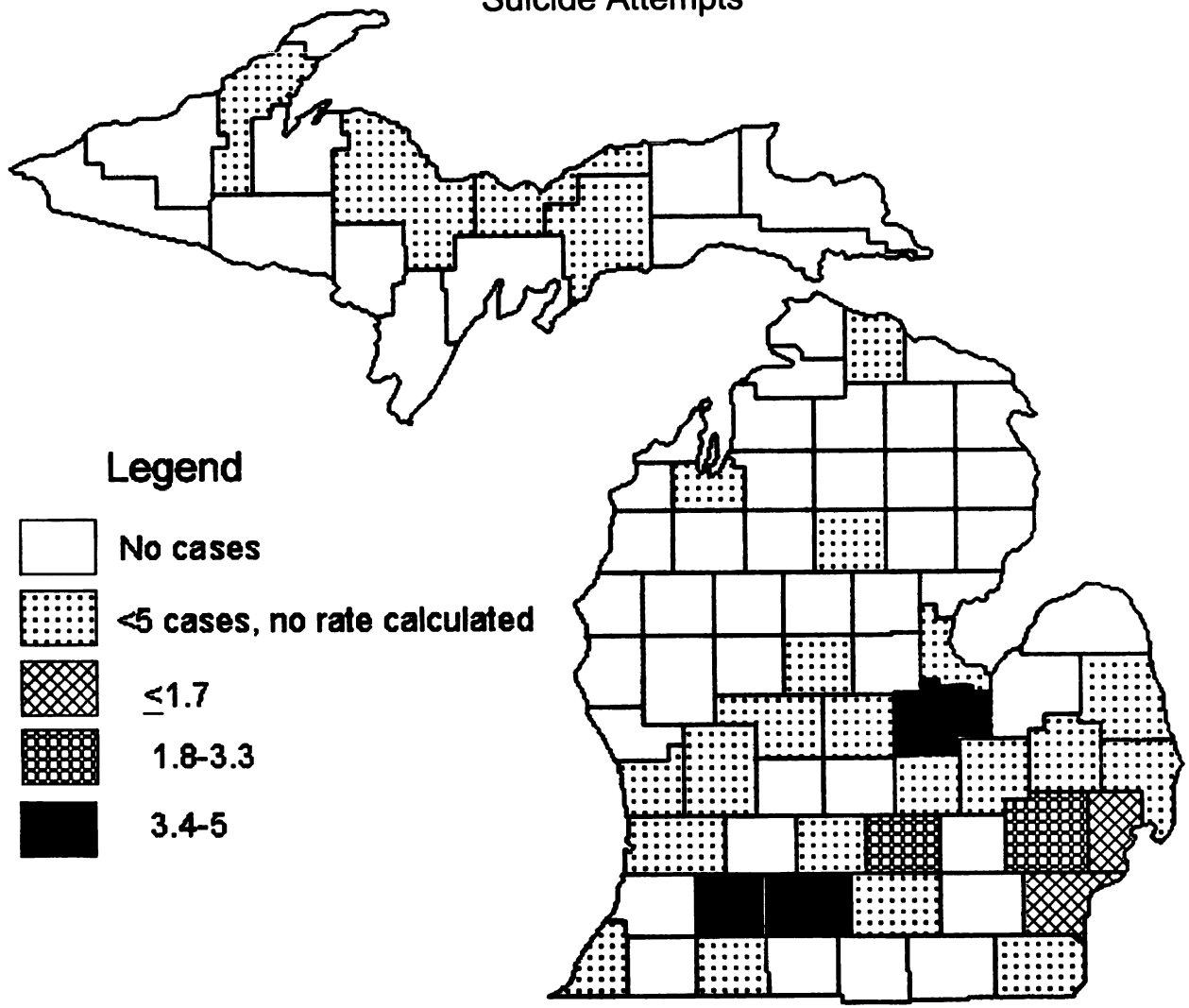
N=111

Figure 5.- CO Poisoning Incidence Rates for all cases



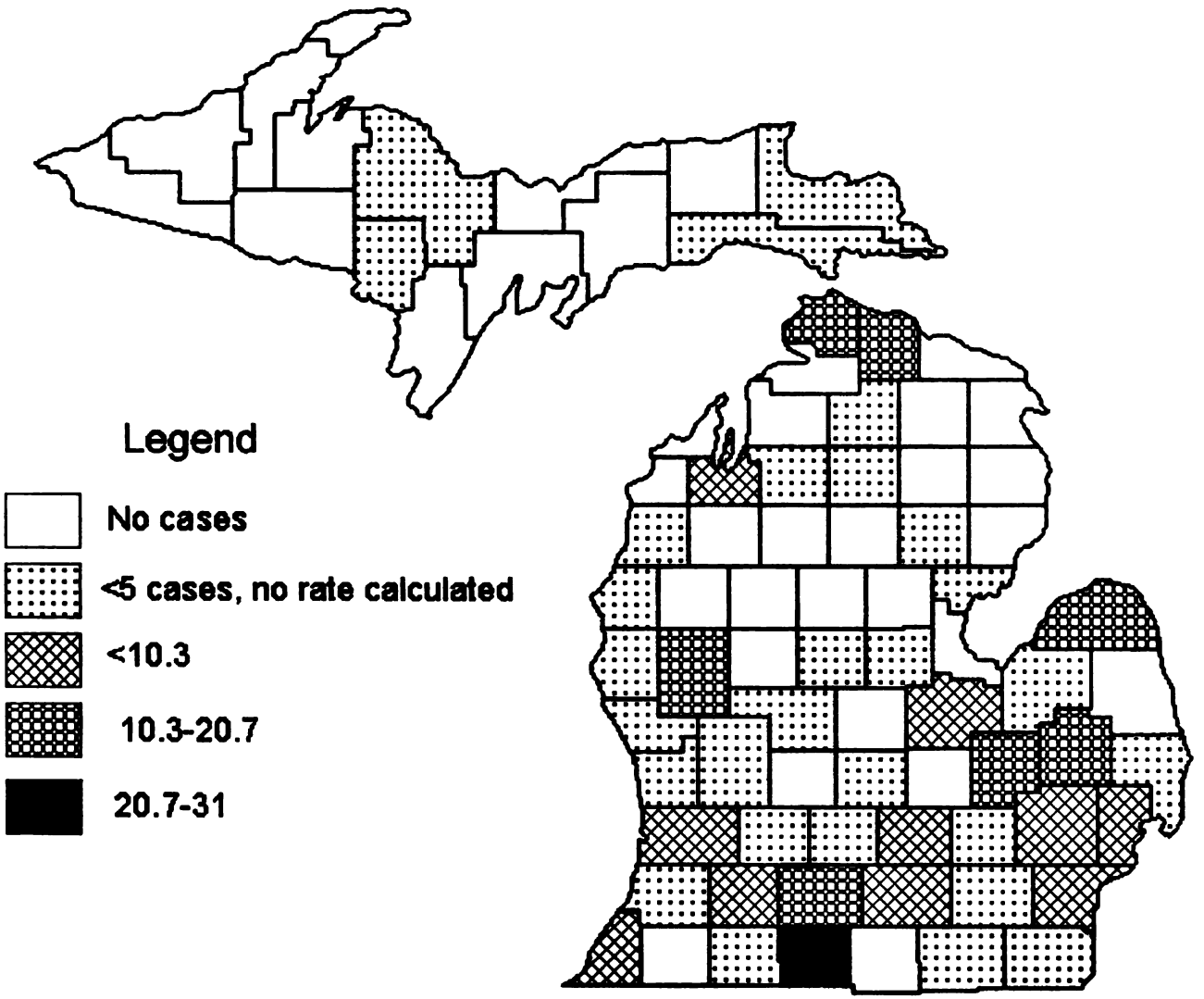
Rates are per 100,000

Figure 6.- CO Poisoning Incidence Rates for Suicide Attempts



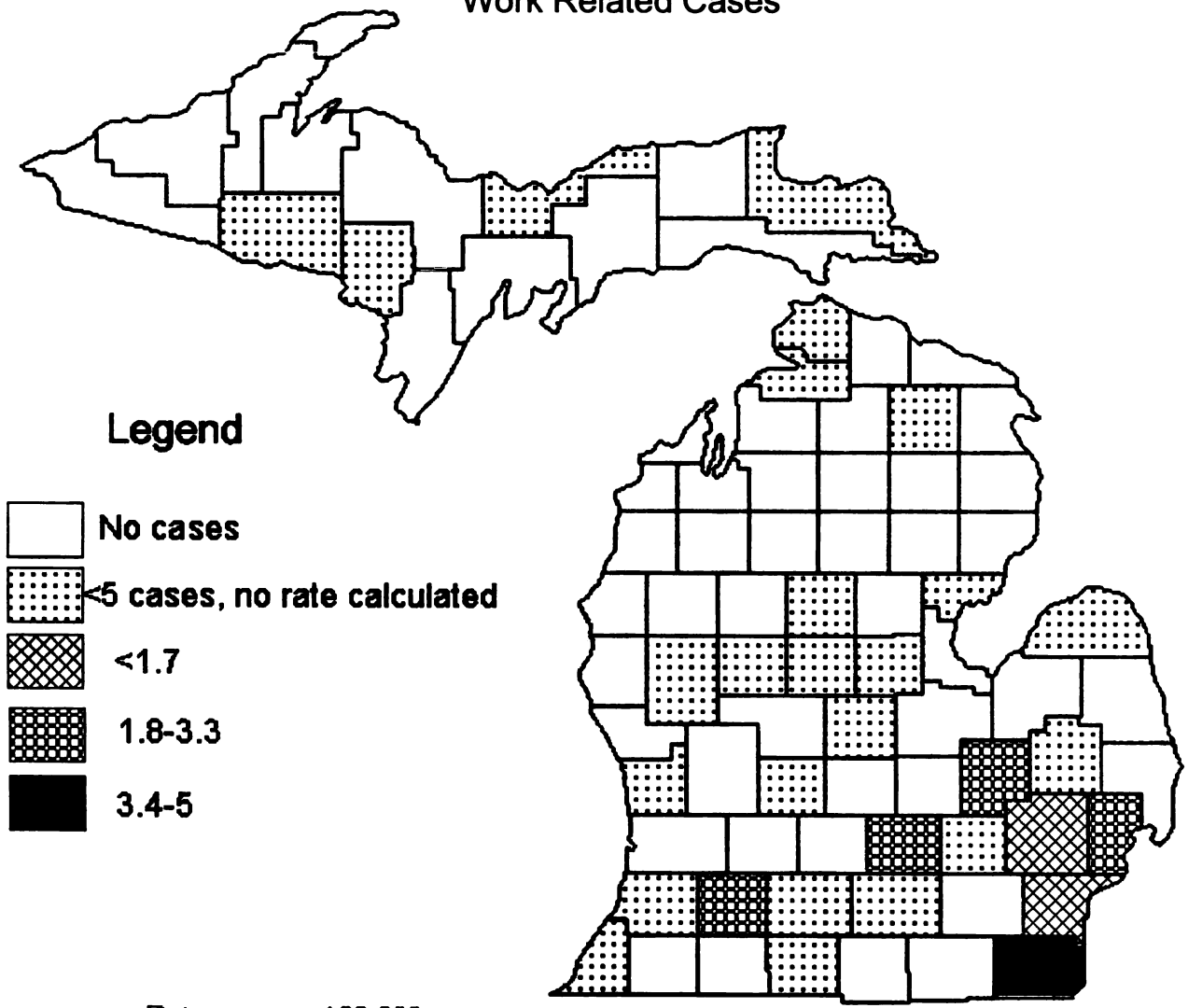
Rates are per 100,000

Figure 7.- CO Poisoning Incidence Rates for Non- Work Related Cases



Rates are per 100,000

Figure 8.- CO Poisoning Incidence Rates for Work Related Cases



Rates are per 100,000

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