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RESEARCH AND PRACTICE ARTICLE

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ABSTRACT:

Objectives: Among all deaths due to poisonings, carbon monoxide (CO) is the leading cause. Development of a surveillance system to track CO poisoning is a recommended public health activity. Initial steps to develop such a system are discussed.

Methods: Michigan hospitals provided face sheets and discharge summaries of hospitalized and emergency department visits for CO poisonings. Reports were divided into three categories; intentional poisoning, non-work-related poisoning, and work related poisoning. The characteristics of the three groups, including demographics, sources of exposure, carboxyhemoglobin levels, and time of year were described.

Results: There were 847 cases of CO poisoning reported. 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. The overall incidence rate for the state was 5.83 CO poisonings per 100,000 individuals.

Conclusions: A CO surveillance system using hospital and ED data as proposed in a CDC/CSTE initiative is feasible. Useful information about source of exposure can be generated to prioritize public health intervention. A more comprehensive system using additional data sources such as poison control center data would increase the timeliness of the reports received.

INTRODUCTION:

Since 2000 the Centers for Disease Control and Prevention (CDC) in conjunction with the Council of State and Territorial Epidemiologists (CSTE) has been developing core environmental health indicators. One of the proposed core indicators is carbon monoxide poisoning[1]. The data sources for this indicator are the number of deaths where carbon monoxide is the cause of death and the number of hospitalizations and emergency department visits attributed to carbon monoxide exposure. In addition one of the objectives in Healthy People 2010 is to increase the number of states monitoring carbon monoxide poisoning.

This study examined the feasibility of setting up a surveillance system for carbon monoxide poisoning in Michigan. The characteristics and the circumstances of CO exposure of individuals who were treated in an emergency department (ED) or were hospitalized in Michigan for CO poisoning was ascertained for the years 1997 and 1998. Comparisons were made between individuals with intentional CO poisoning, and unintentional CO poisoning from either work or non-work exposures. Finally, because there was incomplete reporting by hospitals and EDs, the total number of CO poisoning cases diagnosed in EDs and hospitalized in Michigan in 1997 and 1998 was estimated.

METHODS:

For the years 1997 and 1998, all 170 Michigan hospitals were contacted and 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 were carbon monoxide (CO) poisoning (ICD-986). 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. The Michigan State University Human Subjects Review Board approved this study.

On receipt of the medical records at Michigan State University, information was abstracted from the hospital records 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 abstracted included demographic information (age, gender and race), insurance information, home address, admission date, discharge date, carboxyhemoglobin [COHb] test and value, cigarette smoking information, name of hospital and source of exposure.

Cases were grouped into the following three modes of exposure; intentional exposure (suicide attempt), unintentional non-work-related exposure, and unintentional work-related exposure. Cases that could not be assigned to one of the three poisoning types were grouped together as 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 that the exposure was intentional.

Residential zip codes were used to identify the county of residence. Each county was classified as either metropolitan or non-metropolitan based on the Standard Metropolitan Statistical Areas (SMSA) designations developed by the U.S. Office of Management and Budget[2].

In order to determine the completeness of the medical records provided by the hospitals for hospitalized patients, a computerized list of all Michigan hospitalizations for the years 1997 and 1998 was purchased from the Michigan Health and Hospital Association (MHA). Cases that were identified on the MHA list but were not included in the hospitals required reports to the State were then added to the data set to ensure completeness of CO related hospitalizations.

Patients seen only in an ED were not included in the MHA data set, because the MHA only systematically collects information on hospitalized patients.

Since there was no way to ensure that hospitals reported all ED visits, an estimate of the true number of ED treated CO poisonings per year was developed based on three assumptions. The first was that the number of hospitalizations was complete since the hospital reports were supplemented by the computerized database purchased from the MHA. The second assumption was that hospitals reporting only hospitalized cases did not query their ED records for CO cases. The third assumption was that the ratio of ED cases per hospitalized cases for those hospitals that submitted data containing either both hospital and ED data or ED data only would be equivalent to the ratio of ED to hospitalized cases in hospitals reporting no ED records. To calculate the estimate, the median ratio of hospitalized to ED cases from hospitals reporting both hospitalized and ED cases was multiplied by the number of hospitalizations of CO cases in hospitals not reporting ED records.

Fifty-eight of the 107 hospitals that had at least one case of CO poisoning reported ED cases with or without a subsequent hospitalization. The remaining 49 hospitals reported hospitalizations only. The median ratio of ED visits to hospitalizations was 2.2 among the 58 hospitals reporting both ED and hospitalization cases. This value was applied to the 49 hospitals reporting only hospitalized cases and not reporting any ED cases. The estimated number of unreported ED visits from these 49 hospitals was 312 for this two-year period.

The incidence rate of CO poisoning treated in a hospital or ED is 4.26 poisonings per 100,000 individuals. This incidence rate increased to 5.83 poisonings per 100,000 individuals when the 312 estimated ED cases that were not reported were included.

Differences between mode of exposure groups were tested using chi-squared statistic. Logistic regression using a generalized logit model was used when the outcome was categorical with more than two levels. Finally, ANOVA was used to detect differences between groups for continuous outcomes. All analyses were carried out using SAS statistical software (SAS institute INC., Cary, NC).

RESULTS:

During the 1997-1998 period, 847 cases were identified from the 170 hospitals in Michigan. Sixty-three of the 170 hospitals reported no CO poisoning cases. In 1997 there were 435 total reports comprised of 234 ED visits, 197 hospitalizations and 4 reports for which the location of the health care could not be determined. For 1998, there were 412 total reports for 287 ED visits and 125 hospitalizations.

Of the 847 cases there were 381 (45.0%) cases who had non-work-related unintentional CO poisoning, 156 (18.4%) who had work-related unintentional CO poisoning and 120 (14.2%) who had intentional poisoning. An additional 190 (22.4%) of the hospitalizations and ED visits could not be classified.

Gender, Race & Age

Overall, 57% (483/847) of the cases were male and 43% were females (Table 1).

Table 1- Gender distribution of cases of CO poisoning treated in an ED or hospitalized in Michigan for 1997 and 1998

	Intentional		Non-Work-Related		Work-Related		Total	
Gender	#	%	#	%	#	%	#	%
Male	86	71.7	189	49.6	98	62.8	373	56.8
Female	34	28.3	192	50.4	58	37.2	284	43.2
Total	120	100	381	100	156	100	657*	100

*An additional 110 males and 80 females could not be classified

Men were more likely than women to have CO toxicity from an intentional exposure versus an non-work-related unintentional exposure (OR=2.6, 95%CI: 1.7-4.0). Men were also more likely than women to have a work-related CO toxicity versus a non-work-related unintentional exposure (OR=1.7, 95%CI: 1.2-2.5).

Overall 80.0% of the cases were Caucasian. In the non-work-related unintentional group, Caucasians accounted for 75.6% (213/282) of the cases and African Americans accounted for 22.0% (62/282). Caucasians accounted for 73.3% (77/105) of the work-related cases, while African Americans accounted for 24.8% (26/105) of the cases. In the intentional exposure group, Caucasians accounted for 97.0% (95/98) of the cases and African Americans accounted for 2.0% (2/98) of the cases. African Americans are over represented in the two unintentional groups while Caucasians account for nearly all of the intentional exposures.

Overall, the ages ranged from less than 1 to 97 with a mean of 40.5 years. There was no statistically significant difference in the age distribution across the categories of CO poisonings ($p<.0023$).

Cigarette Smoking

Among 299 cases of CO poisoning with sufficient medical records for adults aged 17 and over to determine cigarette smoking status, 66.2% currently smoked, 2.3% were ex-smokers, and 31.5% had never smoked (Table 2). Among the 47 cases in the intentional exposure group with known smoking status, 78.7% currently smoked and 21.3% never smoked In the 183 cases in the non-work-related unintentional group with known smoking status, 61.8% currently smoked, 2.7% were ex-smokers and 35.5% had never smoked. Of the 69 work-related cases with known smoking status, 69.6% currently smoked, 2.9% were ex-smokers and 27.5% had never smoked.. .

*Table 2.- Smoking distribution of cases of CO poisoning treated in an ED or hospitalized in Michigan for 1997 and 1998**

Smoking	Intentional		Non-Work-Related		Work-Related		Total	
Tobacco	#	%	#	%	#	%	#	%
Current	37	78.7	113	61.8	48	69.6	198	66.2
Ex-smoker	0	0	5	2.7	2	2.9	7	2.3
Never smoked	10	21.3	65	35.5	19	27.5	94	31.5
Total	47	100	183	100	69	100	299	100

*Smoking status was unknown for 548 individuals

Vital Status

Overall, 97.4% (794/815) of the cases survived. Of the non-work-related unintentional cases, 97.9% (368/376) survived. In the work-related group, 97.4% (150/154) survived. Among those in the intentional exposure group, 98.3% (117/119) survived. Vital status was unknown for 32 cases.

Source of Exposure

Source of exposure to CO was categorized into: furnaces or stoves, car and truck exhaust, and other.

Overall, the most frequent source of exposure of CO was car and truck exhaust, which accounted for 35.8% (171/477) of the cases. The second most frequent source of exposure was “other” which accounted for 31.9% (152/477) of the cases. Finally, furnaces or stoves accounted for 31.7% (151/477) of the cases. Source of exposure could not be determined in 329 of the cases (Table 3).

Table 3.- Distribution of source of exposure for cases of CO poisoning treated in an ED or hospitalized in Michigan for 1997 and 1998

	Intentional		Non-Work-Related		Work-Related		Total	
Exposure	#	%	#	%	#	%	#	%
Furnace/Stove	6	5.5	123	44.1	22	25.0	151	31.7
Car/Truck	102	92.7	46	16.5	26	29.5	171	35.8
Other	2	1.8	110	39.4	40	45.5	152	31.9
Total	110	100	279	100	88	100	477*	100

*There were an additional 10 furnace/stove exposures, 7 car/truck exposures and 24 other exposures that were unable to be classified

The main exposure of the non-work-related unintentional cases was from furnace or stove emission representing 44.1% (123/279) of the cases, followed by "other" representing 39.4% (110/279) of the cases. The major components of "other" in this category included fires, and charcoal grills. In the work-related exposure category, 45.5% (40/88) of the exposures were from other sources, and 25.0% (22/88) were from furnace/stoves. Here other sources included forklifts; and similar equipment with combustion engines. In the intentional exposure category, almost all or 92.7% (102/110) were exposed to CO from car/truck exposures and approximately 5.5% (6/110) of the cases were exposed to CO from furnace/stoves.

A furnace/stove was 45.5 times more likely to be the cause of a non-work-related unintentional CO exposure than for an intentional exposure (OR=45.5, 95%CI: 18.7-110.7) and 14.4 times more likely for a work-related CO exposure than for an intentional exposure (OR=14.4, 95% CI: 5.3-39.1).

Car/truck CO exposure was more likely to be the source for an intentional exposure than for a non-work-related CO exposure (OR=121.9, 95% CI: 28.9-525.3) and work-related CO exposure (OR=78.4, 95% CI: 17.8-346.0).

Type of Visit and Length of Stay at the Hospital

Overall 61.8% (521/843) of the cases were ED visits only and 38.2% (322/843) were hospitalized. In 4 cases the type of visit was unknown.

Approximately three-fourths of non-work and work-related exposures were ED visits with 74.0% (282/381) and 81.4% (127/156), respectively. A slightly lower proportion (70.0%) of intentional exposures were hospitalized.

The number of days spent in the hospital ranged from less than one day to 98 days. The median time spent in the hospital was less than one day. Of non-work-related unintentional CO poisonings, 28.1% stayed for one day or longer. Of the work-related poisonings, 19.2% stayed for one day or longer, while 70.0% of the intentional exposures stayed in the hospital for one day or longer (Table 4). Cases that had an intentional exposure spent significantly more time in the hospital than other poisoning types with 20.8% staying four days or more ($p<.0001$).

Table 4.- 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)	Intentional		Non-Work-Related		Work-Related		Total	
	#	%	#	%	#	%	#	%
<1	36	30.0	274	71.9	126	80.8	436	66.4
1	26	21.7	49	12.9	17	10.9	92	14.0
2	18	15.0	14	3.7	1	0.6	33	5.0
3	15	12.5	10	2.6	1	0.6	26	4.0
≥4	25	20.8	34	8.9	11	7.1	70	10.7
Total	120	100	381	100	156	100	657*	100

*An additional 190 cases with known length of stay could not be classified

ED visits were 13.7 (95% CI: 7.7-24.6) times more likely than hospitalizations for work-related CO exposures versus intentional exposures and 8.9 (95% CI: 5.5-14.4) times more likely than hospitalizations for non-work-related CO exposures versus intentional exposures.

CarboxyHemoglobin [COHb] Tests

CO intoxication introduces COHb, an abnormal species of hemoglobin, into the blood. COHb levels were tested in 64.2% (544/847) of the CO poisonings. However, the actual level of COHb was available in the medical records for only 387 of the 544 cases. Background levels of COHb range from 0-9% depending on cigarette smoking status. Of the 387 known COHb levels, the average level was 12.1%. The levels ranged from 1-90%.

Those who had an intentional exposure had an average COHb level of 16.5%, compared to 12.1% in those with non-work-related CO exposure and 9.4% in those with work-related CO exposure.

There were no significant associations of COHb level with smoking or source of CO exposure.

Season

The highest percentage of cases over all types of CO exposure occurred during the winter months (December, January and February with 279 (32.9%) poisonings. There were 250 (29.5%) cases in the fall 209 (24.7%) in the spring but only 109 (12.9%) cases in the summer.

Intentional exposures were more evenly distributed throughout all seasons than other sources of CO exposure.

Geographic Distribution

Most of the CO poisoning cases resided in metropolitan areas (80.6% (662/821). The zip code was not known for 26 of the individuals.

Residency in metropolitan areas was 80.2% (296/369) among non-work-related cases, 82.2% (125/152) among work-related cases, and 84.6% (99/117) among intentional exposures. There was no significant difference.

DISCUSSION:

This study demonstrated the feasibility of conducting surveillance for CO poisoning using hospital and ED data.
From 1997-1998, 847 cases of carbon monoxide (CO) poisoning were identified through hospital and emergency department (ED) records. We estimate that the incidence of cases treated in an ED or hospitalized for CO poisoning was 5.83 per 100,000 individuals.

The results from this study are consistent with many of the findings of previous 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 five previous studies[4-8].

The most common sources of exposure of CO, such as motor vehicles and heating sources were also similar to other studies[5,6,8-10,11]. In Michigan, there were significant differences of CO source between the types of poisoning. Non-work-related poisonings were 46 times more likely to occur by furnace exposure compared to the intentional exposure group. For the intentional exposure group, motor vehicles were the most likely source of CO exposure. Non-work-related CO exposures were three times as likely to be from a furnace exposure when compared to CO exposures at work. These findings can be used to develop outreach materials to increase awareness of some of the main sources of CO exposures both at home and at work.

In agreement with previous studies, a significantly higher number of CO poisonings occurred in the winter months in Michigan[6,7,11-12]. The winter season has a greater risk for exposure to furnaces or heaters as well as greater potential for motor vehicles to be running in enclosed structures such as garages or sheds.

Background levels of COHb can range from 0-9% depending on cigarette smoking status. Most of the COHb levels reported in this study were less than 20% but ranged as high as 90%. The highest average COHb level was found in the intentional exposure group, the longer hospital length of stay found among intentional exposures compared to other modes of CO exposure was not explained by differences in COHb levels at the time of hospitalization (Table 4). Other medical conditions and/or a need for psychiatric care may explain the increased length of stay for the intentional exposure group. The higher average COHb levels observed in the intentional group is not unexpected considering the CO poisoning was intentional. The group with the lowest average COHb level was the work-related group. Some workplaces may actively monitor CO. Additionally, co-workers may either notice an employee with symptoms or experience symptoms themselves and therefore be more likely to seek medical attention.

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 especially in the colder months when the potentials for unintentional exposures is greater. Prevention strategies include not allowing motor vehicles to idle in enclosed areas, regularly checking and maintaining motor vehicle emissions, ensuring all gas appliances are installed correctly and are located in properly ventilated areas and substituting electric powered equipment in the work setting. 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 included CO poisoning cases with 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 an ED or hospital visit are different from those in this study. Missed cases would be more likely to have less severe CO poisoning and would not require the type of medical attention received at a hospital of ED.

Hospital records of CO poisoning are likely an underestimate of the total number of individuals with CO poisoning because of the lack of recognition of CO symptoms and because individuals with less severe symptoms are treated in other health care settings or do not seek medical care. Since CO is colorless, odorless and nonirritating, its presence is not easily detected. Neither patients presenting with non-specific symptoms nor the health care providers evaluating them may be aware that an exposure occurred. Hence even for individuals treated in the hospital, the records are an underestimate[3].

An additional reason for an underestimate was incomplete reporting of ED visits. It was estimated that there were an additional 312 unreported ED visits and an even larger number of ED visits among those hospitals that reported at least one ED visit as there is no overall compilation of ED records in Michigan.

Collection of data reported in this paper was based on hospital reporting of known or suspected CO poisonings. Most hospitals found it easier to report all CO poisonings as suspected and let us sort out if it was work-related. We were able to evaluate this because the computerized print outs from the MHA include all CO poisonings regardless of sources. However, this could not be evaluated for ED visits. New regulations have been proposed in Michigan and are going through the process of being finalized to require the reporting of all poisonings regardless of the source. This will address the possibility that some hospitals reported only work-related CO poisonings and did not include all CO poisonings.

Missing information from the different hospitals due to the manner in which information was provided constitutes another limitation. 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 of the event. Records varied in the amount of information written about the patient, the incident and the treatment. The carboxyhemoglobin levels reported in this study are most likely lower than the

level an individual would have at the time of exposure because the cases were removed from the CO exposure for varying periods of time before their COHb levels were tested at the hospital. Additionally, if oxygen was administered in an ambulance or in the ED prior to the COHb test this would also lower an individual's level. To obtain more accurate COHb levels, the amount of time between exposure and the blood test should be recorded and reported by the hospitals along with any record of oxygen that was administered to the patient. This information was rarely available.

Surveillance of ED and hospitalizations undercounts deaths from CO poisonings. It is likely, that the most severe CO poisoning cases (including those leading to death) would die at the site of exposure and not be seen in an ED or hospital. So a comprehensive system needs to include death certificates as recommended by the CDC/CSTE environmental health tracking group[1].

RECOMMENDATIONS:

This study demonstrates the feasibility of using emergency department and hospitalization data for public health surveillance of CO poisoning. Generally sufficient details are provided in these data to characterize the types and causes of acute CO poisoning. On-going surveillance over time would enable a state to identify trends and evaluate the efficacy of preventive actions. Complementing these data with death certificate data would bring Michigan in line with the CDC/CSTE proposal on carbon monoxide surveillance[1]. Although not included in National recommendations, the inclusion of poison control center data would make the system more timely since there a lag of up to a year and a half in obtaining computerized data from the Michigan Hospital Association. Another change that would improve a CO tracking system in Michigan would be the requirement that hospitals report ED data. ED data is required to be reported to State health Departments in 25 states.

Development of a CO poisoning tracking system is feasible. Further work, however, to evaluate the effectiveness of public health activity that utilizes CO surveillance data to target intervention is needed in order to justify the development of such a tracking system.

REFERENCES:

1. Environmental Public Health Indicators Project. Atlanta, Ga. Centers for Disease Control and Prevention. Environmental Public Health Indicators summary. http://www.cdc.gov/nceh/indicators/summary.htm Accessed November 3, 2006

2. United States. Office of Management and Budget, OMB Bulletin 03-04. "Metropolitan and Micropolitan Statistical Areas in Michigan Based on the 2000 Census." As revised June 23, 2003.

3. Ernst, Zibrak JD. Carbon Monoxide Poisoning.(1998) *New England Journal of Medicine*, 339(22):1603-1608.

4. Cobb, N., Eitzel, R.A. Unintentional Carbon Monoxide- Related Deaths in the United States, 1979-1988. (1991) *Journal of the American Medical Association*, 266(5):659-663.

5. Vajani M, Annest JL, Ballesteros M, Gilchrist J, Stock A. (2005) Unintentional Non-Fire Related Carbon Monoxide Exposures- United States, 2001-2003. *Morbidity Mortality Weekly Report*, 54:36-39.

6. Gregor MA, Van Amburg G, Thrush JC, Wilcox KR. (1992) Unintentional Deaths from Carbon Monoxide Poisoning- Michigan, 1987-1989. *Morbidity and Mortality Weekly Report*, 41:881-883, 889.

7. Yoon, S., MacDonald, S., Parrish, RG. (1998) Deaths from Unintentional Carbon Monoxide and Potential for Prevention with Carbon Monoxide Detectors. *Journal of the American Medical Association*, 279(9):685-87.

8. Miller RL, Toal BT, Foscue K, Hansen H, Bayer M. (1995). Unintentional Carbon Monoxide Poisonings in Residential Settings- Connecticut, November 1993-March 1994. *Morbidity and Mortality Weekly Report.* 1195; 44:765-67.