CARBON MONOXIDE POISONING IN KENTUCKY

Amy Scheerer, MSPH; Tim Struttmann, MSPH

Fatal and nonfatal cases of carbon monoxide (CO) poisoning continue to be widespread. Hospital discharge data were used to identify cases of CO poisoning in Kentucky during 1998-1999. Additional data collection was conducted through medical record abstraction. Information was collected on 205 cases at 33 Kentucky hospitals. Over half of the CO poisoning cases occurred in residential settings. The most common types of equipment operating at the time of exposure were motor vehicles and gas heating sources. Eighteen percent of the cases required hospitalization. Almost half of the incidents occurred during December, January, and February. Incidents of CO poisoning can be reduced through education and implementation of appropriate prevention strategies. Public health professionals and health care professionals should provide education about the sources of CO and the hazards of exposure. Recommendations for prevention are provided.

Fatal and nonfatal cases of carbon monoxide (CO) poisoning continue to be widespread and are reported frequently in the literature. According to the Consumer Product Safety Commission, deaths associated with consumer products and motor vehicle exhaust averaged 534, annually, during 1993-1997.[1] The National Electronic Injury Surveillance System (NEISS) tracks emergency department visits related to consumer products in a representative sample of hospitals in the US. NEISS estimated an average of 10,200 individuals were treated annually for CO poisoning during 1995-1997 (excluding intentional injuries, fire, and motor vehicle exhaust as causes).[1] Through extrapolation, Hampson[2] estimated nearly 43,000 individuals are treated annually for CO poisoning in emergency departments in the US. However, because of the nonspecific symptoms of CO poisoning and often unrecognized sources, the true incidence of CO poisoning is unknown.[3] It is estimated that one third of all CO poisoning cases go undiagnosed.[4]

Both fatal and nonfatal cases of CO poisoning have been known to occur in a variety of settings, including indoor and outdoor as well as residential and workplace. Although CO poisoning commonly occurs in enclosed areas from such sources as motor vehicles, smoke from all types of fires,[5,6] heating systems, gas ovens, grills and portable stoves, gas water heaters, and fuel-powered tools and appliances,[1,5,7,8] there are documented cases occurring in open air (outdoor) settings related to tractor exhaust,[9,10] boating,[11,12,13] and motor vehicle exhaust.[14]

The health effects related to CO depend on factors such as duration of exposure, the concentration in the air and subsequently in the blood, and the individual's general health. Biochemically, CO binds with hemoglobin (Hb) with an affinity about 250 times that of oxygen.[1,15] The combination forms

Both authors are with the Kentucky Injury Prevention and Research Center, University of Kentucky, Kentucky School of Public Health, Lexington, KY. Corresponding Author: Tim Struttman, Kentucky Injury Prevention and Research Center, University of Kentucky, Kentucky School of Public Health, 333 Waller Avenue, Suite 202, Lexington, KY 40504-2915, Phone: 859.257.9483, FAX: 859.257.3909
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carboxyhemoglobin (COHb) which interferes with oxygen transport, delivery, and utilization.[1,15] Usually there are no health effects or symptoms in healthy individuals with COHb levels less than 10%.[1,5,6] Above this level, the exposure can result in symptoms that may not be reversible and could be fatal.[1,6,15,16]

This study was conducted by the Kentucky Injury Prevention and Research Center (KIPRC) at the University of Kentucky in cooperation with the Kentucky Department for Public Health, Cabinet for Health Services. The purpose was to gain a better understanding of the CO poisoning cases treated in Kentucky's hospitals.

METHODS

For this study we used Kentucky's hospital discharge data for 1998 and 1999, the most recent complete years available. This dataset uses Federal Uniform Billing 92 (UB-92) standards. Legislation mandates all hospitals submit UB-92 billing data to the Kentucky Department for Public Health since January 1995. Although submission is required of all hospitals, there have been varying levels of compliance. In 1998, 66% of all expected discharges were reported. In 1999, compliance had improved, and approximately 75% of all expected discharges were reported. Some hospitals submit inpatient data as well as cases where the patient was seen in the emergency department and released. Both were used in this study.

Cases were screened using the International Classification of Diseases (ICD-9) [17] diagnosis code of 986 for *toxic effect of carbon monoxide*. Because the hospital discharge database does not provide a narrative description of the reason for hospital treatment, medical record abstraction was necessary to collect data about the circumstances. The study protocol was approved by the University of Kentucky Institutional Review Board.

In the 1998-1999 hospital discharge data (includes some emergency department data), 267 records from 35 hospitals were found to have a diagnosis code of 986 in one of the 10 available fields. Letters were sent from the Kentucky Commissioner of Public Health to the administrator and medical records director at each hospital to request their cooperation with medical record abstraction for this study. The Health Insurance Portability and Accountability Act (HIPAA) of 1996 allows hospitals to disclose protected health information to the Cabinet for Health Services for purposes of "preventing or controlling disease, injury, or disability, including . . . public health surveillance, public health investigations, and public health interventions . . ."[18] Because this study was conducted by contract from the Cabinet for Health Services, KIPRC was provided with access to medical records at hospitals to obtain the necessary data. Confidentiality was maintained by excluding personal identifiers and having only one abstractor review the medical records. Hospital discharge data does not include personal identifiers such as name or social security number. Since this information was not necessary for the study, hospitals were assured that personal identifiers would not be abstracted from the medical records. Files were identified and abstracted by medical record number only.

A nurse experienced in medical record abstraction and data collection contacted each hospital to explain the study, answer questions, and schedule an appointment to conduct the record reviews. Visits to the hospitals occurred between May 1 and June 30, 2001. Two of the 35 hospitals declined to participate; one was already participating in a study and did not want to assist with another, and the other was reorganizing its medical records department and could not assume additional duties.

Of the 267 records identified in the hospital discharge data set for the two-year period (1998-1999), 25 records were from 2 hospitals that declined to participate, 2 were duplicates, 3 did not have the hospital listed correctly, 4 were not included because they were follow-up visits rather than the initial treatment for the incident and the entire record was not available, and 28 records could not be abstracted because they were either in storage at an off-site locaiton, could not be located, or the identifying number was incorrect. The final dataset included 205 records from 33 hospitals.

RESULTS

Age and Sex

Figure 1 shows females accounted for just over half (53%) of the 205 cases. The ages ranged from <1 to 86 with a mean of 31 years. Figure 2 presents the cases by sex within 10-year age groups. Females outnumbered males in every age group except for 40-49

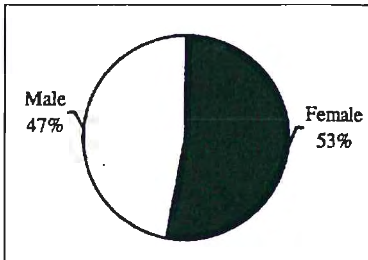

Figure 1. Sex

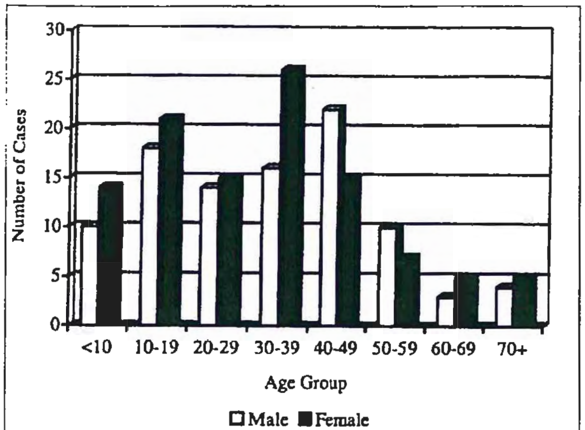

Figure 2. Sex and Age Group

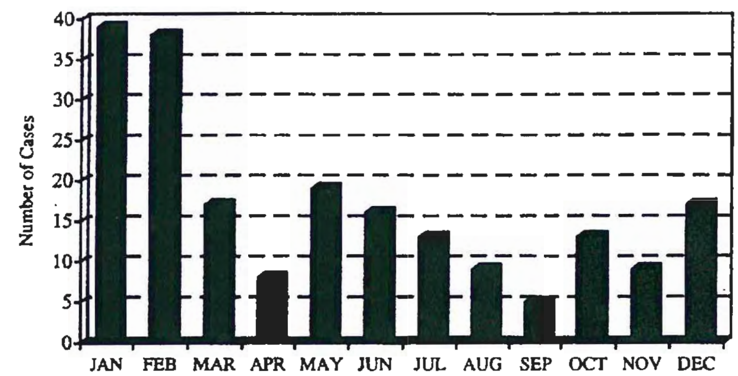

Figure 3. Number of cases per month

and 50-59. For females the largest percentage (24%) occurred in the 30-39 year old age group, while in the males the largest percentage (22%) occurred in the 40-49 year old age group.

Month

Figure 3 shows how many CO poisoning incidents occurred during each month (combined 1998 and 1999). January and February showed the highest number of cases and, when combined, accounted for more than one third of the total (37%).

Treatment

The majority of patients, 69% (143), were treated on an outpatient basis, while 18% (38) were hospitalized, 11% (23) were transferred for further care, and <1% (1) were fatal.

Emergency Medical Services (EMS) responded in 96 cases (47%) and administered oxygen to 62 of those patients. Upon arrival at the hospital, oxygen was administered to 131 patients (64%), 27 of whom received hyperbaric oxygen treatment. Fifty-two patients received oxygen treatment from both EMS and the hospital.

Carboxyhemoglobin (COHb) levels were obtained from the majority of patients (181, or 88%) upon arrival at the hospital for treatment. Initial levels ranged from 0.0% to 51.0% (mean 11.7, sd 11.2). When additional COHb levels were obtained, 39 patients had a second level in the range of 0.2%-32.5%, nine had a third level taken with resulting range of 0.3%-9.6%, and three had a fourth level with resulting range of 0.2%-1.0%.

Insurance Type and Charges

Private insurance was listed as the primary payer in 99 cases. The payer or insurance type was not listed in the record in 16 cases. In the remaining 90 cases, the treatment was paid by one or more of the following: Medicaid (46), self-pay (37), workers' compensation (23), and Medicare (14).

Data included the total charge for each patient's treatment. Charges were available for 197 patients, resulting in a total of $268,285 and averaging $1,326 per patient (range $60-$19,126).

Location and Source

Over half (56%, 116) of the CO poisoning cases occurred in residential settings. Other incident locations included school (21), residential garage (with a vehicle or other equipment operating) (17), motor vehicle (13), worksite (13), campsite/tent (4), storage shed (2), a boat, a field (while burning trash), a greenhouse, and a dental office. In 15 cases, the location of the exposure was unknown or not indicated in the medical record. Even when a location was described, the medical record did not always reveal a clear source of CO. In 65 cases the exposure could not be attributed to a particular source. Gas was indicated as the source of CO in just over half the incidents (105). Other sources of CO were attributed to fire/flame (12), cigarettes (5), cigarettes and/or heater unit (4), charcoal (4), pipe/sewer line (3), kerosene (2), propane (2), gas tank leak at a dental office (1), diesel fuel (1) and oil furnace (1).

The most common type of equipment/machinery operating at the time of exposure was motor vehicle (includes car, truck, school bus), accounting for 51 incidents, and gas heating source/furnace, accounting for 28 incidents. In 61 incidents there was either no equipment operating or the type was not documented. Other sources were furnace (unknown fuel type) (12), gas stove (9), gas generator (7), gas-powered pressure washer (6), gas water heater (5), lawnmower (5), charcoal grill (4), household appliances (not specified) (4), heater/furnace (and cigarettes) (4), kerosene space heater (2), and a forklift, boat, tractor, propane torch, gas tank in dental office, oil heating source, and tow motor.

Symptoms

Table 1 shows the variety of symptoms and physical complaints from patients as recorded on their medical record. The most common symptoms were headache, nausea, and dizziness/lightheadedness. Other clinical manifestations appearing less than 2% of the time are not included here. Cherry red appearance was not mentioned in any of the records.

Table 1. Symptoms and Physical Complaints

Symptom/Complaint	No.	(%)
Headache	116	(56)
Nausea	78	(38)
Dizziness/Lightheadedness	52	(25)
Respiratory problems	38	(18)
Vomiting	25	(12)
Altered consciousness	26	(12)
Weakness	17	(8)
Confusion	16	(7)
Collapse w/loss of consciousness	16	(7)
Chest pain	9	(4)
Syncope	9	(4)
Lethargy	8	(4)
Tachycardia (rapid heartbeat)	8	(4)
Tachypnea (rapid breathing)	7	(3)
Shaking/Trembling	6	(3)
Visual disturbance	5	(2)
Seizure	4	(2)

Hospitalized Cases

The 38 incidents which required hospitalization involved 16 females and 22 males. Their ages ranged from 19-86 years with a mean of 49; one third (32%) occurred in the age group of 40-49. The most common location for the exposure was a residential setting (13), followed by a garage (9), car (3), campsite (2), worksite (2), a field, a storage shed, and a boat; in 6 cases the location was not indicated. Eight incidents were intentional. EMS responded in 18 incidents and administered oxygen to 16 of those patients. The initial COHb levels ranged from 1.0% to 44.0% (mean 17.1%). Nine patients received hyperbaric oxygen treatment after arrival at the hospital; their initial COHb levels ranged from 2.4% to 44.0% (mean 23.2%). Patients' medical histories included problems such as heart/circulatory (17), neurological (14), respiratory (9), and diabetes (9). Records indicated that 19 patients smoked; as recorded for 16 patients, the amount ranged from half a pack to three packs per day. In 21 cases charges were paid by private insurance, followed by Medicaid (10), Medicare (6), self (5), and workers' compensation (3); in one case the payer was not documented.

Hyperbaric Oxygen Treatment

COHb levels were available for 26 of the 27 patients who received hyperbaric oxygen treatment; their initial levels ranged from 2.4% to 44.0% (mean 24.1%). Ages ranged from 18 to 86 years (mean 42 years). Eleven patients had been transferred from other hospitals to receive hyperbaric treatment. The patient who had a COHb level 2.4% was an 86-year-old female with COPD who was found unresponsive in her home. One fatality involved a 79-year-old male who had been trapped in a burning house and presented with an initial COHb level of 43.8%. Four of the incidents were documented as intentional and each was due to automobile exhaust. One incident involved three male workers aged 19, 21, and 33 who were cutting through concrete and struck a pipe (possibly a sewer pipe) releasing fumes/gases; their COHb levels were 13.8%, 17.3%, and 20.4%. The medical records indicated 12 of the patients were known to be current smokers of between half a pack and three packs per day. Eight showed a history of heart/circulatory problems. Private insurance paid for treatment in about half of the cases (14). Other payers included workers' compensation (6), Medicaid (2), and self (1); in two cases the payer was not documented.

Intentional Cases

Thirteen of the CO poisoning cases were indicated as intentional in the medical record, but none were fatal. Nine were male and four were female, ranging in age from 18 to 47 with a mean of 34 years. All four females were between the ages of 31 to 41; males were in the age range of 18-47, with three men in their 20s and three in their 40s. Eleven incidents involved automobile exhaust either in an enclosed garage or with a hose from the exhaust pipe through the vehicle's window. Of the remaining two incidents (both males), one involved a lawn-mower running in an enclosed storage shed and the other occurred in a residential setting with a gas source, but the details are unclear. Medical records indicated two of the incidents also involved alcohol and one involved an overdose of sleeping medication.

CHILDREN

Fifty-seven incidents involved children under the age of 18. Nineteen children aged 10-11 years were taken for treatment after they were exposed to exhaust fumes from a school bus parked with the engine running near a classroom with open windows. Thirty-three occurred in residential settings, one occurred in a dental office, one occurred in a tent with a charcoal grill, two occurred in an RV with a gas generator operating, and details for one were not indicated in the record.

CARBON MONOXIDE DETECTORS

Abstraction of medical records revealed little information about whether a CO detector alerted patients to high levels. In 81% of the cases there was no mention of a CO detector in the record. In the 30 records (15%) which indicated a CO detector had sounded, all occurred in residential settings. Eleven of these homes included more than one person seeking treatment at the hospital, accounting for 28 cases.

LIMITATIONS

One limitation of our study is in the initial screening for cases. Although hospitals are mandated to submit uniform billing forms, some hospitals were lacking in submissions. We chose to use a diagnosis code rather than an external cause of injury code (E-code) for CO poisoning because the E-code field is frequently left blank. A review of 1998-1999 hospital discharge data showed that out of 71,205 inpatient records having at least one diagnosis code indicating injury/poisoning, 54% lacked an E-code. We chose the diagnosis code which we felt would capture the most cases, but it is possible some records were given different codes or miscoded, or patients were misdiagnosed. It is likely the number of CO poisoning cases reported here is underestimated because billing forms were not submitted and because of inaccurate or lack of coding. Also, hospital discharge data would not capture fatal or non-fatal incidents involving CO in which the person never received treatment at a hospital. Death certificates for the same two-year period showed 66 fatalities were likely related to CO poisoning; however, details such as an association with a particular source are not available from these documents. Further follow-up with coroner records would be necessary to uncover details on fatal incidents.

A reporting bias in the inital data may impact the generalizeability of these findings. It is not known if cases submitted by hospitals that included emergency department data were different from those hospitals that only reported inpatient data. If these cases were missing at random, the results would represent the population of Kentucky. However, we cannot assume this to be the case. The results lead to a better understanding of the problem in the state but do not allow for risk calculations.

Another limitation is in the data abstraction process. We were limited to collecting only what information was available in the medical records. Methods of storing medical records varied among the hospitals and included paper, electronic, and microfiche format. Records varied in the amount of information written about the patient, the incident, and the treatment. Information was likely shared during treatment but not written in the chart, thus we did not have access to some details that may have been important to our study. In addition, abstracting the records to glean the necessary information proved to be difficult at times; in particular, records which were handwritten or poor copies were difficult to read.

DISCUSSION

Using hospital discharge data and record abstraction we were able to gain a more comprehensive understanding of CO poisoning in Kentucky. Retrospective record review is valuable but dependent on the initial screening process and the quality of the original data. Since a new vendor has been contracted for the processing of Kentucky's uniform billing forms in 2001, the accuracy, completeness, and timeliness of these data are expected to improve. Perhaps a future study of the data would be valuable for comparison.

The most common causes of CO poisoning incidents in Kentucky, such as motor vehicle exhaust, heating sources, gas appliances and tools, gas water heaters, and fire, were similar to other studies.[1,5,8,19,20,21,22] Four people required hospital treatment as a result of two incidents when charcoal grills were placed inside tents while camping. Other studies have documented both fatal and nonfatal cases of CO poisoning during camping while using grills and camp stoves in enclosed tents.[1,23]

In agreement with other studies, more patients were treated for CO poisoning during the winter months than at other times of the year.[7,20,22,24,25,26] This seasonal difference is due to the use of improperly maintained or defective heating equipment.[26] Almost half (46%) of the incidents in Kentucky occurred during December, January, and February; 33% were attributed to a furnace or other heating source, compared with 14% during the other nine months of the year. Another important source of CO poisoning in the winter is idling motor vehicles with exhaust pipes blocked by snow.[13]

Because CO is colorless, odorless, and nonirritating, its presence is not readily noticed by victims, and patients presenting for treatment may be unaware of exposure. In addition, the symptoms of poisoning are nonspecific; thus, diagnosis by healthcare providers may be missed or delayed[10,15,16,27,28] Further, clinical manifestations may vary among individuals even under similar exposure conditions.[15] Early symptoms of CO poisoning may be similar to flu, such as headache, fatigue, dizziness, nausea.[8,16,19,21] Infants may be irritable and have poor appetites.[21] Other symptoms include visual disturbances, confusion, disorientation, syncope, seizures, shortness of breath and increases in pulse and respiratory rates.[6,19,21] Symptoms identified in this study were similar to those found in the literature with over half (56%) reporting a headache and over one third (38%) reporting nausea. Some physical complaints may have been related to other illnesses present at the time of the exposure. In very young children, two years old and younger, symptoms included irritability, crying, poor appetite, nausea/vomiting, and lethargy. A COHb level should be obtained if there is a suspicion of exposure so proper treatment can be provided and the patient can implement changes to prevent future incidents. However, in some cases the levels may not reflect the severity of the exposure because of the time lapse between the exposure and arrival at the hospital and whether oxygen was administered.[15]

A literature review did not reveal any documented cases of CO poisoning resulting from cigarettes alone. Although tobacco smoke is a significant source of CO, containing about 4%,[6] secondary or passive cigarette smoke contains CO levels about two and a half times the amount of directly inhaled smoke.[16] Tobacco smoke can produce hazardous CO levels, particularly in enclosed environments with multiple combustion sources[6] or poor ventilation.[29] While nonsmokers average about 1% COHb in their blood, smokers typically have levels in the range of 3%-8%, and heavy smokers may reach levels as high as 15%.[6,15] Medical record abstraction in this study showed cigarettes were associated with CO poisoning in nine cases. Initial COHb levels for those patients ranged from 1.8% to 10.0% (mean 5.2%).

Incidents of CO poisoning can be reduced through education and implementation of appropriate prevention strategies. Public health and health care professionals should provide education about the sources of CO and the hazards of exposure. Health care professionals need to be aware of the symptoms of CO poisoning and obtain COHb levels to confirm exposure and thus provide appropriate treatment. To prevent CO poisoning:

- Carbon monoxide detectors should be installed in homes or other buildings where there is a possible source of exposure.

- Gas appliances and equipment should be properly installed and maintained.
- Fuel-burning equipment and gasoline-powered tools and engines should not be used indoors or in enclosed spaces; ensure areas are properly ventilated.
- Motor vehicles should not be allowed to idle in closed or open garages.
- Gas appliances such as ovens and ranges should be used only for their intended purpose, not for heating a home.
- Users of combustion engines need to be aware of early symptoms of CO poisoning and take appropriate action such as increasing ventilation or moving to fresh air.

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