Deaths From Unintentional Carbon Monoxide Poisoning and Potential for Prevention With Carbon Monoxide Detectors

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ABSTRACT

Context.—Unintentional carbon monoxide (CO) poisoning causes approximately 2100 deaths in the United States per year, but the use of CO detectors could potentially prevent many of these deaths.

Objective.—To describe the epidemiology of potentially preventable unintentional CO poisoning deaths in New Mexico.

Design.—Descriptive analysis.

Population Studied.—A total of 136 deaths from CO poisoning investigated by the New Mexico Office of the Medical Investigator, 1980 through 1995.

Main Outcome Measures.—Characteristics of deaths from CO poisoning; estimates of the number of deaths potentially preventable with CO detectors.

Results.—Of 136 people whose deaths were classified as "unintentional carbon monoxide poisoning, not fire related," 49 (36%) most likely were asleep when poisoned. Thirty-nine (49%) of 80 people whose deaths were identified as "residential fatalities" most likely were asleep vs 10 (18%) of 56 of those whose deaths were identified as occurring in or around motor vehicles. A blood-alcohol level greater than 0.01% was present in 56 (42%) of the decedents. Among decedents who had a negative blood-alcohol level (52 in residences and 26 in vehicles), an electronic audible CO detector may have prevented CO poisoning; whereas, among those who had a negative blood-alcohol level and most likely were awake at the time of CO exposure (28 in residences and 23 in vehicles), an electronic detector or a nonaudible, chemical reagent type detector may have prevented CO poisoning.

Conclusion.—Differences exist between deaths due to unintentional CO poisoning that occur in residences and those that occur in or around motor vehicles. Carbon monoxide detectors, whether the electronic or chemical reagent types, may have prevented approximately half of these deaths. The high proportion of decedents with alcohol in their blood indicates that effective public health campaigns must address the role of alcohol in CO poisoning deaths.

Keywords: alcohol drinking, carbon monoxide poisoning, carbon monoxide detectors, death, health education.

Each year, unintentional carbon monoxide (CO) poisoning is estimated to cause approximately 2100 deaths in the United States and is a problem in other industrialized countries as well. Efforts to educate the public on how to prevent CO poisoning have focused mainly on increasing awareness of the dangers of CO and on promoting the proper maintenance of potential residential sources of CO, such as furnaces and water heaters.

The use of CO detectors is a relatively recent phenomenon. Although their use has been discussed by Cook et al and Leikin, the number of lives that could be saved with CO detectors has not been estimated. Krenzelok et al observed that the use of CO detectors can eliminate the medical cost of treating CO-exposed patients but did not provide the number of people that may be affected.
In this study, we examine deaths reported to the New Mexico Office of the Medical Investigator (OMI), Albuquerque, that were found to be caused by unintentional CO poisoning and assess whether those deaths might have been prevented by using either a nonaudible chemical reagent CO detector or an electronic audible CO detector.

**METHODS**

We identified deaths due to unintentional CO poisoning in New Mexico from 1980 through 1995 by searching the computerized records of deaths investigated by the New Mexico OMI. In the New Mexico OMI data, the circumstances of unintentional death from CO poisoning are listed in 1 of 14 categories. These include fire (code A40), inhalation (code A37), or 1 of 26 automobile collision categories, such as colliding with a fixed object or hitting another car. Only deaths categorized as due to inhalation were included in our analysis. Fire-related CO poisonings were not included in the analysis because of the uncertainty of the actual cause of these deaths and our inability to determine whether the deaths might have been prevented had smoke detectors been used.

The data include 75 descriptive fields for each death in the main database, plus additional toxicology fields in a separate database. Those fields most applicable for this study are manner of death (eg, "accident," "suicide"); manner-of-death code (designates specific kind of death, eg, "driver of auto in collision with moving vehicle," "hanged self with . . ."); how the injury occurred (ie, poisoning); place of injury; cause-of-death code; and 9 lines of text describing the circumstances surrounding the death. Other data related to the deaths, such as the race of those who died, were not used for the analysis. We selected final cases to be included in the analysis by searching for records that listed "A37" (unintentional inhalation) in the "manner-of-death" code field and "C12" (CO intoxication) in the "cause-of-death" code field. Cases of "vehicular accident" deaths with CO intoxication listed as cause of death were not included in the final analysis.

We further examined cases matching unintentional CO intoxication to determine whether CO poisoning and death most likely occurred while the person was sleeping. We inferred whether the decedent was asleep at the time of death based on documentation on the circumstances of death contained in the database. When searching the circumstances-of-death text, we considered key phrases such as "found supine in bed" or "found in the bedroom" as indicating that the decedent most likely was asleep at the time of the CO poisoning. For deaths that occurred in motor vehicles, a phrase such as decedent was "in the sleeping bag" was taken as an indication that the decedent was most likely asleep at the time of death. We examined but did not analyze time of injury (poisoning) because only 9 deaths had time of injury (poisoning) listed.

We stratified data on the basis of whether the decedent was under the influence of alcohol. The rationale for the stratification was that those under the influence of alcohol may not have been able to react properly even if a CO detector had been in use. "Type-of-death" codes, either alcohol present, alcohol not present, or not tested for alcohol, were used to ascertain whether alcohol was present in the blood. Although the blood-alcohol level used as the cutoff, 0.01%, is less than the level usually identified with intoxication, we decided to use that value to be more conservative in our estimates. Those with the type-of-death code "alcohol present" were assumed to be under the influence of alcohol at the time of death. Additional analysis was done on a separate toxicology database containing the actual blood-alcohol level to confirm the appropriateness of using the 0.01% cutoff.

We analyzed data using dBaseIV (Borland Corporation, Scotts Valley, Calif) and EpiInfo (Centers for Disease Control and Prevention, Atlanta, Ga) software. We performed analyses of frequencies and bivariate cross tabulations and calculated confidence intervals (CIs) to show the precision of point estimates.

We assumed that CO detectors were not in use at the time of the deaths since this information was not available in the database. We estimated the number of deaths that potentially could have been prevented had either chemical reagent or electronic CO detectors been correctly used. We assumed that (1) if a person was awake and actively monitoring the detector during the time of poisoning, a chemical reagent CO detector might have alerted the individual to the presence of CO and therefore could have prevented the poisoning; and (2) if a person was asleep during
the time of poisoning, an electronic CO detector with audible warning might have awakened the sleeping individual and, thus, prevented the poisoning.

**RESULTS**

Between 1980 and 1995, 695 deaths (0.98% of all deaths) in New Mexico investigated by OMI were the result of CO poisoning (as identified by cause-of-death code C12). Of these deaths, 136 (19.6%) were coded as unintentional inhalation (Figure 1). Of the 136 decedents whose deaths were coded as unintentional inhalation, 36 (26%) were female and 100 (74%) were male. The median age was 39 years (range, <1-87 years) (Table 1). The 56 people who died of CO poisoning in or around motor vehicles had a median age of 32 years, whereas the 80 people who died at a residence had a median age of 41 years. The 80 deaths listed as occurring at a residence included 2 people who died at a motel and 4 who died in tents.

Deaths from unintentional carbon monoxide poisoning, New Mexico, 1980 to 1995, classified according to location and whether the decedent was most likely awake at the time of CO poisoning and blood alcohol status. The asterisk indicates that 1 individual was not included because of missing blood-alcohol content information.

On the basis of descriptive information for each decedent, we found that the majority of decedents most likely were awake during poisoning by CO: 82% of people who died in motor vehicles were judged to be awake, although only 51% of those who died at a residence were, a difference of 31 percentage points (95% CI, 16-46).

Of the 134 decedents tested for the presence of alcohol, 56 (42%) had a blood-alcohol level greater than 0.01%. Such an elevated blood-alcohol level was found more often in people who died in motor vehicle–related CO deaths (n=29, 53%) than in those who died in residential CO deaths (n=27, 34%): a difference of 19 percentage points (95% CI, 2-35). However, the presence or absence of alcohol had little correlation with the proportion of decedents who were judged to be awake at the time of CO poisoning. Among decedents whose deaths were motor vehicle–related, 23 (88%) of 26 of those who were negative for alcohol most likely were awake at the time of CO poisoning vs 22 (76%) of 29 of those who were positive for alcohol (P=.23). Among decedents who died at a residence, 28 (54%) of 52 of those who were negative for alcohol most likely were awake at the time of CO poisoning vs 12 (44%) of 27 of those who were positive for alcohol (P=.43). An analysis using a higher blood-alcohol cutoff value of 0.1% showed similar results (data not shown).

Deaths from CO poisoning occurred in 24 counties in New Mexico. Only 2 counties had more than 10% of the fatalities: Bernalillo, which contains the metropolitan Albuquerque area, had 30 of the fatalities (22%), and rural Dona Ana County had 14 (10.4%). Using the population figures from the 1990 census, we found that the average annual mortality rate for New Mexico was 0.6 per 100000, 0.4 per 100000 for Bernalillo County and 0.6 per 100000 for Dona Ana County.

Most poisoning incidents involved a single fatality. However, 20% of fatal incidents involved multiple victims. In 1 incident, 4 people were poisoned. During all poisoning incidents, people were likely to be awake regardless of the number of deaths per incident. During the 5 poisoning incidents in which 3 or more people died, all of those who died were judged to be awake at the time of CO poisoning.
Although CO poisoning occurred throughout the year, 25 (45%) of the unintentional motor vehicle–related CO poisonings and 45 (56%) of the residential CO poisonings occurred during November, December, or January. The most common source of residential CO was unvented supplemental heaters, either natural gas or propane fueled, which accounted for 37 deaths (46%).

Of the decedents without the presence of alcohol in their blood, we estimate that 78 deaths (52 residential, 26 vehicular) could have been prevented if audible electronic CO detectors were used; whereas, 51 deaths (28 residential, 23 vehicular) could have been prevented if nonaudible chemical reagent CO detectors were used. The potential number of deaths prevented is greater for audible electronic CO detectors because the device can alert people who are asleep.

**COMMENT**

The results of our study suggest that differences exist between deaths due to unintentional CO poisoning that occur in residences and those that occur in motor vehicles. The median age of those who died of CO poisoning in residences was greater than that of those who died in motor vehicles, which suggests that health education campaigns about these 2 categories of CO poisoning may need to be targeted to different age groups. For older people, health education may need to focus on ways of eliminating possible sources of CO in a residence. For younger people, health messages also need to address ways of reducing the likelihood of unintentional CO poisoning in vehicles.

The appropriateness of different types of CO detectors is determined by the characteristics of the environment and the people being protected. Carbon monoxide detectors must be sensitive enough to allow people to respond in a timely manner in the presence of CO and yet be resistant to false alarms: CO detectors with high false-alarm rates have caused problems in Chicago, Ill. The threshold for response varies by detector type; electronic detectors respond at a lower level (as low as 35 parts per million [ppm]) than chemical reagent detectors (about 100 ppm). However, the accuracy of chemical reagent CO detectors may be poor and could result in CO poisoning even with proper use.

An electronic CO detector must generate an audible and visible alarm loud enough to arouse a sleeping person or be heard over the ambient noise of a workplace or a factory. Electronic detectors that emit audible warnings are usually more effective than nonaudible detectors except when used by people with impaired hearing or by people working and living in noisy environments. Electronic detectors usually rely on a power source and will not issue an effective warning if the source of power is not functioning. A detector that relies solely on a visible warning, such as a change in its surface color, will be less effective at night and in darkened places or for people whose vision is impaired, and it will be ineffective for people who are asleep. The size of the device may not be as crucial in a motor vehicle because the protected space is small, but the display must be visible both day and night.

The presence of alcohol or other drugs in victims of CO poisoning may limit the effectiveness of CO detectors, whether the alarm is audible or visual. In our study, 56 decedents overall (42%) (27 who died at a residence [34%] and 29 who died in or around a motor vehicle [53%]) had alcohol present in their blood, a rate similar to that reported in other studies, and 22 (16%) (15 who died at a residence [19%] and 7 who died in or around a motor vehicle [13%]) had positive blood-alcohol levels and were asleep. The challenge in trying to prevent these deaths is to develop CO detectors that could be effective in alerting people who are under the influence of alcohol.

The use of residential heating devices varies by season. The number of CO poisoning fatalities in this study also showed seasonality. Approximately half of all fatalities occurred during the winter months, when people are indoors and may be using improperly maintained or defective heating equipment. Another seasonal risk factor is motor vehicles with exhaust pipes blocked by snow drifts. The use of an in-vehicle CO detector may help alert passengers before the CO reaches a critical level.

The results of this study should be applicable to other states, but the limited availability of
similar data in other states may make it difficult to examine this. Measures to prevent unintentional CO poisoning should include public health messages about the dangers of CO poisoning and about the potential sources of CO in residences and vehicles. The public needs to be advised that properly maintaining all fuel-burning appliances and motor vehicles is necessary to reduce the chance of that appliance or motor vehicle creating CO, and warnings about operating motor vehicles during and after snow storms should be issued. The public also should be made aware of the usefulness, limitations, and proper use of both chemical reagent and electronic CO detectors and should be encouraged to test their CO detectors regularly to ensure that they are operating properly.

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