Job Fatalities Due to Unintentional Carbon Monoxide Poisoning, 1992-96

In any given year, numerous deaths result from accidental exposure to carbon monoxide poisoning.

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Carbon monoxide is a clear, colorless, odorless toxic gas that is a product of incomplete combustion. It is one of many chemicals found in engine exhaust. Carbon monoxide can rapidly accumulate even in areas that might appear to be well ventilated. Carbon monoxide combines with hemoglobin to form carboxyhemoglobin which interferes with the oxygen-carrying capacity of blood, resulting in a state of tissue hypoxia.[1] Carbon monoxide exposure levels of 80–100 parts per million (ppm) for 1 to 2 hours can create adverse health affects. The concentration that the National Institute of Occupational Safety and Health (NIOSH) considers immediately dangerous to life and health is 1,200 ppm.[2] The Occupational Safety and Health Administration has set permissible exposure levels to 50 ppm for an 8-hour time weighted average.[3]

Carbon monoxide poisoning is common in the United States with an estimated 10,000 persons seeking medical attention or missing at least 1 day of normal activity each year because of it.[4] In any given year, numerous deaths result from the accidental exposure to this toxic gas. Studies from the Center for Disease Control indicate that there are as many as 600 deaths annually in the United States due to unintentional carbon monoxide poisoning.[5] The Bureau of Labor Statistics (BLS) estimates that there were 867 nonfatal poisonings requiring time away from work to recuperate and 32 fatal poisonings in private industry in the United States in 1992.[6]

Most fatal unintentional carbon monoxide poisonings are associated with motor vehicles and are preventable. Exposure can result from these primary sources: The operation of a motor vehicle with a faulty exhaust system or an inadequately ventilated passenger compartment; the operation of a motor vehicle in an enclosed space; and the use of auxiliary fuel burning heaters.[7]

Other studies have identified various pieces of power equipment as the primary sources for a number of carbon monoxide deaths. Examples of such equipment include power washers, space heaters and generators.[8]

Safety standards are in place that are designed to minimize a person's exposure to lethal levels of carbon monoxide in the workplace. These standards establish protection requirements and limit the levels of carbon monoxide a person may be exposed to. While these standards are effective in reducing the potential for carbon monoxide poisoning, many cases still result from activities that are not recognized as hazardous by the victims.

The purpose of this study is to identify the industries and activities that most often result in carbon monoxide poisoning. By identifying these situations, prevention measures can be developed and directed to those who would benefit the most.

Unintentional carbon monoxide poisonings

From January 1, 1992 through December 31, 1996, unintentional carbon monoxide poisonings caused 148 fatalities. The service sector accounted for the largest share of the fatalities, 25 percent. (See table 1.) Within this sector,

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TABLE 1. **Unintentional carbon monoxide fatalities by industry, 1992-96**

Industry	Number of deaths	Percent of total
Total	148	100.0
Agriculture	21	14.2
Mining	5	3.4
Construction	21	14.2
Manufacturing	22	14.9
Transportation	7	4.7
Wholesale trade	4	2.7
Retail trade	11	7.4
Finance, insurance, and real estate	4	2.7
Services	37	25.0
Public administration	9	6.1
Nonclassifiable[1]	7	4.7

[1] Nonclassifiable includes establishments which cannot be classified in any other industry.

automotive repair, services, and parking industries accounted for almost half of the unintentional carbon monoxide deaths.

Proportionate mortality ratios identified three industries with proportions of deaths due to carbon monoxide poisoning that were significantly different than what was expected. (See table 2.) The transportation industry had significantly fewer carbon monoxide deaths than expected while the services industry and the nonclassifiable industries had significantly more.

The services sector includes vehicle repair and vehicle maintenance occupations. Employees in these occupations who died from carbon monoxide poisoning were most often overcome by fumes while they were maintaining or repairing a vehicle with the engine running in an enclosed space.

In the nonclassifiable industries, the majority of deaths also involved automobile exhaust. Victims were most often found dead in, or near, a vehicle with a running engine. Gasoline powered equipment such as power saws, pumps, and space heaters accounted for the majority of the remaining deaths. In most instances, the victims were using the equipment in an enclosed space.

Prevention strategies

Occupational fatalities caused by unintentional carbon monoxide poisoning accounted for approximately 5 percent of all fatal unintentional carbon monoxide poisonings in the United States during the period 1992-96. Prevention strategies for these types of deaths should include the incorporation of both engineering and administrative controls.

Engineering controls include the use of carbon monoxide detectors like those used in private homes. Their use should be expanded to the workplace especially to automobile repair and maintenance facilities. It would not be unreasonable to incorporate the installation of carbon monoxide detectors into the building codes for those occupancies that might be exposed to potentially lethal concentrations of carbon monoxide. Engineering controls should also include the use of ventilation systems that attach to the exhaust pipe of a vehicle and safely discharge exhaust fumes to outside air. The cost of this equipment is small and the benefits would include a reduction in the number of fatal and nonfatal carbon monoxide poisonings that occur each year in the workplace.

Administrative controls should include the development and enforcement of safety policies and procedures. Working on running vehicles in enclosed areas without proper ventilation should be prohibited.

A number of deaths occurred when the victims were working alone on a vehicle after normal work hours. Prohibiting this practice or assigning a second person to be available outside of the workspace to periodically check on the person performing the work, could prevent some deaths.

Other deaths resulted from the use of various types of gasoline powered equipment such as cement cutters and generators. Prevention strategies for these types of equipment should include their proper maintenance and use. When equipment is not running efficiently, the incomplete combustion process tends to release higher concentrations of carbon monoxide. Equipment should be used with adequate ventilation and, if necessary, proper personal protective equipment including a self-contained breathing apparatus. Maintaining equipment will help reduce the levels of carbon monoxide released during combustion.

Finally, employee training should be conducted to inform employees about the hazards of carbon monoxide poisoning. Studies show that potentially lethal levels of carbon monoxide can be reached in a matter of seconds when small gasoline powered engines are running in enclosed spaces. People do not fully understand the hazards of carbon monoxide or the situations that can produce lethal carbon monoxide levels. Training should include the identification of equipment and job tasks that present a carbon monoxide hazard, the proper use of gasoline powered equipment and personal protective equipment, and a review of all employer provided hazard control policies and equipment.

Methodology

Data. This study used BLS data from the Census of Fatal Occupational Injuries (CFOI). The CFOI is an official, systematic, verifiable count of fatal occupational injuries that occur during the year.[9] It has been adopted by the National Safety Council and other organizations as the authoritative source for a count of fatal work injuries in the United States.

To ensure that the fatalities are work related, cases are substantiated with two or more source documents or a source document and a follow-up questionnaire. Work-related deaths are classified as such if a working relationship has been established. A working relationship is established if an employee is on the employer's premises to work, the employee is off the employer's premises but there to work,

TABLE 2. **Proportionate mortality ratios for carbon monoxide poisoning fatalities by industry, 1992-96**

Industry	Total deaths	Carbon monoxide deaths	Expected carbon monoxide deaths	Variance	X^2	Proportionate mortality ratio
Total	31,323	148				
Agriculture	4,050	21	19.1	16.6	0.11	109.7
Mining	844	5	4.0	3.9	.07	125.4
Construction	5,072	21	24.0	20.0	.60	87.6
Manufacturing	3,751	22	18.0	15.5	.92	124.1
Transportation	4,880	7	23.0	19.4	14.15[1]	30.4
Wholesale trade	1,306	4	6.2	5.9	1.21	64.8
Retail trade	3,699	11	17.5	15.3	3.17	62.9
Finance	598	4	2.8	2.8	.16	141.6
Services	4,297	37	20.3	17.4	15.05[1]	182.2
Public administration	2,449	9	11.6	10.6	.89	77.8
Nonclassifiable[2]	377	7	1.8	1.8	12.71[1]	393.0

[1] Indicates the probability of obtaining these results due to chance is less than .001.

[2] Nonclassifiable includes establishments which cannot be classified in any other industry.

or the event or exposure is related to the person's work or status as an employee.

This study analyzed deaths that occurred from January 1, 1992 through December 31, 1996 as a result of carbon monoxide poisoning. Deaths classified as self-inflicted were removed from the analysis. This ensured that the 148 cases selected were unintentional and not suicides that occurred at work. For each case, the industrial classification, date of the event, and narrative description of the event were analyzed. The cases were classified according to their major standard industrial classification groups following the methodology outlined in the *Standard Industrial Classification Manual 1987*.[10]

Proportionate mortality ratios. A proportionate mortality ratio (PMR) was calculated for each industry classification following the procedures described by Spiegelman, Wang, and Wegman[11] and Mantel and Haenszel.[12] Proportionate mortality ratios compare the observed fatalities in a group to the expected number of fatalities for a particular reason. The expected number of fatalities is derived from the fatality experience for the entire population. In this study, the observed number of fatalities due to carbon monoxide poisoning for each industry was compared to a statistically expected number of fatalities based upon the proportions of all fatalities for all industries.

Mantel-Haenszel Chi-square tests of significance. Mantel-Haenszel Chi-square tests of significance were performed to determine if the observed deaths were significantly different from what could be expected. ■

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[1] Hypoxia is a deficiency in the amount of oxygen reaching body tissue. For additional information, see M. Sittig, *Handbook of Toxic and Hazardous Chemicals,* Noyes Publications, New Jersey, 1981, p. 137.

[2] NIOSH Alert: P*reventing Carbon Monoxide Poisoning from Small Gasoline-powered Engines and Tools,* National Institute of Occupational Safety and Health, Publication No. 96-118, 1996, p. 3.

[3] "Code of Federal Regulations, 1910.1000," Occupational Safety and Health Administration, Washington, DC, U.S. Government Printing Office, 1997.

[4] S. M. Silvers and N. B. Hampson, "Carbon Monoxide Poisoning Among Recreational Boaters," *Journal of the American Medical Association,* Vol. 274, 1994, pp. 1614-16.

[5] See Netzel R. A. Cobb, "Unintentional Carbon Monoxide-related Deaths in the United States, 1979-1988," *Journal of the American Medical Association,* Vol. 226, 1991, pp. 659-663.

[6] NIOSH Alert: P*reventing Carbon Monoxide Poisoning,* p. 5.

[7] "Deaths from Motor-vehicle-related Unintentional Carbon Monoxide Poisoning—Colorado, 1996, New Mexico, 1980-1995, and United States, 1979-1992," *Morbidity and Mortality Weekly Report,* Vol. 45, 1996, pp. 1029-32.

[8] Center for Disease Control, "Carbon Monoxide Poisoning from use of Gasoline-fuel Power Washers in an Underground Parking Garage—District of Columbia, 1994," *Morbidity and Mortality Weekly Report,* Vol. 44, May 12, 1995, pp. 356-64.

[9] Data on fatal work injuries are from the Bureau of Labor Statistics' Census of Fatal Occupational Injuries (CFOI), 1992-96.

[10] Industry is classified according to the *Standard Industrial Classification Manual 1987*.

[11] D. Spiegelman, J. D. Wang, and D. Wegman, "Epidemiologic Programs for Computers and Calculators," *American Journal of Epidemiology,* Vol. 118, October 1983, pp. 599-607.

[12] N. Mantel and W. Haenszel, "Statistical Aspects of the Analysis of Data from Retrospective Studies of Disease," *Journal of the National Cancer Institute,* Vol. 22, April 1959, pp. 719-48.