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Occupational Carbon Monoxide Fatalities in the US From Unintentional Non-Fire Related Exposures, 1992–2008

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Abstract

Objective—To analyze characteristics of, and trends in, work-related carbon monoxide (CO) fatalities in the US.

Methods—Records of unintentional, non-fire related fatalities from CO exposure were extracted from the Bureau of Labor Statistics' Census of Fatal Occupational Injuries and the Occupational Safety and Health Administration's Integrated Management Information System for years 1992–2008 and analyzed separately.

Results—The average number of annual CO fatalities was 22 (standard deviation = 8). Fatality rates were highest among workers aged ≥65, males, Hispanics, winter months, the Midwest, and the Fishing, Hunting, and Trapping industry subsector. Self-employed workers accounted for 28% of all fatalities. Motor vehicles were the most frequent source of fatal CO exposure, followed by heating systems and generators.

Conclusions—CO has been the most frequent cause of occupational fatality due to acute inhalation, and has shown no significant decreasing trend since 1992. The high number of fatalities from motor vehicles warrants further investigation.

Keywords

carbon monoxide; fatalities; occupational; surveillance; CFOI

INTRODUCTION

Carbon monoxide (CO) is the most common acute chemical inhalation exposure leading to death in the US population [Valent et al., 2002]. During 2001–2003, approximately 500 people died and an additional 15,000 people were treated in emergency rooms because of unintentional non-fire related CO exposures [Centers for Disease Control and Prevention,

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2005]. CO is a colorless, odorless, tasteless, and non-irritating gas which makes it difficult for those who are exposed to detect it. Because CO lacks sensory warning properties it is commonly known as the "silent killer."

CO disrupts the human body's oxygen transport by binding to hemoglobin at a rate 200–250 times greater than oxygen [Rodkey et al., 1974]. This action diminishes the oxygen carrying capacity of the blood causing tissue hypoxia and eventually death by chemical asphyxiation. CO is produced as a by-product of the incomplete combustion of carbon containing fuels, for example, gasoline, coal, wood, propane, and natural gas. Common workplace sources of CO include fuel-powered engines (motor vehicles, forklifts, generators, pumps, saws, etc.), fuel-burning heaters (furnaces, water heaters, boilers, space heaters, etc.), coke ovens, and blast furnaces.

An analysis of CO poisonings among the general population in Maine reported that 23% of all cases were occupational [Graber and Smith, 2007]. Among CO-related calls to national poison control centers, the proportion that reported the workplace as the site of exposure was 12% [Centers for Disease Control and Prevention, 2011]. Although the majority of fatalities resulting from CO exposures occur outside the workplace, from 1992 to 1998 there were 175 occupational fatalities from CO exposure, making it the leading cause of acute fatalities from an inhaled substances among U.S. workers [Valent et al., 2002].

Sources of Fatality Data

The Census of Fatality and Occupational Injury (CFOI) is a database of national statistics maintained by the Bureau of Labor Statistics (BLS) [US Bureau of Labor Statistics, 2012a]. Data collection is accomplished through a federal-state cooperative program that has been implemented in all 50 States and the District of Columbia since 1992 [US Bureau of Labor Statistics, 2012a]. To compile counts that are as complete as possible, CFOI uses multiple sources to identify, verify, and profile fatal worker injuries. The sources include death certificates, workers' compensation reports, Occupational Safety and Health Administration (OSHA) reports, police reports, and medical examiner reports. At least two independent source documents are required to confirm that the fatalities are work-related. Previous studies using CFOI data for fatalities from acute chemical inhalation include hydrogen sulfide and CO [Janicak, 1998; Hendrickson et al., 2004].

OSHA routinely investigates workplaces for enforcement of regulations and provides consultative assistance to employers upon request. OSHA also investigates fatalities that are within OSHA's jurisdiction. A limitation of using the data for national surveillance purposes is that the agency does not investigate all occupational fatalities that occur in the US. OSHA has limited authority in industries such as mining, agriculture, and fishing [Henn et al., 2011]. Information collected during OSHA visits are maintained in OSHA's Integrated Management Information System (IMIS). Previous studies have used OSHA's IMIS data to identify fatalities resulting from hydrogen sulfide exposures [Suruda and Agnew, 1989; Fuller and Suruda, 2000; Dorevitch et al., 2002].

The objective of this research was to analyze workplace CO fatalities using two national data systems, CFOI and IMIS, to obtain a better understanding of trends, patterns, and CO sources of workplace CO fatalities in the US.

METHODS

CFOI

Work-related fatalities due to CO exposure that occurred between 1992 and 2008 were extracted from CFOI. We obtained access to restricted CFOI data which contains information on the sources for fatality cases. In CFOI, BLS defines a fatal injury as work-related if it occurred to a non-institutionalized person while working either at the employer's premises or outside of the employer's premises.

CFOI variables are coded using the BLS Occupational Injury and Illness Classification System (OIICS) [US Bureau of Labor Statistics, 2012b]. OIICS provides detailed codes for the type of injury event, primary source and secondary source of injury, nature of injury, and body part affected. Fatalities resulting from CO poisoning were extracted from BLS' CFOI data, for years 1992 to 2008, where either the primary or secondary source was coded as CO (source code: 0941). The narrative text of all remaining fatalities was searched for the words "carbon" and "monoxide." All the fatalities that met either criterion were then manually checked to confirm their appropriateness as a case. Work-related fatalities resulting from inhalation during a fire, explosion, or motor vehicle crash were excluded, as well as fatalities resulting from suicides and homicides.

IMIS

Fatality records that indicated CO as the contributing cause of death were identified and extracted from OSHA's IMIS data for years 1992 (the first year of CFOI data available) through 2008 (the last full year of IMIS data available). Circumstances and source information for the CO deaths were retrieved from OSHA's public website by entering the unique number for each fatality investigation to obtain the summary report of the investigation. Fatalities where fire, explosion, motor vehicle crash, suicide, or homicide was the contributing source were excluded.

For both CFOI and IMIS, major industry sector and subsector groups from 1992 through 2002 were coded using the 1987 Standard Industrial Classification system (SIC) and from 2003 through 2008 using the 2002 North American Industrial Classification System (NAICS). To allow analyses including all years, we converted SIC to NAICS codes using standardized crosswalk information [US Census Bureau, 2011]. Furthermore, we converted NAICS codes to National Occupational Research Agenda (NORA) sector groups using crosswalk information [National Institute for Occupational Safety and Health, 2009].

Sources for Employment Data

The number of full-time equivalent workers (FTE, 1 FTE = 2,000 hr worked per year) was obtained from the BLS Current Population Survey (CPS) from 1992 through 2008. It includes hours for primary and secondary jobs worked by an employee. The CPS, sponsored jointly by the U.S. Census Bureau and the BLS, is the primary source of labor statistics in the US [US Census Bureau, 2012]. It is a monthly household survey of approximately 50,000 civilian, non-institutionalized residents aged 16 years and older and provides information on employment, demographics, country of birth, occupation, industry, and other workforce characteristics. Industry group codes in CPS come from the Bureau of Census (BOC) industry coding system. The CPS data from 1992 to 2002 use the 1990 BOC industry codes, and the CPS data from 2003 to 2008 switched to use the updated 2002 BOC industry codes. Furthermore, the BOC industry codes used in the denominator were cross-walked with the SIC/NAICS coding in the numerator so that industry groupings were matched in both numerator and denominator.

Rate Calculation and Statistical Analysis

Occupational CO fatality rates for 1992 through 2008 were calculated as the total number of fatalities divided by the estimated number of FTEs during this period and expressed as the number of fatalities per 100,000 FTEs per year. All statistical analyses were performed using SAS, version 9.3 (SAS Institute Inc., 2010). For analysis of rates, univariate rate ratios were calculated and significance tests among strata within each variable (demographics, seasons, industry groups, CO sources) were performed using Poisson regression (GENMOD procedure in SAS). For tests of trend in OSHA IMIS and CFOI fatality counts, linear regression was performed using SAS's REG procedure. In the assessment of trend significance, the Durbin–Watson statistic was calculated to account for potential yearly autocorrelation in fatality counts.

The CFOI data file provided to NIOSH by BLS contained no personal identifiers and the OSHA data used in this study are in the public domain. Therefore, a NIOSH Institutional Review Board approval was not required.

RESULTS

A total of 727 occupational fatalities resulting from CO exposure were identified in CFOI for the years 1992–2008. Fatalities attributed to CO inhalation during fire, explosion, or motor vehicle crash were excluded from analyses (n = 199) along with those that were intentionally caused by the decedent through suicide (n = 154), leaving 374 for analyses.

There were 60,102 fatality records in OSHA's IMIS between years 1974 and 2008. CO was the most frequent cause of occupational fatality due to acute chemical exposure. After restriction to years 1992–2008, 120 fatalities were identified with CO as the reported primary cause of death. Fatalities where the source of CO was determined to be from a fire were excluded (n = 9), leaving 111 for analyses.

Annual occupational CO fatalities reported in CFOI and IMIS are shown in Figure 1 for years 1992–2008. The annual average of CO fatalities was 22 (standard deviation = 8) in CFOI and 7 (standard deviation = 4) in IMIS. Overall, the number of fatalities reported in IMIS was 30% of those reported in CFOI (111 compared to 374).

Trends in Fatality Counts

A slight decrease in occupational CO fatalities was observed from 1992 to 2008 in both CFOI and IMIS. However, the decreasing slopes were not statistically significant for overall trend of the CFOI ($\beta = -0.27$; $P = 0.4860$) and IMIS ($\beta = -0.06$; $P = 0.7581$).

Sector and Subsector Comparisons

Fatalities between the two datasets are also compared by NORA sector in Table I. The counts of CO fatalities were highest in the Services sector in CFOI (n = 114) and highest in the Manufacturing sector in IMIS (n = 30); the fatality rate was highest in the Mining, Oil, and Gas Extraction sector for CFOI (0.135).

The CFOI data file obtained for this study did not contain personal identifiers which prevented the ability to match records with IMIS to identify specific cases of overlap. Since IMIS records captured only a portion of the overall CO fatalities that occurred in the US for years 1992–2008, additional analysis of the characteristics and circumstances of the CO fatality events were limited to the CFOI data.

Among the CFOI fatalities, major industry sectors were subdivided into NAICS subsectors and occupational fatality rates were reported at the finest level of detail possible allowed by the data (range from 2 to 4 digit NAICS level). The ten subsectors with the highest fatality rates are shown in Table II. The Fishing, hunting and trapping subsector had by far the highest CO-related fatality rate (0.796 per 100,000 FTEs), almost 47 times the all-industry average rate of 0.017 per 100,000 FTEs. Subsectors automotive repair and maintenance (0.151), mining and support activities for mining (0.135), and oil and gas extraction (0.135) had CO-related fatality rates that ranged from approximately eight to nine times the all-industry average rate.

State Comparisons

Occupational CO fatalities in CFOI by state are listed in Table III and shown geographically in Figure 2. Due to BLS reporting criteria, 24 states did not meet the minimum threshold to be shown separately, so they are grouped into all other states in Table III and designated as data N/A in Figure 1. California had the highest total number of fatalities at 45 which was 12% of the total for the US. CO fatality rates were by far the highest in Wyoming and Montana, 0.183 and 0.124 per 100,000 FTEs respectively, which were 11 and 7 times higher than the US average of 0.017, respectively. When states were combined into regions, the Midwest region had the highest fatality rate (Table IV).

Demographic, Seasonal, and Source Comparisons

Demographic and seasonal information for CO fatalities in CFOI are shown in Table IV. Fatality rates were highest among workers greater than 65 years of age, males, Hispanics, and in the winter.

The sources of CO which contributed to the fatalities in CFOI are shown in Table V. The leading source of CO fatalities was motor vehicles (including automobiles, trucks, highway vehicles, passenger vans, and light delivery vehicles), accounting for 25% of all fatalities. The next most prevalent source was furnaces, heaters, and boilers (14%).

CO fatality counts in CFOI are shown in Table VI by establishment size category and employment status. Rates could not be calculated because FTE information by these CFOI variables is not available in the CPS. The number of occupational CO fatalities was highest among the smallest employers, with establishment size category of 1–10 employees, accounting for 63% of the total fatalities (149 of 238) with reported establishment size. Of the 149 fatalities in this category, the majority (n = 105, 70%) were among self-employed workers. Overall, self-employed workers accounted for 28% (105 of 374) of the total fatalities from 1992 to 2008. In comparison, during a similar time period (1994–2008) self-employed workers made up 12% of the total US workforce [US Bureau of Labor Statistics, 1992].

DISCUSSION

From the 60,102 fatality records extracted from OSHA's IMIS between years 1974 and 2008, the leading cause of death from acute chemical exposure was carbon monoxide with 322 fatalities. A previous study of CFOI (1992–1998), also found CO to be the number one source of occupational inhalation fatality [Valent et al., 2002]. The prevalence of CO fatalities is likely due to three things: (1) CO is ubiquitous in workplaces, (2) CO has poor warning properties, and (3) CO has nonspecific early-warning symptoms of overexposure (fatigue, nausea, or headache) that are often attributed to common illnesses and could be easily mistaken for work-related fatigue.

Annual CO fatalities have declined slightly, but did not show a significant downward trend over the years 1992–2008 for either CFOI or IMIS. Comparison of the two data systems used in this study revealed that IMIS captured approximately 70% fewer CO fatalities than CFOI for the years 1992–2008. This finding is consistent with findings from a study in 10 states that found OSHA investigated only 32% of all occupational fatalities [Stout and Bell, 1991]. This is likely because the occupational fatalities were outside of OSHA's jurisdiction. For instance, OSHA does not have jurisdiction over public employees (if not covered by state OSHA plan), mineral mining, self-employed, interstate trucking, ships at sea, volunteers, family farms as well as parts of maritime, aviation and railroad. The number of self-employed CO fatalities in CFOI was 166 (31%), and would not be reported in IMIS. A previous study found that as many as 43% of all work-related fatalities occurred outside of OSHA's jurisdiction in the state of New Jersey for years 1984–1985 [Stanbury and Goldoft, 1990]. The same study determined that 3% of fatalities that were under OSHA jurisdiction were not investigated by OSHA because they were not aware of the fatality in their jurisdiction.

The CO fatality rate by age category showed a trend, increasing from youngest to oldest age group, with those over 65 to be at most risk. A similar pattern was found among all CO deaths including non-occupational for the US [Centers for Disease Control and Prevention, 2007]. Higher CO poisoning rates among older persons has been attributed to mistaking CO symptoms (fatigue, nausea, or headache) to other causes that are common among this group [Harper and Croft-Baker, 2004].

Occupational CO deaths were primarily among men, accounting for 95% of total fatalities and a rate that was in excess of 10-fold higher to female workers (0.029–0.002 per 100,000 FTEs). It is likely that males have a greater tendency to be employed in jobs using tools or equipment that burn fuel and thus have a greater potential for overexposure. Additionally, the workforce in high-risk industries, such as Agriculture, Forestry, and Fishing is predominantly male. CO fatalities have been found to be higher among men in studies that also included non-occupational exposures [Centers for Disease Control and Prevention, 2007; Harper and Croft-Baker, 2004].

Nearly 40% of all occupational CO fatalities occurred during the winter season. CO poisonings presented in emergency departments have also been shown to be significantly higher in winter months for the general public [Partrick et al., 2009]. The colder temperatures present in winter likely resulted in attempts to enclose the work environment (with the CO source inside) from the outdoors creating an environment where CO could build up to dangerous levels. Workers may seek shelter inside a running vehicle to stay warm, wait, or sleep. In addition, the use of heaters, which is shown to be one of the top sources of CO fatalities, is predominate during the winter season and can release high amounts of CO if not functioning or ventilated properly. Among the majority of fatalities in the IMIS database where the identified CO source was a heater, OSHA's investigation concluded that the heater was malfunctioning. This underscores the need for proper maintenance and inspection of heating equipment prior to the winter season and the installation of CO detectors in indoor or confined work areas where a source of CO is present.

By region, the rate of CO fatalities was lowest in the South (0.013 per 100,000 FTEs) and surprisingly the rate for the Northeast was nearly identical at 0.014, despite the colder climate. The Midwest and West had significantly higher rates of 0.023 and 0.019, respectively. This indicates that although regional climatic differences may play a role in CO fatality rates, there are other important factors that may contribute to regional differences (e.g., prevalence of industries with CO sources).

A total of 92 (25% of total) fatalities in the years 1992–2008 occurred from motor vehicles. The subset of 92 CO-related deaths with motor vehicles as the source was further examined using narrative text. The majority of the cases (37%, n = 34) had specific mention of the decedent being poisoned by exhaust from the running vehicle while working on it, tuning up, changing oil, or tires. It was also assumed that the decedent was working on the vehicle if the narrative described the decedent as an auto mechanic or in an auto shop. The second most common scenario (34%, n = 31) was when the decedent (often a truck driver, taxi driver, laborer, or security guard) was inside a vehicle, without specific mention of working on the vehicle. It was often mentioned that the decedent was in the vehicle waiting, trying to keep warm, sleeping, or being stranded in the vehicle due to snow or a flood. The third most common circumstance (23%, n = 21) was when the death was due to being in an enclosed space in close proximity to a vehicle (without mention of working on the vehicle). These occurred often in garages (sometimes even with the garage door being found open) or in an upstairs room located above a garage. The last group of cases was considered unclassifiable and no details were provided in the narrative.

The next most frequent cause, heaters, furnaces, and boilers was responsible for 53 deaths (14% of total). A study examining the number of workers' compensation claims for CO poisoning in the state of Washington for 2000–2005 found that the most prevalent cause (45% of total) was due to forklifts [Reeb-Whitaker et al., 2010]. Our results indicate that only 2% of fatalities are caused by forklifts. This inconsistency highlights a limitation of solely analyzing fatality data, which does not include the much more frequent instances of non-fatal CO poisoning. CO poisoning from forklifts is a well-documented hazard [Fawcett et al., 1992; Ely et al., 1995; McCammon et al., 1996] and prevention should continue to be a high priority for employers. Generators, responsible for 13% of all CO fatalities, continue to be a significant hazard source. Generators are also a significant cause of CO fatalities among the public with increases in cases usually seen during and after severe weather events and natural disasters [Ernst and Zibrak, 1998; Centers for Disease Control and Prevention, 2009; Lutterloh et al., 2011].

The highest fatality rate among industry subsectors occurred in the Fishing, Hunting, and Trapping subsector. The most frequently cited source of CO poisoning in this industry subsector was "boat." CO-related fatalities in recreational boaters have been described by Silvers and Hampson [1995], who also found an increase in fatal events in winter months. There are factors present in the Fishing, Hunting, and Trapping industry subsector that may lead to a higher risk of CO fatality, such as the need for portable heating sources, work in confined spaces [e.g., boat cabin, water holding tanks [Massachusetts Department of Public Health (MDPH), 2010], work in remote locations far from medical care, and often solitary work. People working in close proximity to other workers may be more likely to seek help than are solitary workers. Additional risk factors for people that work in solitude include the difficulty of receiving safety training and the lack of safety oversight. On-the-job feedback and reinforcement of new training, and knowledge of consequences for non-conformance are considered to be critical parts in the transition from knowledge to behavior change [Quintana, 1999]. It is not known to what degree workers in this industry are trained on CO hazard recognition and mitigation, but for workers who perform many of their tasks in isolation, on-the-job feedback may be particularly difficult [Olson and Austin, 2001].

The high number of fatalities among self-employed workers and those in establishments with 10 or fewer workers, 105 and 149, respectively, suggest working alone is a significant risk factor of CO deaths. Working alone may increase the chances that a CO exposure results in a fatality because the early stages of CO poisoning, including disorientation, can inhibit the workers ability to evacuate the area or turn off equipment, thereby allowing the buildup of lethal levels of CO. If working with others, nearby workers could help in identifying signs of a dangerous work environment, and if multiple people are having the same symptoms simultaneously, this may alert workers that a dangerous health hazard is present.

Prevention

As stated previously, CO is the most frequent cause of fatalities from occupational inhalation exposure. Exposures can be controlled or minimized through education, properly maintained equipment, ventilation controls, and the use of continuous CO detectors/alarms. Education is important because even in people who are aware of the dangers of CO poisoning, preventative measures (such as appropriate placement of CO detectors, or procedures to follow once CO is detected) are not always performed properly [Rupert et al., 2013]. The National Institute for Occupational Safety and Health recommends limiting CO exposures below 35 parts per million time weighted average concentration during a work shift [National Institute for Occupational Safety and Health, 1972]. Worker training on CO needs to be provided in all workplaces where CO sources exist, especially where fuel burning motors are operated.

Suicide plays a significant role in CO-related deaths; in the general population, the proportion of non-fire related CO deaths due to suicide is approximately 64% [Cobb and Etzel, 1991]. Although much lower in the working population, the large number of intentional (suicide and homicide) CO fatalities (159, or 29% of all non-fire related occupational CO deaths) occurring at work, mostly from suicides, illustrates the need to be able to recognize early warning signs of potential suicidal tendencies among employees. This is especially true in workplaces where CO exposure exists. Inhaling CO is a well-known and commonly practiced method for committing suicide because it is viewed as a non-violent method and CO is typically readily available. Consensus warning signs for suicide developed by the American Association of Suicidology include: threatening or seeking ways to hurt or kill themselves; talking or writing about death, dying, or suicide; exhibiting hopelessness, rage, or anger; seeking revenge; acting reckless or engaging in risky activities; feeling trapped; increasing alcohol or drug use; withdrawing from friends, family, or society; anxiety; agitation; unable to sleep or sleeping all the time; dramatic changes in mood; and no sense of purpose in life [Rudd et al., 2006].

Gasoline powered engines should not be operated indoors or in partially enclosed spaces. In a matter of minutes a small gasoline powered motor running in an enclosed space can produce CO levels that are dangerous to life and health [Centers for Disease Control and Prevention, 1996]. Engines, such as generators, should be placed at a safe distance outdoors and away from air intakes to make certain exhaust is not pulled back into the work environment. The most frequent CO source was motor vehicles accounting for 25% of all CO-related fatalities. The frequency of encounters that workers have with motor vehicles in the work environment contributes greatly to this number. A study of CO deaths from motor vehicle exhaust found the majority of garage-related incidents occurred despite open garage doors [Baron et al., 1989]. Although the data used in this study did not provide enough consistent detail to properly compare the instance of closed vs. open doors, there were more anecdotal references in the fatality narratives to doors being closed than to doors being found open. Controls such as exhaust removal systems attached to the exhaust pipe and appropriate mechanical ventilation can be used to minimize buildup of CO. CO detectors that sound an alarm when CO has accumulated at dangerous levels should be installed in all work locations where motor vehicles are routinely operated. This could be particularly

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important in auto repair shops as well as auto cleaning and detailing shops. Additional prevention measures should address caution for remote workers that may seek a running vehicle to stay warm.

Although this study excluded CO fatalities due to fires from analyses, it is important to note that these fatalities compromise a significant portion of occupational CO fatalities (27%, 199 of 727 fatalities). Fires can potentially occur in any workplace, and impact on human health can be minimized with installation of smoke detectors and alarms, adequate egress, and evacuation training.

Analyses of occupational CO fatalities in IMIS indicate that for comprehensive occupational health surveillance purposes, it is inadequate. This is due largely to OSHA's limited jurisdiction which does not cover self-employed workers, certain public workers, or workers within certain industries. CFOI data is a more robust surveillance data source of fatalities because it incorporates multiple sources of information for compiling fatalities. Nonetheless, year-to-year trends were very similar between IMIS and CFOI (Fig. 1) and would therefore perform similarly to CFOI in any overall temporal analysis. OSHA data are useful when more specific information surrounding a fatal incident is needed. For instance, IMIS data were used to describe fatalities resulting from co-workers attempts to rescue fallen workers related to hydrogen sulfide exposure [Fuller and Suruda, 2000]. Each fatality appearing in OSHA's data is accompanied by an incident summary written by an OSHA officer who visited the site, conducted interviews, and investigated the circumstances involved in the fatality.

In conclusion, annual occupational CO fatalities for the study period averaged 22 (standard deviation = 8). Of the 374 fatalities, 105 (28%) were among self-employed workers and 149 of 238 fatalities with reported establishment size occurred in establishments with 1–10 employees. This suggests working alone or with few co-workers may be a significant risk factor in CO-related fatalities. Fatalities attributable to motor vehicles as the CO source accounted for 92 (25%) of the fatalities, suggesting more education of workers and further research is needed to reduce these numbers. The highest fatality rate among NAICS industry subsectors was within the Fishing, Hunting, and Trapping subsector at 0.796 per 100,000 FTEs, which was almost 47 times the all-industry average rate of 0.017 per 100,000 FTEs.

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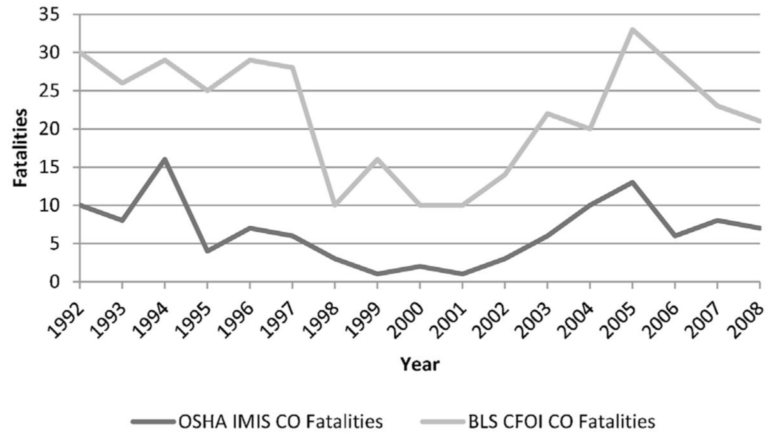

FIGURE 1.

Annual occupational CO fatalities reported in BLS' CFOI (n = 374) and OSHA's IMIS (n = 111), 1992–2008. *Note*: Counts generated by the authors with restricted access to BLS CFOI data. The views expressed here do not necessarily reflect the views of the BLS.

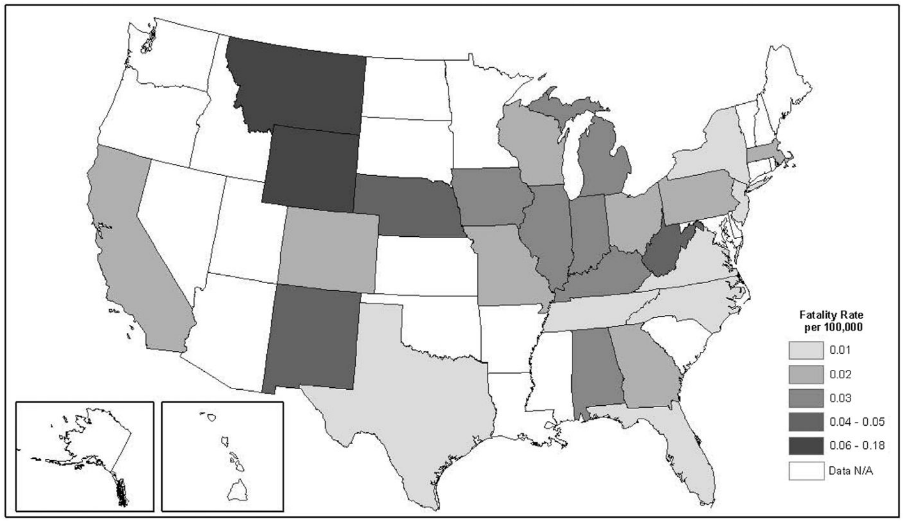

FIGURE 2.

Rate of CO fatalities per100,000 FTEs by state reported in BLS' CFOI (n = 372), 1992–2008. *Note*: Rates generated by the authors with restricted access to BLS CFOI data. The views expressed here do not necessarily reflect the views of the BLS.

TABLE I

Occupational CO Fatalities by NORA Sector Reported in BLS' CFOI (n = 374) and OSHA's IMIS (n = 111), 1992–2008

NORA sector	FTEs in100,000s	CFOI fatalities (%)	CFOI fatality rate per100,000 FTEs	IMIS fatalities (%)
Agriculture, Forestry, & Fishing	540	47 (13)	0.087	5 (5)
Construction	1,601	94 (25)	0.059	29 (26)
Health Care & Social Assistance[a]	2,483	6 (2)	0.002	0 (0)
Manufacturing	3,378	37 (10)	0.011	30 (27)
Mining, Oil & Gas Extraction	126	17(5)	0.135	7 (6)
Services, including public safety	8,831	114 (30)	0.013	26 (23)
Transportation,Warehousing, & Utilities	1,276	20 (5)	0.016	6 (5)
Wholesale & Retail Trade	3,958	33 (9)	0.008	8 (7)
Unknown	N/A	6 (2)	N/A	0 (0)
Total	22,194	374 (100)	0.017	111 (100)

Counts and rates generated by the authors with restricted access to BLS CFOI data. The views expressed here do not necessarily reflect the views of the BLS.

[a]Veterinary services were included in the "services, including public safety" category as corresponding employment data (current population survey) were not available for years1992–2002.

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TABLE II

Top10 Occupational CO Fatality Rates by Industry Reported in BLS' CFOI (n = 374), 1992–2008

NAICS industry subsector	FTEs in100,000s	CFOI fatalities (%) of total CO fatalities	Fatalities per100,000 FTEs	Rank
Fishing, hunting, and trapping	11	9 (2)	0.796	1
Automotive repair and maintenance	218	33 (9)	0.151	2
Mining and support activities for mining	74	10 (3)	0.135	3
Oil and gas extraction	52	7 (2)	0.135	4
Iron and steel mills and steel product mfg	77	9 (2)	0.117	5
Services to buildings and dwellings	146	15 (4)	0.103	6
Crop production	165	16 (4)	0.097	7
Animal production	212	17 (5)	0.080	8
Investigation and security services	107	8 (2)	0.075	9
Chemicals and allied products	81	6 (2)	0.075	10
All NAICS industry subsectors	22,194	374 (100)	0.017	

Counts and rates generated by the authors with restricted access to BLS CFOI data. The views expressed here do not necessarily reflect the views of the BLS.

TABLE III

Occupational CO Fatalities by State Reported in BLS' CFOI (n = 374), 1992–2008

State	FTEs in 100,000s	CFOI fatalities (%)	Rate per 100,000 FTEs	Rank
Wyoming	44	8 (2)	0.183	1
Montana	73	9 (2)	0.124	2
New Mexico	133	7 (2)	0.053	3
West Virginia	123	6 (2)	0.049	4
Nebraska	154	6 (2)	0.039	5
Iowa	258	8 (2)	0.031	6
Alabama	338	10 (3)	0.030	7
Kentucky	303	9 (2)	0.030	7
Illinois	988	26 (7)	0.026	9
Indiana	498	13 (3)	0.026	9
Michigan	767	19 (5)	0.025	11
Missouri	462	11 (3)	0.024	12
Wisconsin	468	11 (3)	0.024	12
Ohio	896	18 (5)	0.020	14
Colorado	370	7 (2)	0.019	15
California	2,591	45 (12)	0.017	16
Pennsylvania	937	16 (4)	0.017	16
Massachusetts	507	8 (2)	0.016	18
Georgia	670	10 (3)	0.015	19
New York[a]	1,389	19 (8)	0.014	20
Tennessee	447	6 (2)	0.013	21
New Jersey	664	8 (2)	0.012	22
Virginia	590	7 (2)	0.012	22
Texas	1,679	19 (5)	0.011	24
North Carolina	635	6 (2)	0.009	25
Florida	1,242	10 (3)	0.008	26
All other states	4,968	52 (14)	0.010	
Total	22,194	374 (100)	0.017	1–50

Counts and rates generated by the authors with restricted access to BLS CFOI data. The views expressed here do not necessarily reflect the views of the BLS.

[a]Data for NewYork City were only available for 2003–2008.

TABLE IV

Characteristics of Occupational CO Fatalities Reported in BLS' CFOI (n = 374), 1992–2008

	FTEs in100,000s	CFOI fatalities (%)	Rate per100,000 FTEs	Rate ratio
Age category[a]				
20–24	2,027	24 (6)	0.012	1.0
25–34	5,390	69 (18)	0.013	1.1
35–44	6,075	100 (27)	0.016	1.4
45–54	5,049	95 (25)	0.019	1.6*
55–64	2,429	48 (13)	0.020	1.6*
≥65	547	32 (9)	0.059	4.9**
Sex				
Female	9,338	17 (5)	0.002	1.0
Male	12,855	357 (95)	0.029	16.0**
Race				
White	18,625	303 (81)	0.016	1.0
Black or African American	2,381	44 (12)	0.018	1.1
Other	1,188	19 (5)	0.016	1.0
Not reported	N/A	8 (2)	N/A	
Hispanic origin[b]				
Not Hispanic	17,611	300 (80)	0.017	1.0
Hispanic	2,267	53 (14)	0.023	1.4*
Not reported	N/A	21 (6)	N/A	
Region				
South	7,887	101 (27)	0.013	1.0
Northeast	4,114	58 (16)	0.014	1.1
Midwest	5,271	123 (33)	0.023	1.8**
West	4,923	92 (25)	0.019	1.5**
Season				
Summer	5,481	64 (17)	0.012	1.0
Fall	5,627	75 (20)	0.013	1.1
Winter	5,521	147 (39)	0.027	2.3**
Spring	5,565	88 (24)	0.016	1.4
Total	22,194	374 (100)	0.017	

Counts and rates generated by the authors with restricted access to BLS CFOI data. The views expressed here do not necessarily reflect the views of the BLS.

[a]Values do not sum to total because age less than 20 and age not reported were deleted as they do not meet Bureau of Labor Statistics reporting criteria.

[b]Hispanic rate is from1994 to 2008 as employment data for ethnicity were only available since1994.

*$P < 0.05$.

**$P < 0.01$.

TABLE V

Sources of Occupational CO Fatalities Reported in BLS' CFOI (n = 374), 1992–2008

CO source	CFOI fatalities (%)
Motor vehicle	92 (25)
Furnaces, heaters, boilers	53 (14)
Generators	48 (13)
Heating and cooking machinery and appliances	14 (4)
Powered tools	13 (3)
Boats	12 (3)
Pumps	12 (3)
Tractor	9 (2)
Forklift	9 (2)
Air compressors	8 (2)
Tanks, bins, vats	8 (2)
Engines, turbines, except vehicle	7 (2)
Mines, caves, tunnels	5 (1)
Other	59 (16)
Missing	25 (6)

Counts generated by the authors with restricted access to BLS CFOI data. The views expressed here do not necessarily reflect the views of the BLS.

TABLE VI

Occupational CO Fatalities by Establishment Size and Employee Status Reported in BLS' CFOI (n = 374), 1992–2008

	CFOI fatalities (%)
Establishment size	
1–10 employees	149 (40)
11–99 employees	39 (11)
100+employees	50 (13)
Not reported	136 (36)
Employee status[a]	
Self employed	105 (28)
Work in family business	11 (3)
Work for compensation, including volunteers	253 (67)

Counts generated by the authors with restricted access to BLS CFOI data. The views expressed here do not necessarily reflect the views of the BLS.

[a]Values do not sum to total because active duty armed forces and not reported were deleted as they do not meet Bureau of Labor Statistics reporting criteria.