

Appendices: Research and References

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- Appendix A: CO Poisoning Scenarios and At-Risk Populations
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- Appendix D: Formative Research on Winter Storm CO Poisonings
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Appendix A: CO Poisoning Scenarios and At-Risk Populations

RTI International conducted a review of the literature on unintentional carbon monoxide (CO) poisoning through a contract with the U.S. Centers for Disease Control and Prevention (CDC). This review, conducted in 2008, identified epidemiological, behavioral, and prevention information on unintentional CO poisoning to inform the design and development of CO poisoning prevention activities. In conducting this review, we examined published research studies, newspaper articles, and consumer-oriented materials concerning unintentional CO poisoning.

The literature review had two primary objectives:

Objective 1: Identify epidemiological and/or case data that help in targeting groups in the English-speaking U.S. population that are at greater risk for CO poisoning and that suggest potential audience segments for targeted CO poisoning prevention activities.

Objective 2: Identify existing materials, campaigns, and strategies that have been proven to be successful in preventing CO poisoning.

Summary of Review Methods

In identifying literature for this review, RTI staff used rigorous library science techniques, including the use of Boolean search algorithms based on well-defined keywords, to search leading scientific and public health article databases. In addition to the systematic literature search, RTI staff conducted more focused searches using Internet search engines (e.g., Google, Yahoo!). The purpose of these searches was to identify information or materials from additional sources not traditionally included in academic resources.

Summary of Search Results

After RTI project staff identified relevant articles, we reviewed each of the collected abstracts and articles to identify categories of information available on unintentional CO poisoning. This initial review focused on organizing journal articles into like categories and resulted in identifying three main categories of articles relating to epidemiology, prevention, and medical care. These categories are not mutually exclusive, but rather an attempt to organize each article based on its primary content. Following this sorting, we re-reviewed the articles in each of the main categories and, when appropriate, divided them further into subcategories based on specific content.

Summary of Articles by Category

After RTI staff organized the articles, we reviewed and summarized the major content of the articles in the categories of epidemiology and prevention. Consistent with the objectives outlined for this review, we excluded the medical care articles from further review.

General Epidemiology

Dubbed the silent killer for its lack of odor and color, CO is a by-product emitted from fuel-burning devices as a result of the incomplete combustion of fossil fuels. Common CO-emitting devices include many household appliances, such as gas-burning furnaces, gas stoves, hot

water heaters, and kerosene heaters, as well as other items found around homes, such as portable generators, charcoal and gas grills, and automobiles.

Information Available on CO Poisoning in the United States

The United States does not have a comprehensive national system of CO surveillance, and only a limited number of states and territories regularly report CO deaths and injuries (Graber et al., 2007). Research on deaths and injuries related to consumer products is one of the main sources of information on CO poisoning in the United States. National estimates of annual deaths and injuries from CO poisoning are established using a combination of information from the Consumer Product Safety Commission's (CPSC's) National Electronic Injury Surveillance System All Injury Program (NEISS-AIP) and the National Vital Statistics System (NVSS) (CDC, 2005c).

The lack of comprehensive surveillance contributes to gaps in our understanding of the distribution of CO-related injuries and deaths. In terms of prevention, this also limits our ability to effectively identify and target groups at greater risk for CO poisoning. Further, a lack of surveillance at local, state, and national levels diminishes our ability to evaluate potential prevention programs (Graber et al., 2007).

Annual Cases of CO Poisoning in the United States

CO is the leading cause of poison-related deaths in the United States. Between 1999 and 2004, at least 439 persons died each year from unintentional, nonfire-related CO exposure, 16 percent of all the CO deaths in the United States (CDC, 2007). Estimates of annual emergency room visits for treatment from exposure to CO gas range from 15,000 to 50,000 individual visits (CDC, 2005c; Hampson & Weaver, 2007).

Rates of CO poisoning vary primarily by demographic subgroup, month of the year, and state. Rates were highest among adults aged 65 years or older, men, whites, and African Americans. The higher rate in men has been attributed to high-risk behaviors among men, such as working with fuel-burning tools or appliances. The average number of deaths was highest during January. For the most part, states with elevated death rates were in the West or Midwest (CDC, 2007).

A 2002 study suggests that CO-related deaths have been declining over the past 2 decades (Mott et al., 2002). Significant to this decline is the reduction of mortality related to automobile exposure, attributed in part to better automobile emission technology. However, some sources indicate that in recent years the number of nonfatal poisonings has not changed significantly (Hampson, 2005).

Findings from seven studies that report on CO poisoning at the state level, for the most part, support our understanding of the major trends in CO poisoning, suggesting seasonal and environmental conditions as significant influences in the rate and incidence of CO poisonings. In addition, several suggest alcohol consumption as a potential factor for individuals' risk.

Social and Behavioral Risks

A number of different products and scenarios cause CO poisoning every year. However, because there is no comprehensive surveillance system for CO exposures, no one source can

depict which products, situations, and behaviors are most likely to trigger these poisonings or which populations are most likely to be affected.

Most unintentional poisonings (64 percent) occur in residential homes and garages, with a smaller percentage (21 percent to 23 percent) occurring in occupational settings or other public areas (Graber et al., 2007; CDC, 2005c). Poisonings are most likely to occur during fall and winter, and CO death rates are highest in western and midwestern states (Graber et al., 2007; Moolenaar, 1995).

Table 1 shows the percentage of poisonings associated with each of the leading devices associated with CO poisonings. Regardless of geography or setting, faulty furnaces and motor vehicles are by far the products most responsible for CO death and poisoning. These two products often alternate as the leading cause of death or poisoning (depending on the study setting and population), but furnaces are generally the leading cause of nonfatal poisoning and the second leading cause of CO death (CDC, 2005c; Scheerer & Struttman, 2002; Clifton et al., 2001; Cook, 1995). Conversely, most studies show that motor vehicle poisonings are the leading cause of CO death and the second most common cause of nonfatal poisoning (CDC, 2005c; Yoon et al., 1998; Cook, 1995; Moolenaar, 1995; CDC, 1992).

Table 1. Leading Causes of Nonfatal, Nonfire-Related CO Poisoning

CO Source	Percentage of Poisonings	Percentage of Poisonings (Excluding Unknown Sources)
Furnace	19%	32%
Motor vehicle	9%	16%
Stove (gas)	5%	9%
Gas line leak	5%	9%
Water heater (gas)	4%	7%
Generator	3%	5%
Portable/space heater	2%	3%
Machinery	1%	3%
Other	9%	16%
Unknown	43%	—

Source: CDC, 2005c.

Yet several other products are also responsible for CO poisoning. Home appliances, such as stoves, water heaters, and grills, cause a number of residential poisonings every year (CDC, 2005c; Bizovi et al., 1998; Howell et al., 1997). Gasoline-powered forklifts, saws, and pressure washers are the most common causes of occupational poisoning (Lofgren, 2002a; Hawkes et al., 1998; Ely et al., 1995). Even boats, houseboats, and airplanes are responsible for CO poisoning in recreational settings (CDC, 2004a; Earnest et al., 2002; Zelnick et al., 2002; Silvers & Hampson, 1995).

Despite the range of products that cause CO poisoning, there are clear patterns of exposure and risk behavior. First, CO poisonings can be segmented into either emergency or nonemergency situations. Emergency situations include hurricanes, tornados, ice storms, floods, and other severe weather events that cause destruction and power outages. Under these circumstances, CO poisoning is likely to be caused by generators, portable heaters, chainsaws, and other devices used for power, heat, and debris removal. Conversely, in nonemergency situations, poisoning is more likely to be caused by faulty appliances, motor vehicles, and occupational tools. Second, CO poisonings can be segmented into specific scenarios relating to season of use and setting or devices used—scenarios that differ in behaviors that cause CO exposure. When put together, these factors suggest unique pathways to exposure. The existing research suggests the existence of six main scenarios in which CO poisoning occurs (Table 2).

Table 2. Main CO Poisoning Scenarios

Type	Season	Setting/Device
Nonemergency	Fall/winter	Residential
Nonemergency	Winter	Motor vehicle usage
Nonemergency	Year-round	Occupational activity
Nonemergency	Year-round	Recreational activity
Emergency—Storms	Summer	Power outage
Emergency—Storms	Fall/winter	Heating and power outage

The remainder of this section explores each scenario by describing the products that lead to CO exposure, the circumstances that place individuals at risk, and the populations most likely to be poisoned.

Nonemergency Poisonings: Winter—Residential

Residential settings, including homes, apartments, mobile home/trailers, hotels, and resorts, are the most common location for CO poisonings (CDC, 2005c; Scheerer & Struttman, 2002). Almost one-third (33 percent) of residential poisonings occur in single-family homes, with multiunit homes (27 percent) and cabins/tents (23 percent) being slightly less common locations (Clifton et al., 2001; Liu et al., 2000). CO poisonings also occur in hotels, motels, and resorts, although these settings account for only 3 percent of such poisonings (Clifton et al., 2001). Despite single-family homes being the most common location for residential poisonings, individuals living in multiunit homes are actually at higher risk. The relative risk for multiunit poisonings is twice that of single-family homes (Liu et al., 2000). Residential poisonings are also more likely to occur during the winter months (December—February), and almost half (49 percent) of residents are asleep at the time of poisoning (Scheerer & Struttman, 2002; Yoon et al., 1998).

One of the main reasons that poisonings are more likely to occur in the winter months is the number of CO poisonings that result from home heating systems. Faulty furnaces and heating systems account for almost all residential poisonings—fatal and nonfatal alike (Scheerer &

Struttman, 2002; Liu et al., 2000). More than 85 percent of all households in the United States use natural gas, oil, or wood to power their heating systems, as opposed to electric fuel, indicating that a majority of households are at potential risk for CO exposure (Runyan et al., 2005). Upper-income homes, single-family homes, and owner-occupied homes are most likely to use gas and wood heat (Runyan et al., 2005). Different geographic regions are also more likely to use different heating fuels: oil fuel is more common in New England (37 percent), electric heat is most common in the South (54 percent), and natural gas is most prevalent elsewhere (Runyan et al., 2005). Nevertheless, all geographic areas have a substantial number of households that use fossil fuel-burning furnaces.

Aside from furnaces and heating systems, common causes of residential CO poisoning are blocked chimneys, water heaters, stoves and ovens, and grills (Clifton et al., 2001). These products account for approximately 15 percent of residential poisonings, with water heaters, stoves, and ovens the most likely sources (Clifton et al., 2001; Bizovi et al., 1998; Howell et al., 1997).

Nonemergency Poisonings: Winter—Motor Vehicles

Although motor vehicle CO deaths have declined steadily since 1975 following the addition of catalytic converters, automobiles, trucks, and other vehicles still account for 40 percent to 55 percent of all CO deaths (Mott et al., 2002; Yoon et al., 1998; Cook, 1995; Moolenaar, 1995). In fact, motor vehicles are generally shown to be the leading cause of unintentional CO death and the second most common cause of unintentional, nonfatal CO poisoning (CDC, 2005c; Cook, 1995; CDC, 1992). These findings suggest that motor vehicle exposures may be more likely to be fatal than residential poisonings from furnaces and appliances. Older cars, especially pre-1975 vehicles without catalytic converters, are more likely to be involved in CO deaths (Marr et al., 1998).

Motor vehicle poisonings also can take place in nontraditional vehicles, such as mobile trailers, recreational vehicles (RVs), and campers (Liu et al., 2000). When used in garages and carports, motor vehicles can poison individuals in homes and residences, accounting for up to 20 percent of in-home CO detectors sounding (Bizovi et al., 1998). Distinguishing between residential and motor vehicle poisonings is difficult when the motor vehicle poisonings occur at a residence. Nevertheless, in most cases where vehicles emit fumes into a home or where vehicles serve as residences, the source of CO is categorized as “motor vehicle.”

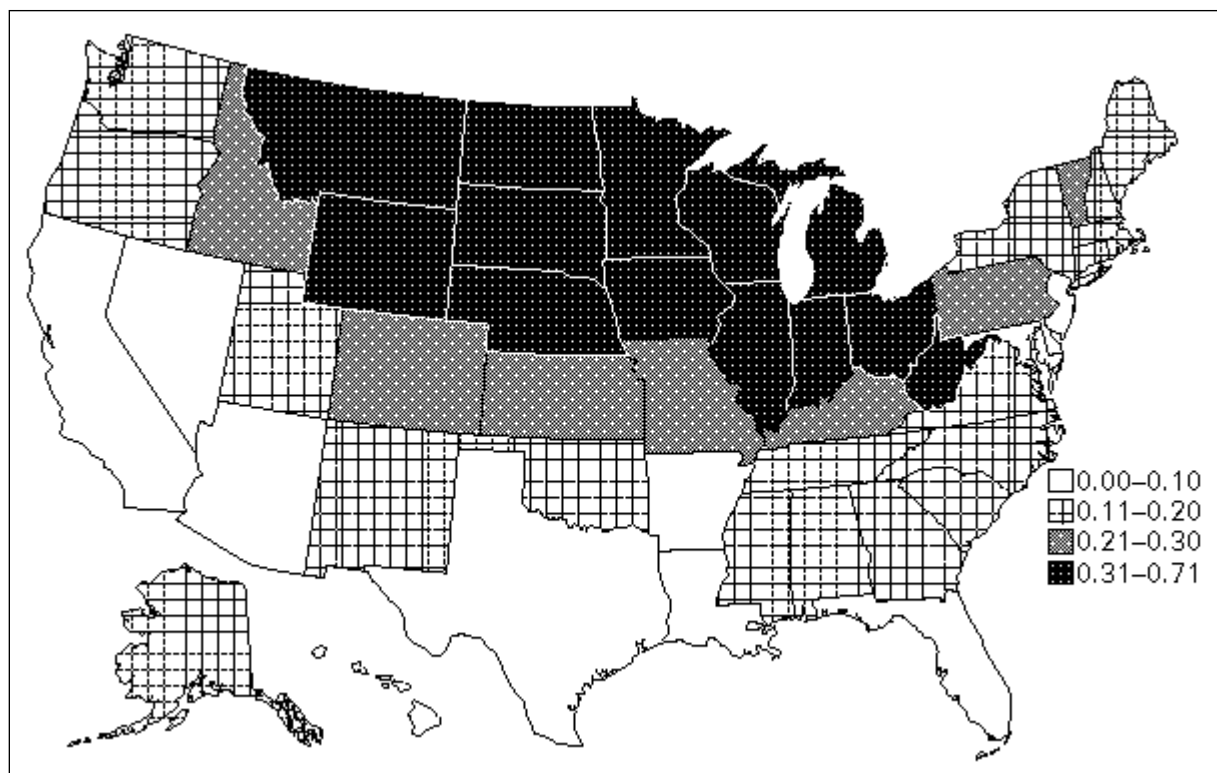
There are generally three types of motor vehicle-related CO poisoning (CDC, 1996c). First, individuals can operate a vehicle with both a faulty exhaust system, which emits too much CO, and a poorly ventilated passenger compartment, which traps CO in the vehicle. Second, individuals can operate a vehicle in an enclosed space, such as a garage or carport. Finally, individuals can use a portable heater in a vehicle, usually a camper or mobile home.

Faulty exhaust systems are the leading cause of vehicle poisonings (46 percent to 62 percent), and running vehicles in enclosed spaces (39 percent) and using heaters in vehicles (18 percent) are less common causes (CDC, 1996c; Baron, 1989). Surprisingly, the vast majority of motor vehicle CO deaths (81 percent) occur in outdoor settings, such as roadside rest stops, in empty parking lots, or outside residences (Baron, 1989). Of those that did occur in enclosed garages, the main garage door was open in almost half (42 percent) of the cases (Baron, 1989).

At the time of fatal poisoning, more than 95 percent of vehicles are stationary. With the exceptions of being stuck or being repaired in garages (4 percent and 6 percent, respectively), almost all of these vehicles are stationary while couples romance (23 percent) or while individuals drink alcohol (62 percent) (Baron, 1989).

As with residential poisonings, motor vehicle poisonings are most likely to occur during winter months, and death rates are highest in western and northern states (see Figure 1) (CDC, 1996c; CDC, 1992). Research also suggests that children, young adults, elderly individuals, whites, and Native Americans are most at risk for vehicle poisoning; however, other studies do not show these same trends (Mendoza & Hampson, 2006; Ralston & Hampson, 2000).

Figure 1. Death Rates (per 100,000 Population) by State for Unintentional Motor Vehicle-Related CO Poisonings



Source: CDC Morbidity and Mortality Weekly Report, November 29, 1996.

While reports are only anecdotal at this point, a new concern for motor vehicle poisoning is the increasing availability of remote control starter systems for cars. If used in unventilated settings, there is the potential for increased CO exposure.

Nonemergency: Year-Round—Occupational Poisonings

Almost 25 percent of all CO poisonings occur in the workplace, although these occupational poisonings may be declining slowly (Graber et al., 2007; Lofgren, 2002a). Forklifts, motor vehicles, furnaces, and gasoline-powered tools are the most common causes of occupational poisoning, and individuals in certain industries, such as agriculture, construction, and wholesale

trade, are more often affected (Erdogan et al., 2004; Lofgren, 2002a). Occupational CO poisonings occur because of workers' close contact with gasoline-powered engines and tools, often in enclosed warehouses or storage facilities that may not be well ventilated (Earnest et al., 1997).

Forklifts

Forklifts cause the majority of CO poisonings in the wholesale trade, agriculture, and manufacturing industries, and fruit packing and storage workers had the highest number of poisonings caused by forklifts (Lofgren, 2002a). Gasoline- and propane-powered forklifts are by far the most common cause (42 percent) of occupational CO poisoning and air quality violations (Lofgren, 2002a; 2002b). Injuries from using forklifts mostly occur in warehouses and enclosed spaces when forklift drivers or other workers are exposed to fumes from the machine (CDC, 1997; Ely et al., 1995). Cold rooms, such as refrigerated and freezer rooms, were also a risk factor, with a large number of forklift poisonings occurring in these settings (Lofgren, 2002a).

Motor Vehicles

Motor vehicles, including trucks, vans, buses, and cars, are the second most common source of occupational CO poisoning (Lofgren, 2002a; 2002b). These vehicles account for more than 20 percent of occupational poisonings, and CO poisoning by vehicle occurs in several different industries (Lofgren, 2002a). In many cases, exhaust leaks into the passenger compartment are responsible for the poisoning. However, working in close proximity to idling or running vehicles also can be dangerous.

Unsurprisingly, motor vehicles are the leading cause of poisoning in the transportation industry, and they are a leading cause in the services, wholesale trade, and retail trade areas (Lofgren, 2002a). The type of vehicle responsible for CO poisoning tends to vary by industry. Tractors are often responsible for poisonings in agriculture, while trucks, buses, and cars dominate in the transportation, wholesale, and retail industries (Lofgren, 2002a; CDC, 1997).

Gasoline-Powered Tools

Concrete saws are the most frequent source of nonvehicle poisonings in the workplace (Hawkes et al., 1998). Although few studies have examined risk behaviors and use of concrete saws, these saws are used most frequently in construction and cause very few poisonings in other industries (Lofgren, 2002a). Almost all concrete saw poisonings occur in enclosed spaces (Hawkes et al., 1998). In most cases, construction workers use the wheelbarrow-sized saws to cut concrete or brick in partially constructed buildings. The level of exhaust from concrete saws can cause more severe CO poisoning in shorter time periods compared to other gasoline-powered equipment (Hawkes et al., 1998).

Finally, several other types of equipment can cause occupational CO poisoning. Pressure washers used in enclosed areas, such as barns, parking garages, and warehouses, have been linked to fatal CO poisoning (CDC, 1995a; CDC, 1993b). Portable heaters, compressors, insulation blowers, and ovens cause poisoning in several different industries (Lofgren, 2002a). Explosives used in blasting and construction projects can even cause poisoning by sending CO through soil into manholes and other structures (Deitchman, 1998). Although poisonings from these sources are less common than forklifts, motor vehicles, and saws, they still account for almost 30 percent of occupational poisonings (Lofgren, 2002a).

Non-emergency: Year-Round—Recreational Poisonings

A small percentage of CO poisonings (8 percent to 10 percent) occur during recreational and vacation activities (CDC, 2000a; Silvers & Hampson, 1995). The most common locations for recreational poisonings are houseboats, boats, and airplanes, and these poisonings usually occur when individuals are overwhelmed by exhaust from these vehicles (Zelnick et al., 2002; CDC, 2000a; Silvers & Hampson, 1995).

Houseboat poisonings account for the majority of recreational poisonings and for 67 percent of all boat poisonings (Earnest et al., 2002). In general, these poisonings occur on boats with side exhaust pipes (rather than vertical exhaust stacks) that pump CO into the cabin and sleeping quarters (Hammond et al., 2006). Exhaust pipes are not necessarily blocked during poisonings; CO can seep in because numerous boats congregate in one area or because the fumes naturally drift back toward the cabin (CDC, 2004a; CDC, 2000a).

Motorboats account for the remaining boat poisonings and usually affect swimmers, water skiers, or sunbathers who spend time on the rear boat deck or in the path of motor exhaust (Earnest et al., 2002; Silvers & Hampson, 1995). Individuals who are next to exhaust pipes can collapse within minutes, and many victims drown while unconscious (CDC, 2004a). Most motor boat poisonings occur on boats that are 10 years or older, have enclosed cabins, and are longer than 22 feet (Silvers & Hampson, 1995). Almost all boat poisoning victims—motorboat and houseboat alike—are white (Ralston & Hampson, 2000).

Finally, private airplanes and jets can cause CO poisoning (Zelnick et al., 2002). In these cases, CO enters the cockpit or cabin because of improperly working exhaust systems. Poisonings are most common on single-engine aircraft and on planes that heat the cabin by passing air over the exhaust manifold (Zelnick et al., 2002).

Emergency: Summer Storms—Power Outage

Summer storms and emergency scenarios account for a small but predictable number of CO poisonings. In these conditions (hurricanes, tornados, and floods), individuals are often poisoned by products that provide electrical power or clean up debris, and poisonings peak within 2 to 3 days of storms. Hurricanes, tornados, and floods are major risk factors for summer poisonings because they cause power outages and severely damage property (Van Sickle et al., 2007; McVay, 2007; CDC, 2006a; CDC, 2005b; Daley et al., 2001). Such power outages lead to portable generator use, and property damage leads to using chainsaws, pressure washers, and other gasoline-powered tools for restoration.

Power outages and generator use, in particular, are often widespread following summer storms. Following the 2004 Florida hurricane season, more than 18 percent of households reported using generators, and every CO poisoning victim reported losing power after the hurricanes hit (Van Sickle et al., 2007; CDC, 2005b). Sales of generators have also been increasing steadily since 2000, and individuals use these products to power items ranging from refrigerators (86 percent) to televisions (49 percent) to air conditioners (46 percent) (Van Sickle et al., 2007; CDC, 2005b).

Generators

Portable generators cause almost all fatal and nonfatal CO poisonings in summer storm scenarios, especially during hurricanes (Van Sickle et al., 2007; CDC, 2006a; CDC, 2005a).

Because generators emit CO when running, placing the products indoors near air conditioners or near individuals can result in poisoning. This type of misplacement—as opposed to product malfunctions—is responsible for almost all generator poisonings (Cukor & Restuccia, 2007; CDC, 2005a).

Surprisingly, most generator poisonings (62 percent to 64 percent) are caused by generators located outside the home (Cukor & Restuccia, 2007; Van Sickle et al., 2007). However, studies show that such generators are often located only about 7 feet from the house, near air conditioners, windows, and other air intake routes (Cukor & Restuccia, 2007; Van Sickle et al., 2007; CDC, 2006a). Even when individuals do place generators outdoors, more than half place the still-running generators indoors or in garages overnight (Cukor & Restuccia, 2007). The remaining generator poisonings are caused by generators located inside garages or carports (33 percent), inside the home (15 percent), or in sheds and basements (Van Sickle et al., 2007; CDC, 2005b). Of those households that place generators in garages, more than 60 percent close the garage door (Van Sickle et al., 2007).

These locations are not random choices. Most individuals choose generator locations based on concerns about theft, concerns about exhaust, the need to power air conditioners and electric panels, length of extension cords, desire to protect the generator from weather, and noise concerns (Van Sickle et al., 2007; CDC, 2006a). Almost all placement decisions (89 percent) are made by male household members (Van Sickle et al., 2007).

In contrast to motor vehicle and residential poisonings, generator poisonings are most likely to occur during summer and fall months and to take place in coastal states, where hurricanes are more likely, such as Texas, Louisiana, Alabama, Florida, South Carolina, and North Carolina (Van Sickle et al., 2007; CDC, 2006a; CDC, 2005a).

Poisonings are also most likely to occur overnight, and most victims have never owned or operated a generator prior to the storm (Van Sickle et al., 2007; CDC, 2005b). Hispanics and blacks are more likely to be poisoned than whites, and more than 20 percent of victims do not speak English as their primary language (Van Sickle et al., 2007; CDC, 2005b).

However, several factors suggest outlets for preventing generator poisonings. Most victims (66 percent) purchase generators from large home improvement stores or discount retailers (Van Sickle et al., 2007). The vast majority of victims do not own CO detectors, and those who heard CO prevention messages were twice as likely to place generators outside the home (Van Sickle et al., 2007; CDC, March 10, 2006a).

Pressure Washers and Other Tools

While generators account for the overwhelming majority of summer storm and emergency poisonings, several other tools are also responsible. Pressure washers and chainsaws cause CO poisoning following floods, tornados, and other storms that damage property (McVay, 2007; Daley et al., 2001). Most of these poisonings result from using the gasoline-powered tools indoors or in partially enclosed areas because of inadequate hose length or weather concerns (Daley et al., 2001). As with generators, men are more likely than women to be poisoned by these tools (Daley et al., 2001; CDC, 1993a).

Emergency: Winter Storms—Heating and Power Outages

As with summer storms, winter storms and emergency scenarios cause a small but significant number of CO poisonings (Ghim & Severance, 2004; CDC, March 12, 2004c). Unlike summer storms, however, winter storm poisonings are attributable to a number of different causes and can especially impact minority or non-English speaking residents. Winter ice and snow storms often cause power outages, which is a major risk factor for CO poisoning from generators (Hampson, 2006; CDC, March 12, 2004c; Daley et al., 2000). When winter storms knock out power, residents turn to alternative heat sources that emit CO, including charcoal briquettes, gas grills, portable heaters, and motor vehicles (Daley et al., 2000; Liu et al., 2000; Hampson et al., 1994).

No study has estimated the proportion of CO deaths and poisonings attributable to winter storm scenarios. Nevertheless, studies show that these events poison hundreds of individuals and that CO is the leading cause of injury during ice storms (Broder et al., 2005; Ghim & Severance, 2004; CDC, 2004c). Most poisonings occur in homes—more than 90 percent without CO detectors—and happen within the first week of power loss (CDC, 2004c; Daley et al., 2000).

Generators

Approximately 30 percent of households can rely on generators after winter storms, and portable generators are one of two leading causes of winter storm poisonings (Lin & Conners, 2005; Daley et al., 2000; Wrenn, 1997). Specifically, generators cause 40 percent to 70 percent of CO poisonings, and CO death rates from winter generator use have remained steady (Hampson & Zmaeff, 2005; Daley et al., 2000; Houck & Hampson, 1997; Wrenn, 1997).

In most poisonings, generators are used when electrical power is disrupted, and the generators are placed indoors, in garages, and in basements (Hampson & Zmaeff, 2005; Daley et al., 2000). In contrast to summer storms, almost all individuals poisoned by generators during winter storms are white (Houck & Hampson, 1997).

Charcoal/Grills

Charcoal briquettes, hibachis, and stand-alone grills are the other leading cause of winter storm poisonings, accounting for approximately 54 percent of poisonings during winter storms and 16 percent of all CO poisonings (Liu et al., 2000; Houck & Hampson, 1997; Wrenn, 1997; Liu et al., 1993). Charcoal and grill poisonings occur mostly during winter power outages; individuals use the products to provide heat and cook meals when home heating systems and appliances stop functioning (Liu et al., 2000; Hampson et al., 1994). In most cases, individuals burn charcoal or operate grills indoors or in attached garages (Hampson, personal communication, 2007; Lin & Conners, 2005).

The majority of charcoal and grill poisonings occur during winter months and in regions that are hit by ice and snow storms—the Northwest, Plains, Midwest, and New England (Hampson et al., 1994). Surprisingly, almost half of charcoal CO deaths take place in vehicles, such as RVs, campers, and mobile homes, when individuals use the products for supplemental heat (Liu et al., 1993).

Charcoal and grill poisonings occur almost exclusively among ethnic and racial minorities. Between 85 percent to 100 percent of charcoal poisoning victims are minorities, and Asians, blacks, and Hispanics all have elevated risks for charcoal and grill poisonings compared to

whites (Mendoza & Hampson, 2006; Ralston & Hampson, 2000; Houck & Hampson, 1997; Hampson et al., 1994; Liu et al., 1993; CDC, 1993a). More important, more than half of these poisoning victims do not speak English (Houck & Hampson, 1997; Wrenn, 1997). One expert explained that some minority ethnic groups, Asians and Africans in particular, use charcoal as a primary heat source and live in generally open-air homes in their countries of origin. When these individuals emigrate to the United States, many continue to use charcoal as a heat source, despite living in closed and less-ventilated homes (Hampson, personal communication, 2007).

Portable Heaters

Kerosene and propane heaters cause approximately 30 percent of winter storm poisonings, yet little research has documented risk behaviors or misuse of the products during emergency scenarios (Daley et al., 2000; Yoon et al., 1998; Wrenn, 1997). As with charcoal, individuals use the portable heaters during power outages to heat homes, shelters, and vehicles. Since most heaters are designed for camping or open-air environments, using the heaters in enclosed areas can lead to poisoning. Compared with furnaces and other residential sources of CO, portable heaters carry an extremely high relative risk of poisoning (Liu et al., 2000). Most portable heater poisonings occur among whites, and males are also more likely to be poisoned by these products (Ralston & Hampson, 2000).

Motor Vehicles

Although the majority of motor vehicle poisonings occur in nonemergency situations, a small percentage is associated with winter snow storms (CDC, 1996b). Most of these poisonings occur while attempting to clear snow from around idling automobiles (CDC, 1996b). While some individuals clear the snow, others rest in the heated car and are exposed to CO because of snow-obstructed tailpipes. One study suggests that children and elderly individuals are most likely to be poisoned by CO from motor vehicles during winter storms, perhaps because these individuals are more likely to sit in the vehicles and less likely to clear snow from around them (CDC, 1996b).

CO Poisoning Prevention

Prevention strategies for CO poisoning fall into two major categories: primary prevention and secondary prevention. Primary prevention efforts seek to avert situations that are likely to cause CO poisoning through either technological solutions or consumer education. Secondary prevention refers to efforts to mitigate the harm done when primary prevention strategies fail and CO conditions exist. For example, CO detectors can warn people when dangerous levels of CO levels are present so that they can evacuate the area.

Primary Prevention

We identified two strategies for primary prevention: technological solutions and consumer education.

Technological Solutions

Technological solutions are efforts to change or modify CO-emitting devices to reduce the risk of potential CO exposure. For example, the catalytic converter, added to cars in 1975, was added to auto exhaust systems to help limit the levels of CO in exhaust. Ventilation of areas is another important facet of design that can help prevent CO poisonings.

The introduction of the catalytic converter on automobiles had a profound impact on reducing CO poisonings (Mott et al., 2002). When assessing CO risks, one can segment cars into pre- and post-1975 groups. After the introduction of the catalytic converter, CO emissions fell 76.3 percent from their pre-1975 levels, which led to an 81.3 percent drop in fatalities due to unintentional CO poisoning. Moreover, deaths from intentional CO poisoning suicides in vehicles decreased 43.3 percent (Mott et al., 2002). However, the risks of an idling car in a garage still pose a threat of CO poisoning. The risk of death ranged from 16 percent to 21 percent for a 3-hour exposure in a garage. However, if all cars from pre-1975 are removed, that risk can fall between 25 percent and 66 percent, depending on the exposure scenario (Marr et al., 1998).

Properly ventilating areas where CO-emitting devices are used can decrease CO exposure. One negative result of the increased energy efficiency movement that arose from the 1973 oil embargo was a concerted effort to reduce airflow in structures. Although energy-efficient buildings use less energy, they make proper ventilation more difficult. Gas cooking stoves, as well as furnaces and gas water heaters, have led to symptoms sometimes called “housewife blues,” reflecting the symptoms of CO poisoning such as fatigue and nausea. As a solution, experts recommend limiting use of unvented heaters and increasing ventilation in the areas where they operated. Doing so can help dilute the concentration of CO (Williams, 2004).

Properly ventilating houseboats is also an effective way to reduce CO poisoning. The National Institute for Occupational Safety and Health (NIOSH) retrofitted a houseboat with a new exhaust stack that extended 9 feet above the uppermost deck. Testing air quality before and after the retrofitting showed a dramatic decrease in CO levels. Levels were at least 10 times lower at many locations on the houseboat. At the back of the boat, at the rear swim area, which is a frequent place for people to mingle, the CO levels decreased from an average of 606.6 ppm to 2.85 ppm, which translates into more than a 99 percent reduction in CO gas. The results prove the effectiveness of the ventilation brought by having an exhaust stack installed either at the factory or retrofitted later onto a houseboat (Earnest et al., 2002). NIOSH has tested two designs of exhaust stacks: a flagpole exhaust and a vertical stack. The modified flagpole design was found to be more effective at lower CO levels, although both designs were much more effective than the standard water level, side-exhaust system that is standard on boats now (Hammond et al., 2006).

CO poisoning plays a relatively minor role in aviation because it only occurs in single-engine piston-driven aircraft. CO poisoning usually occurs when air is passed over the exhaust manifold to warm the cabin. Frequent maintenance and inspection of the exhaust system can typically mitigate these risks (Zelnick et al., 2002).

When using equipment that emits CO, the manufacturer’s label often will advise that the equipment only be operated in a “well-ventilated” area. However, this term was never quantified until a 1997 study that sought to understand what is necessary for an environment to be “well-ventilated.” Researchers used the 200 ppm ceiling on CO set by NIOSH for unsafe levels of CO. The researchers ran models based on a 5-hp concrete saw incident in a bathroom that killed two workers from CO poisoning. They found from modeled and field-generated data that it would require a ventilation rate of 5,000 ft³/min or 120 air changes per hour to stay under the 200 ppm threshold (Earnest et al., 1997). These findings only apply to one specific device; other devices most likely exhibit different air exchange rates and require separate testing and calculations in determining safe ventilation.

Consumer Education

One of the most common strategies for educating consumers about CO risks is to provide information at the time of purchase. Automobile and boat manufacturers provide warnings of the risk of CO poisoning in their owner's manuals. The National Maritime Manufacturers Association, in conjunction with the U.S. Coast Guard, has developed brochures on CO safety that boat manufacturers can purchase to supply with other manufacturers' documentation provided at the time of purchase.

In the boating arena, safety warning stickers have been developed to warn users of CO risks. Again, these stickers are available through the National Maritime Manufacturers Association and are mandatory on recreational boats in California. Similar stickers are mandatory on all new generators, following a U.S. CPSC requirement passed in 2007 (CPSC, 2007). In 1996, the CPSC also revised the CO warning label on charcoal packaging to include a pictogram warning of the dangers of CO in burning charcoal in indoor or enclosed settings (Hampson, personal communication, 2007).

Furnace manufacturers also provide a warning of the risks of CO poisoning in their manuals. However, in terms of prevention, the CPSC recommends having heating systems (including chimneys and vents) inspected and serviced annually by a trained service technician. Local utility companies often provide similar recommendations to their customers.

Other education efforts have focused on providing information seasonally at times of greater risk or during emergencies. In Rochester, N.Y., physicians at the University of Rochester School of Medicine were afforded the unique opportunity to measure the effectiveness of a public health campaign to inform local citizens of the hazards of CO poisoning, through a natural experiment (Lin & Conners, 2005). In an ice storm in 1991, the emergency department saw 55 patients for CO poisoning. A major public health campaign was launched before the next ice storm in 2003. Educational messages were disseminated via radio, TV, and newspapers and from the governor. Although it is not possible to quantify the difference in intensity of educational efforts, they were more intense in 2003 compared to 1991. The result was 10 fewer cases of CO poisonings in 2003 (45 vs. 55). Cases of CO poisoning from indoor grill use were eliminated compared to the six cases in 1991. The study does not control for the severity of the two storms (i.e., number of days without power or the number of consumers without power). However, it does provide a framework to follow in developing future pre-storm interventions. Our literature review indicates the clear absence of any rigorously evaluated prevention campaigns focused on primary prevention of CO exposure.

A 1993 study after the floods in the Midwest improved researchers' understanding of consumers' awareness of CO poisoning risks (Greife et al., 1997). Researchers conducted a survey that asked the following:

"Small gasoline engines (5–15 horsepower) are often used to power generators, pressure washers and lawn mowers. Would it be safe to operate a small gasoline engine indoors:

- a) With closed windows and doors?
- b) With a window open?
- c) With open windows and open doors and a running exhaust fan?"

For each of the three questions (a, b, and c), respondents could answer either “yes” or “no.” Answering “no” to a, b, and c was considered a 100 percent correct response. Only 1 percent of respondents answered “yes” to question “a,” and 54 percent answered “yes” to question “c.” These findings are similar to those identified in CDC’s analysis of the 2005 Healthstyles survey data, where half of all respondents reported that it was “okay” to run a generator in one’s garage or basement.

The flood study recommended disseminating age-appropriate risk information after finding that younger populations were disproportionately more misinformed than older populations (Greife et al., 1997). The study also found that 72 percent of respondents had not heard public health announcements about CO poisoning, but of those who did, most heard them from TV and radio. This suggests that in emergency situations, TV and radio can be an effective means of delivering messages, assuming the population has the electrical power to operate these devices.

In addition to the need to educate consumers, information that consumers receive needs to be more accurate. Consumers are often faced with misinformation. Researchers from the University of Connecticut sampled 91 heating oil distributors to inquire about their responses to questions regarding CO toxicity (Drescher et al., 1999). Researchers hoped to gauge the quality of information distributors would give to their customers about the risks of oil furnaces. When asked if there is a “risk of CO poisoning from an oil burner,” 23 percent of respondents said “no.” Additionally, of those who did say “yes,” 71 percent qualified their answer by minimizing the dangers of CO poisoning. Most often a respondent would qualify his/her yes answer by saying there was minimal risk because of the warning odor. Of the entire study population, only 22 percent or 24 percent gave unqualified “yes” answers. When asked how a consumer should respond if a CO detector sounded an alarm, 95 percent recommended calling the fire department or oil company, but only 14 percent recommended turning off the furnace until the source of the alarm could be found.

Sometimes the local news media has taken a proactive role in educating the public about CO poisoning. A June 2007 article in *The Monitor* in McAllen, Texas, warned the public of the dangers encountered when using portable stoves, heaters, and lanterns while camping and specifically the risk of poisoning from CO emissions in an enclosed tent (Be Safe While Camping, 2007). In Biloxi, MS, the *Sun Herald* warned their readers that electrical generators can be hazardous, even when they are operated outside (Bergeron, 2007).

Secondary Prevention

Even effective primary measures such as technological solutions and good consumer education cannot always eliminate the risk of CO emissions and dangerous conditions. When primary prevention fails, secondary prevention seeks to mitigate the harm by warning those at risk for exposure. Secondary prevention most often comes in the form of a CO detector.

Legal Efforts to Require CO Detectors

A study in Charlotte, N.C., demonstrated the potential effectiveness of CO detectors in preventing CO poisoning (CDC, 2004c). Prior to an ice storm in December 2002, the county had mandated CO detectors in the majority (64.6 percent) of residences. Houses exempt were houses with no gas appliances and no attached garage. A detector with a battery back-up, however, was not mandated. During the ice storm, 78.9 percent of households lost power and

124 people presented with cases of symptomatic CO poisoning. Of these, 109 (87.9 percent) were from homes that had no functioning CO detector. Of those with severe poisoning, 25 (96.2 percent) were from homes with no functioning CO detector. Notably, 83.6 percent of CO exposures came from portable devices (grills and electric generators). This speaks to the need to have CO detectors universally in all houses, instead of those with just gas appliances and an attached garage.

The *Bradenton Herald* in Florida reported that the state of Florida added smoke and CO detectors to its list of tax-free items that could be purchased in May during the hurricane tax-free holiday (Wright, 2006). Programs like this create economic incentives through legislation to encourage consumers to buy CO detectors.

Effectiveness of Detectors

In New Mexico, researchers investigated 136 nonintentional deaths in the state from 1980 to 1995. (The total number of deaths including intentional deaths was 695.) To control for intoxication where an audible alarm may not wake an individual, the researchers only examined 134 of the 136 cases (two cases had no blood alcohol level testing done postmortem). Of the 134 remaining cases, 42 percent ($n = 56$) had a blood-alcohol level greater than .01 percent and were excluded from the study. Of the remaining 78 individuals studied, two-thirds died in a residential setting and one-third in a motor vehicle. Additionally, 65 percent of the deaths occurred while the victim was awake. The researchers estimated that 51 of the 78 deaths could have been prevented in the presence of a nonaudible chemical reagent CO detector. However, they also estimated that an audible CO detector would have prevented all 78 deaths (Yoon et al., 1998).

A second study in the *American Journal of Emergency Medicine* confirms the effectiveness of CO detectors (Krenzelok & Roth, 1996). The study examined all calls to a 911 emergency service concerning CO detector signaling or possible CO exposures. Of all calls, 59.4 percent were from a CO detector. When a CO detector was present, the CO concentration in the home was found to be 18.6 ppm, as opposed to 96.6 ppm found in homes without a detector. This finding suggests that a detector served as an early warning device, notifying occupants of high concentrations before the levels escalated. Homes without the detectors, however, had levels nearly five times higher, suggesting CO levels were not discovered until victims became symptomatic. In addition, 63.4 percent of victims with no detector were symptomatic, as opposed to 13.3 percent of victims with a detector. The results point to the effectiveness of detectors in notifying potential victims of the presence of CO and also reducing the number of victims becoming symptomatic. Despite the effectiveness of detectors, researchers from the University of North Carolina discovered in a random digit-dial survey that only 29 percent of households in the continental United States had CO detectors (Runyan et al., 2005).

The case for detectors was set back after a weather anomaly in Chicago in December 1994 (Bizovi et al., 1998). Between the study's time frame, from July 15, 1994, to January 26, 1995, the median number of times the Chicago Fire Department responded to a CO detector was three times per day. However, the number of calls jumped dramatically on December 12 (29 calls), December 21 (69 calls), and December 22 (128 calls—nearly 43 times the median). Thirty-one percent of the cases were found to be false alarms, and the cause was not determined in 51 percent of the cases. People reported illness in 4.8 percent of cases. The dramatic increase in false alarms brought negative attention to both detectors themselves and future legislative efforts to require CO detectors. On October 1, 1994, less than 3 months before

the increase in calls, a Chicago city ordinance went into effect requiring the use of CO detectors. It was later discovered that a temperature inversion during the same time of the increased calls caused an increase in ambient CO levels. A similar phenomenon was observed in the first 5 days of February 1995. A similar thermal inversion occurred then, too, and the Chicago Fire Department received 2,776 reports of alarms signaling compared with 162 in the time period before. Since the incident, the Underwriters Laboratories has changed the standards on detectors to try and prevent any issues that arose in Chicago from happening again.

Despite the setbacks in Chicago, there has been a growing trend nationwide to distribute CO detectors to residents. Fire departments are often the biggest advocates of detectors. In Newport News, VA, the fire department gave out 200 detectors valued between \$30 and \$40 in August 2007 to the city's residents who were least likely to be able to afford them (O'Brien, 2007). In Delray Beach, Fla., the city's fire and rescue team teamed up with Home Depot in May 2007 to give out a free \$20 CO detector with the purchase of a generator (Burdi, 2007).

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Appendix B: Formative Research on Residential CO Poisonings

Introduction

Appendix B summarizes findings from focus groups held in Chicago, IL, as part of formative research with homeowners. Prior to this research, CDC conducted an extensive literature review (Appendix A) to identify trends in CO poisoning and at-risk audience segments. The literature review identified six distinct poisoning scenarios, one of which was non-emergency residential poisonings.

Methodology

Four focus groups were conducted in Chicago, IL, on August 19–20, 2009. Each focus group lasted approximately 2 hours. The focus groups were segmented by age—two groups of younger adults (25 to 45 years old) and two groups of older adults (60 years or older)—to examine differences in knowledge and practice by experienced and newer homeowners.

Recruitment and Eligibility

To be eligible to participate, individuals had to own a single-family home that uses either a gas or oil-burning furnace for heating. Although race and ethnicity were not eligibility criteria, we aimed for diversity in race and ethnicity across participants as well.

Participants were recruited by a professional recruiting and focus group firm. Potential participants were contacted by telephone, administered a verbal consent, and screened for eligibility. If eligible, individuals were enrolled in a focus group and reminded of the group 48 hours in advance.

Data Collection

When participants arrived at the focus group facility, we welcomed them and administered a written informed consent form and a written questionnaire. A trained moderator and core project team member moderated the focus groups using a semistructured guide, and a dedicated note taker documented the conversation. In addition, we audio recorded the focus groups and transcribed the recordings. Some questions on the guide were adjusted between rounds to better solicit participant responses. At the conclusion of the interview, we provided each participant with a \$75 incentive.

Data Analysis

Following each focus group, we held informal debriefings to identify salient findings and note possible patterns and themes. Based on written notes and audio recorded transcripts, we entered the qualitative data into an ordered meta-matrix that segmented responses by focus group and interview question. This approach allows the organization of a large volume of qualitative data for cross-case analysis, a common technique in qualitative research (Denzin, 2002; Miles, 1994; National Science Foundation, 1997).

Findings

Participant Characteristics

A total of 29 individuals participated in the four focus groups. Two groups included participants aged 25 to 45, and two groups included participants aged 60 or older. Thirteen participants were in the younger adult groups and 16 participants were in the older adult groups.

Tables 1 through 4 provide additional information on focus group participants.

Table 1. Education Level

Education	Aged 25–45 (n = 13)	Aged 60+ (n = 16)
Less than High School	--	6.3%
High School	--	18.8%
Technical School or Some College	7.7%	31.3%
College Graduates	61.5%	31.3%
Post-College Degree	23.1%	12.5%

Table 2. Retailers Used to Purchase Hardware

Retailer	Aged 25–45 (n = 13)	Aged 60+ (n = 16)
Lowes	15.4%	18.8%
Home Depot	53.8%	75.0%
ABT	7.7%	--
Menards	23.1%	25.0%
Sears	15.4%	18.8%
Local Hardware Store/Other	7.7%	12.5%

Table 3. Smoke Detector Installation

Installation Arrangement	Aged 25–45 (n = 13)	Aged 60+ (n = 16)
Detector Was Preinstalled	7.7%	12.5%
Detector Was Installed by Participant	53.8%	81.3%
No detector/Unknown	38.5%	6.3%

Table 4. Items Bought to Improve Home Safety

Retailer	Aged 25–45 (n = 13)	Aged 60+ (n = 16)
Smoke Detector	38.5%	56.3%
CO Detector	46.2%	43.8%
Fire Extinguisher	23.1%	12.6%
Burglar Alarm	7.7%	6.3%
New Locks	7.7%	6.3%
Safety Lighting	15.4%	18.8%
Railing for Bath or Stairs	--	18.8%
Window Escape Ladders	15.4%	6.3%

Home Safety

Common home safety purchases among participants include smoke detectors, CO detectors, and fire extinguishers. Six participants also reported having monitored security systems installed in their homes, and one of these participants specifically mentioned the ability to protect against fire when not at home as a reason for this purchase. In one of the older adult groups, several members also commented on their lack of knowledge on how to use their fire extinguisher in the event of a fire. Other purchases include deadbolts for door, radon detectors, fire ladders, step brakes, step ladders, and a fire grate for the fireplace.

Actions participants have taken to improve the safety of their homes include conducting routine maintenance of appliances, prohibiting smoking, not leaving the stove unattended while cooking, locking doors and windows, not running appliances when away from home, keeping items off the stairs, installing handrails, installing GFCI outlets, and having chimneys swept periodically. Furnace maintenance was mentioned most often in relation to home appliances, with homeowners reporting changing their furnace filters, cleaning vents, and scheduling regular service visits.

To further improve safety in their homes, participants reported wanting to replace older appliances (including furnaces), remove or seal any asbestos, remove lead-based paint, ensure proper ventilation in attics, and install motion-detecting lights outside.

When asked what motivates them to improve home safety, a common response was “piece of mind.” Linked to this statement were concerns about protecting one’s children and other loved ones from danger and protecting one’s value and investment in their home. Personal experience with a household danger, such as a previous home fire, was also a strong motivator, as were stories on the news of death and injury from household dangers. A few participants acknowledged state or local laws requiring safety devices, such as smoke detectors, as motivators.

Furnace Safety

In addressing furnace safety, maintenance was the most recognized safety precaution. Many participants from both age groups checked or had a professional check their furnaces in the last year. However, many of these individuals also reported not having their furnace checked previously. Thus, inspections appear to be sporadic, rather than regular, for many participants. Younger adults are also slightly more likely to have an inspection than older adults, and very few individuals have service contracts for their furnace.

The few participants who have service contracts have twice-yearly inspections and service, with one of the service visits usually occurring in the fall to prepare the system for winter. Costs for an inspection range from \$30 to 50 for a single, uncontracted visit to \$100 for a biannual service contract.

Although some participants hire a professional service company to maintain their furnace, others inspect the furnace themselves or have a friend or family member do it for them. Homeowner maintenance often includes changing filters, checking the color of the flame, vacuuming the burner tray, cleaning out dust and debris, changing couplings, and conducting soap tests to check for natural gas leaks.

In general, participants were supportive of regular furnace inspections. However, participants' comments on improving furnace efficiency and protecting themselves from costly repairs in the future indicate a significant emphasis on the maintenance benefit of these visits. More than one individual likened annual inspections to regularly changing the oil in one's car. In addition to safety and maintenance, one individual saw them as a preventive action related to asthma.

Participants offered several reasons for why individuals may not regularly inspect or maintain furnaces. The most common barriers are cost/perceived cost, trustworthiness, lack of awareness about the need for maintenance, and the potential cost of fixing a problem. Participants feel—or, in some cases, suspect—that the cost of a professional inspection is too high, and they fear an inspection may uncover the need for expensive repairs. Participants are also generally unsure what types of annual maintenance need to be performed, and they are unsure what tasks require a professional versus ones they can perform themselves.

Concern about finding a reputable professional to inspect and service the heating system was a major barrier to furnace inspection. Participants were unsure how to identify a qualified, trustworthy professional and how to distinguish between warranted and unwarranted repairs. However, several participants shared strategies for identifying a reputable professional. The most common strategy was to ask friends for a recommendation. Other strategies included investigating how long a company has been in business, not picking the cheapest professional, and getting multiple quotes when a repair is required.

Members of the older adult groups tended to believe they were responsible homeowners and to attribute their engagement in preventive maintenance to having greater concerns for safety, a more long-term view on things that comes with age, and understanding the value of preventive actions. Interestingly, older adults felt that younger people would be less likely to engage in regular service activities, a view not supported by focus group findings. Younger homeowners also were supportive of regular maintenance activities, although they were more likely to emphasize efficiency and avoiding costly repairs than to emphasize safety.

When asked about ideas for encouraging furnace inspections and safety, participants suggested free inspections and checks for gas or CO leaks in one's home. The gas company was seen as the most likely source for this type of service. One member of one of the older adult group even contemplated having additional fees added to his/her gas bill to fund free checks for customers. Others suggested including safety information in gas and other utility bills, creating a reminder system or reminder calls from the gas company, having furnace companies supply CO detectors when installing new furnaces, and educating consumers on what to expect when getting their furnace serviced.

CO Knowledge

Participants identified CO as an odorless and colorless gas. Individuals in the younger adult groups were slightly better at describing the symptoms or signs of CO poisoning, including lethargy, headache, dizziness, and blue lips. Several individuals identified CO as the “silent killer,” and several participants described it as killing people in their sleep. More vividly, one participant described it as being able to move quickly through a house and put people to sleep.

Overall, participants were somewhat confused about the difference between gas and CO. Some participants interchanged the terms and confused them in their discussions. For instance, when discussing household sources of CO, one participant expressed concern over children bumping and accidentally turning on a gas stove. Participants also identified multiple sources of CO. Grills, boilers, furnaces, gas fireplaces, kerosene space heaters, gas clothes dryers, gas stoves, and cars were all mentioned as potential household sources of CO.

Concern about CO

Participants indicated that CO, although clearly an important safety issue, was not something they think about regularly. They partially attributed this to a lack of strong visuals associated with CO as compared to other household risks, such as home fires and gas explosions. They also reported CO poisoning was not usually mentioned at safety awareness activities, whereas fire safety is commonly covered. Many individuals are more likely to think about CO in the fall as they prepare for winter.

One individual compared the potential for CO in the home to the presence of radon gas and said there is a need to test even if there may not be any sign that it is present.

CO Detectors: Awareness, Ownership, and Maintenance

The majority of participants have a CO detector in their home, although older adults are more likely to have detectors than younger adults. Many also reported that CO detectors are a housing code requirement in Chicago. When asked to describe the CO detectors in their home, several have them on multiple levels; however, some others have a single detector. Nevertheless, participants had questions about the appropriate number of detectors and their proper placement in their home to have adequate coverage. Many placed CO detectors near furnaces or major appliances—such as in basements or utility rooms. Others placed the detectors in a bedroom, hallway, kitchen, or dining room.

Participants also do not think about their CO detectors often. Members of the group were split on whether they change the batteries in their CO detectors every 6 months or simply wait until the unit beeps.

Hypothetical Reaction to CO

When asked what they would do if they found CO in their home, participants reported they would leave their homes and call the fire department or gas company. Two individuals suggested they would call for a repair person first. One person mentioned turning off the gas to their home. Another couple reported they would open windows. Another suggested the need to investigate the detector and see if it was malfunctioning.

In one group, a participant was concerned that the fire department would charge a fee for a home visit, particularly if they had a previous home visit that year.

Sources of CO Information

Very few participants encountered educational information on CO poisoning. Those who did recalled seeing segments on news shows (e.g., “60 Minutes”) or articles in parenting magazines. Local news stories about CO poisoning deaths and injuries were the most common information sources.

Preventing CO Poisoning

Participants shared their recommendations for preventing CO poisoning. Educating homeowners was the most common suggestion, and realtors were identified as one group that could help educate new homebuyers, particularly at the time of home inspection. In addition, individuals recognized that children often learn safety information in school and share it with their parents. Public service announcements also were suggested along with having information about CO in gas bills, on billboards, and in stores. Presentations at health fairs and informational kiosks at malls were also identified as ways to reach people.

Cost was often mentioned as a potential barrier to regular furnace inspections, with coupons, discounts, and homeowner insurance rebates suggested as ways to overcome this barrier. One individual suggested enacting a law requiring homeowners to have an annual furnace inspection. Another suggested government incentives for replacing older furnaces.

To promote the use of CO detectors, participants suggested offering coupons for discounted purchase. One participant also suggested using a peer network as a means of sharing information and distributing discounted CO detectors. Participants suggested that prevention messages needed to let individuals know that furnace safety could be affordable and that CO poisoning can be deadly. Having a succinct and catchy slogan was recommended.

Recommendations

Based on the findings above, we provide several recommendations for educating consumers about furnace inspections, CO poisoning, and CO detectors:

- Provide a guide to homeowners on what to expect when their home furnace is being serviced.
- Provide homeowners with tips or strategies for selecting a reputable and affordable furnace service company. If possible, provide regional estimates for a furnace inspection.

- Give home furnace service technicians instructions on showing homeowners the activities conducted as part of their regular service.
- Develop a checklist or tip sheet for homeowners on how to perform a quick furnace inspection to ensure that safety checks are included in regular maintenance activities.
- Collaborate with community gas and utility companies to better advertise their free, as well as paid, services related to home heating systems.
- Partner with community gas companies and home repair professionals to offer incentives or discounts for households that have regular furnace and other appliance inspections.
- Emphasize both the safety and savings that can potentially result from regular furnace maintenance. Counter the perception of furnace maintenance as costly by outlining the long-term cost savings of efficient operation and avoided repairs.
- Educate homeowners about the difference between natural gas and CO and how these differences influence safety and safety precautions.
- Develop a symbol or icon that is universally recognized for CO poisoning and that can be used to immediately identify CO safety information.
- Develop free curricula for fire departments to use with the public when educating them on household safety and risks.
- Provide guidance to homeowners on the proper number and placement of CO detectors. Many individuals know they need a detector but are unsure as to what constitutes adequate coverage.
- Partner with utility companies or home insurance companies to offer incentives or discounts for the purchase of CO detectors.
- Develop a clear action plan for homeowners to follow when their CO detector sounds or if they suspect a CO leak.
- Create educational messages that are thought provoking but not tragic or shocking. People do not want to worry about CO, and it is not attention-grabbing like fire and flu.

Appendix C: Formative Research on Summer Storm CO Poisonings

Introduction

Appendix C summarizes findings from two focus groups held in Wilmington, NC, as part of formative research with portable generator owners. Prior to this research, CDC conducted an extensive literature review (Appendix A) to identify trends in CO poisoning and at-risk audience segments. The literature review identified six distinct poisoning scenarios, one of which was summer storm poisonings.

Methodology

We conducted two focus groups in Wilmington, NC, on July 29, 2009. Each focus group lasted approximately 2 hours, and a total of 17 individuals participated in the two groups.

Recruitment and Eligibility

To be eligible to participate, individuals had to own a portable gasoline-powered generator and have used it during a storm-related power outage, such as one caused by a hurricane, tornado, or flood. Participants also had to be the primary person responsible for operating the generator during an outage. Although race and ethnicity were not eligibility criteria, we aimed for diversity in race and ethnicity across participants as well.

Participants were recruited by professional focus group recruiting firm, which used a preexisting database of individuals who expressed interest in research studies. Potential participants were contacted by telephone, administered a verbal consent, and screened for eligibility. If eligible, individuals were enrolled in a focus group and subsequently reminded of the group 48 hours in advance.

Data Collection

When participants arrived at the focus group facility, we welcomed them and administered a written informed consent form and a written questionnaire. A trained moderator and core project team member moderated the focus groups using a semistructured guide, and a dedicated note taker documented the conversation. In addition, we audio recorded the focus groups and transcribed the recordings. Some questions on the guide were adjusted between rounds to better solicit participant responses. At the conclusion of the interview, we provided each participant with a \$75 incentive.

Data Analysis

Following each focus group, we held informal debriefings to identify salient findings and note possible patterns and themes. Based on written notes and audio recording transcripts, we entered the qualitative data into an ordered meta-matrix that segmented responses by focus group and interview question. This approach allows the organization of a large volume of qualitative data for cross-case analysis, a common technique in qualitative research (Denzin, 2002; Miles, 1994; National Science Foundation, 1997).

Findings

Participant Characteristics

A total of 17 individuals participated in the focus groups: eight in the first group, and nine in the second. Because of an oversight in one group (several participants failed to turn over the questionnaires to the second page), some information is missing for seven participants. Tables 1 through 3 provide additional information on the focus group participants.

Table 1. Education Level

Education	Percent
High school education	20%
Technical school or some college	60%
College graduates	10%
Postcollege degree	10%

Table 2. Retailers Used to Purchase Hardware

Retailer	Percent
Lowes	77%
Home Depot	35%
Other	6%

Table 3. Smoke Detector Installation

Installation Arrangement	Percent
Detector was preinstalled	11.8%
Detector was installed by participant	64.7%

Storm Preparations

Participants described making multiple preparations in advance of hurricanes and major storms. Many purchase supplies, such as groceries, pet food, water, gasoline, and batteries, from local stores and often fill cars with gas in case of service station closures. Several participants also use appliances that will cease working during power outages (i.e., filling tubs with water if on a well, cooking stovetop meals in advance). Many store lawn furniture and other items that might blow away and prepare plywood for boarding up windows.

Multiple participants start up their generator in advance of needing it. They want to ensure that the generator is working properly, especially if they anticipate a power outage. Some

participants also cited the need to run generators occasionally throughout the year, regardless of power outages, and many said they run their generator through a cycle two to four times each year outside of storm season.

Reasons for Using Generator/Key Items Powered

We asked participants at what point they typically decide to activate their generator and what factors drive that decision. About half of participants wait until losing power to fire up their generator; the other half proactively turn on the generator in anticipation of an outage. Those who wait do so to make sure it is safe to go outside and to gauge the extent of the power outage. (Several participants described looking around the neighborhood to gauge storm damage and the extent of an outage. If the outage looks extensive, they'll activate their generator.) Others wait until they feel power is genuinely necessary, such as at nightfall.

Participants agreed that several appliances were critical to power: freezers, refrigerators, air conditioning window units, window and ceiling fans, and televisions and radios. Freezers and refrigerators are essential for preserving food, fans and A/C units keep residents cool during hot weather, and televisions and radios provide news updates and entertainment for children. In addition, several respondents cited microwaves, hot water heaters, and even computers as important items to operate after a summer storm.

Many participants also cycle through appliances. In other words, rather than powering all items at once, they power appliances individually as needed. For instance, participants described running power to the freezer/refrigerator in hour intervals, because these appliances stay cool unless opened for extended periods. Likewise, other participants described powering stoves and refrigerators during the day, then powering fans and televisions at night.

Generator Placement

Almost all participants have a standard, predetermined location for their generator, but these locations vary considerably. Most participants place their generator either in an attached garage/carport or outside in their yard. However, others place their generator on attached screened porches, on covered patios, in detached garages, or in separate utility buildings/sheds. Generators placed outside are located anywhere from 10 to 50 feet from the house, and those who place generators in an attached garage almost always open the garage door. (They said this provides “ventilation.”) Two participants mentioned building a small covered concrete pad in their yard to house their generators in a storm.

Access to appliances and power boxes was the biggest determinant of generator placement. Most participants said they chose the generator's location based on what they wish to power, the length of their power cords, and the ease of connecting the generator to these items. Many participants also chose the generator's location based on the convenience of operating it. Because outages can last for days, they need to access the generator regularly to switch power cords and add fuel.

Many participants mentioned ventilation as an issue, and at least one respondent in each focus group specifically mentioned avoiding “carbon monoxide.” Many nodded or echoed their agreement—without prompting from the moderator—about avoiding CO exposure. Some participants also mentioned noise, keeping the generator out of the wind/rain, and other generator safety issues (i.e., gas fumes, heat output, gas overflow) as influencing generator

placement. A few individuals briefly mentioned theft as a concern, but most did not consider this a serious threat.

When asked where they *would not* place a generator, most participants agreed they would not operate one indoors or in the house. Individuals did not appear to notice a conflict between this belief and their behavior of placing generators inside covered structures, such as garages and porches. Some participants also said they would not run a generator in a garage with the door closed. However, others stated earlier that they do close their garage door when operating the generator. In general, participants are confident in their current generator placement and its safety.

We also asked participants to describe their generator setup. Most respondents use extension cords (“drop cords”) and run them to individual appliances, such as freezers or window air conditioning units. However, some participants connect the generator to the central power box, thus running power to their entire house. They then switch off the power breakers for the rooms or appliances they do not wish to operate. A few participants also mentioned having a dedicated input outlet for their generator in their breaker box for their generators, along with a shut-off switch for the outside power.

Overnight Generator Usage

Approximately half of participants run their generators overnight, and most use it to power key appliances, such as freezers, refrigerators, air conditioning, ceiling fans, and televisions. These participants cited food preservation (freezer, refrigerator) or comfort (air conditioning, ceiling fans) as the main reasons. Those who do not run their generators overnight cited the need to conserve power and gas, and many also said they felt unsafe sleeping while the generator was running.

Interestingly, not a single participant moves their generator at night. Every participant keeps their generator in the same location as the daytime, regardless of overnight usage. Participants cited the inconvenience and difficulty of moving the generator and the lack of a clear advantage, as reasons not to relocate it.

Perceived Risks of Generators

Electrical safety and possible electrocution are by far participants’ most common concern when using generators. Almost all participants cited this issue, and many respondents explained that, although they take precautions, the risk of electric shock is extremely serious. In addition to personal safety, participants are also concerned about electrical risks like overloading the generator and accidentally shocking power line workers by sending electricity backward from the generator.

Ventilation, fumes, and CO poisoning are the second most common concerns among participants. (Participants conceptualized these three items as a single issue and used the terms interchangeably.) Almost all participants talked about the need to properly ventilate generators, but none could truly articulate what this meant or outline any ventilation criteria. A third concern mentioned by participants was gasoline safety, such as the risk of spilling gas or refilling the generator while hot.

When asked what they do to avoid or minimize these risks, participants outlined a handful of precautions. Several participants said they maintain and check their generator/power cords regularly to ensure they're working properly. Others cited general safety precautions, such as following instructions, ensuring the generator and power cords are dry, and using common sense.

Several participants also cited keeping the generator away from the house and keeping it “well ventilated” as an important precaution. However, respondents were again unable to define what it meant for a generator to be well ventilated. Most suggested a generator is properly ventilated if the exhaust is pointed away from the house. Others said opening a garage door or having a semiopen space, such as a covered patio, is sufficient. One individual actually recalled how his dog was almost killed by CO poisoning. The participant placed his running generator in the garage, the same location his dog slept. The garage door was closed, but two large windows were open. He found the dog unconscious a few hours later and, fortunately, was able to revive him. His conclusion: Next time open the garage door to provide more ventilation.

CO Knowledge

Most participants are familiar with CO and had heard about CO poisoning. As mentioned earlier, participants even raised the issue of CO before we introduced it into the discussion. Specifically, participants were familiar with CO's characteristics (colorless, tasteless, odorless), knew it often affects sleeping individuals, and recalled that victims were unlikely to know they were being poisoned. However, a few participants incorrectly thought they would smell CO and confused the issues of CO emissions and natural gas leaks. Participants also recognized most symptoms of CO poisoning (headache, drowsiness, dizziness) and knew that it could be fatal.

When asked, participants identified several sources of CO, including cars, gas furnaces/appliances, portable stoves/appliances, portable heaters, grills, generators, gas log fireplaces, and hot water heaters. Most participants—all in one focus group, about half in the other group—knew generators emitted CO and reiterated that ventilation was critical to preventing CO poisoning.

Concern about CO

Despite raising it as an issue earlier, most participants said they were not highly concerned about CO poisoning. Instead, they cited electrocution and electrical safety as the primary risk when using generators. Further discussion revealed that, even though participants think CO poisoning is serious, they seem to believe they are adequately ventilating their generators and, consequently, are at very low risk for CO poisoning. Thus, participants' statements of minimal concern about CO poisoning might be interpreted as low perceived susceptibility (rather than low perceived severity).

CO Detectors: Awareness, Ownership, and Maintenance

Almost all participants knew about CO detectors and their purpose, although most individuals do not have CO detectors installed in their homes. (Two participants in the first group and five in the second group had CO detectors.) A few participants have CO detectors as part of a home security system (i.e., ADT). When pressed, they were unaware that the security system—including the detectors—may not function during a power outage. Participants also knew that CO detectors were sold at home improvement stores, citing Lowes and Home Depot as examples.

Most participants associate CO detectors with gas furnaces and gas appliances, and several participants said they have all-electric homes and, thus, do not need CO detectors. (Upon probing, however, these same individuals often recalled they have gas log fireplaces or gas dryers.) Other participants echoed this sentiment, saying that CO detectors are uncommon in the city because few residents have natural gas.

All participants understood the difference between CO detectors and smoke alarms, and most understood that CO detectors should be installed in different locations. However, participants were generally unclear on where the detectors should be installed and why their placement should be different than smoke alarms. Regarding installation, most participants believe CO detectors would be easy to install, and several individuals have installed the detectors themselves.

For those who have CO detectors, the devices are located in various places around participants' homes. Most individuals with detectors have them either near the smoke alarms or near gas appliances, such as furnaces, stoves, or fireplaces. In particular, several participants have detectors located in the basement near their furnaces. Other participants installed the detectors in common areas, such as kitchens, and two respondents have CO detectors installed in the home's bedrooms. In addition to room location, participants are generally unsure at what height to install CO detectors. Several respondents thought the detectors should be located in the ceiling (near smoke alarms); others thought they should be near the floor.

Finally, most participants—but not all—recognize they should change their smoke alarm and CO detector batteries twice a year. Several cited the recommendation to change batteries when changing the clocks for daylight savings time. Yet many individuals do not follow this recommendation. The most common response was that participants change the batteries when the alarms/detectors chirp.

Hypothetical Reaction to CO

We asked participants how they would respond hypothetically if they discovered CO in their home. All participants said they would evacuate the house, and almost all said they would call 911 as well. Several individuals would also turn off the main natural gas valve, and others would try to ventilate the home—such as opening windows and doors—before evacuating.

Preventing CO Poisoning

Most participants see CO detectors as the best—and, in some cases, only—way to protect themselves and their family from CO poisoning. Some participants also suggested primary prevention strategies, such as not idling cars in the garage, visually inspecting gas appliances, and scheduling an annual furnace inspection. When discussing prevention, several respondents again cited their all-electric homes as a reason they do not worry about CO poisoning.

Asked about CO safety when using a generator, participants echoed earlier comments about improving ventilation. Several participants would improve generator ventilation by opening garage doors or closing windows near an outdoor generator to prevent CO from seeping into the home. Others would place the generator in a safe location, such as outside in the yard or away from air conditioning units.

Sources of CO Information

Participants remembered several sources of information about CO safety. Most individuals recalled news stories about fatal and near-fatal poisonings on the local news broadcast or on programs/stations like Dateline, 20/20, and the Discovery Channel. Most of these stories covered poisonings that occurred after hurricanes and storms, but some highlighted nonemergency poisonings or intentional exposures. Other participants recalled that the Weather Channel and local TV and radio news stations have broadcast generator safety tips before major storms. Finally, a few participants remembered receiving information from hurricane preparedness booths at local shopping malls.

Participants had mixed feelings about the information's value. Most participants saw the information—especially news coverage of poisonings—as a general reminder of CO safety rather than a truly instructional resource. Because most of the information is after-the-fact news, the sources rarely provide safety tips or discuss CO poisoning in-depth. Likewise, several participants said that news stories rarely mention sources of CO, even when covering fatal poisonings.

Promoting CO Detectors

Focus group participants offered several ideas for encouraging CO detector installation. Most participants cited advertising, especially television advertising, as an effective strategy for promoting detectors. A few respondents suggested that retailers—such as Lowes, Home Depot, and Sam's Club—sell generators and CO detectors in combination. One respondent also suggested having social workers check homes for CO detectors. She explained that social workers often visit homes for other reasons (i.e., check on families receiving social assistance) and already check for smoke alarms and other safety features. Finally, one participant suggested promoting CO detectors to the “captive audience” at hurricane shelters in the days following a major storm.

Participants also recommended several outlets for promoting CO detectors, such as TV and radio stations, newspapers, and community Internet sites. Several participants suggested that gas and utility companies enclose a promotional notice or reminder with the monthly bill. Others thought homeowner insurance companies should offer discounts for CO detector installation or that local code ordinances should require CO detectors in new homes. In addition, several participants recommended hosting fire department safety demonstrations at home and garden shows, shopping malls, and city schools.

Finally, respondents identified several reasons people may not have or want a CO detector. Most participants thought being unaware of CO and its severity was the biggest obstacle to detector installation. Others suggested that if people have all-electric homes, they may believe they do not need a CO detector. Cost, or even perceived cost, of CO detectors was cited as a barrier. Several participants also pointed out that individuals who rent may not consider CO detectors their responsibility, especially since a landlord or owner installed the smoke alarms.

Future Generator Usage

We closed the focus groups by asking participants if they intended to use their generators any differently in the future. Despite many individuals having no CO detector and placing generators in enclosed or semi enclosed areas, almost all of the respondents said they would continue using their generators as before. The few individuals who would use their generator differently

said they would try to ventilate the area more thoroughly (i.e., open garage door) or purchase a CO detector. No respondent said he/she would relocate the generator.

Recommendations

Based on the findings above, we outline several recommendations for educating consumers about generator safety and for promoting the use of CO detectors:

- Gas stations may be a good outlet for promoting CO safety and CO detectors, because consumers tend to gas up vehicles prior to a storm and because they tend to test generators before a storm hits.
- Target individuals who place generators in attached garages and covered patios. These seem to be the most common “dangerous locations” for generators, so targeting these individuals may have the biggest impact. Emphasize that any attached building with a roof is not ventilated enough. Emphasize that opening a garage door is not sufficient to ventilate a generator.
- Find ways to make the ideal generator placement (i.e., 25 feet from house) more convenient. Individuals consistently cited cord length, access to appliances/power box, and ease of attending to the generator as key factors in generator placement.
- Clearly define “well ventilated” for consumers. Individuals want to make sure the generator is well ventilated; they just are not sure what “well ventilated” means and how they achieve it.
- Dovetail CO safety with electrical safety. Individuals are seriously concerned about electrical safety when using generators and appear willing to learn more about it. If we combine electrical and CO safety messages, individuals may be more likely to listen.
- Noise was identified as a factor in generator placement and may be useful in reinforcing the need to locate the generator away from the house.
- Debunk the “all-electric house” myth. If you use a generator, you do not have an all-electric house. If you have an attached garage, you do not have an all-electric house. If you have a fireplace, a wood stove, a gas dryer, or a gas water heater, you do not have an all-electric house. People commonly cited this reason for not having a CO detector, so emphasizing the reality could have a major impact.
- Educate individuals about CO detector placement. Few individuals placed CO detectors in bedrooms, common areas, or garages; most stuck them in the basement or attic near the furnace.
- Explore innovative routes for CO safety education—school demonstrations, home and garden shows, hurricane shelters, gas/utility bill notices, etc.

Appendix D: Formative Research on Winter Storm CO Poisonings

Introduction

Appendix D summarizes findings from two focus groups held in Asheville, NC, as part of formative research with portable generator owners. Prior to this research, CDC conducted an extensive literature review (Appendix A) to identify trends in CO poisoning and at-risk audience segments. The literature review identified six distinct poisoning scenarios, one of which was winter storm poisonings.

Methodology

We conducted two focus groups in Asheville, NC, on August 5, 2009. Each focus group lasted approximately 2 hours, and a total of 15 individuals participated in the two groups.

Recruitment and Eligibility

To be eligible to participate, individuals had to own a portable gasoline-powered generator and have used it during a storm-related power outage, such as one caused by a snow or ice storm. Participants also had to be the primary person responsible for operating the generator during an outage. While not eligibility criteria, we aimed for diversity in race and ethnicity across participants as well.

Participants were recruited from the community by placing ads on Craigslist and in the *Asheville Citizen Times* or by a professional focus group recruiting firm. Potential participants were contacted by telephone, administered a verbal consent, and screened for eligibility. If eligible, individuals were enrolled in a focus group and subsequently reminded of the group 48 hours in advance.

Data Collection

When participants arrived at the focus group facility, we welcomed them and administered a written informed consent form and a written questionnaire. A trained moderator and core project team member moderated the focus groups using a semistructured guide, and a dedicated note taker documented the conversation. In addition, we audio recorded the focus groups and transcribed the recordings. Some questions on the guide were adjusted between rounds to better solicit participant responses. At the conclusion of the interview, we provided each participant with a \$75 incentive.

Data Analysis

Following each focus group, we held informal debriefings to identify salient findings and note possible patterns and themes. Based on written notes and audio recording transcripts, we entered the qualitative data into an ordered meta-matrix that segmented responses by focus group and interview question. This approach allows the organization of a large volume of qualitative data for cross-case analysis, a common technique in qualitative research (Denzin, 2002; Miles & Huberman, 1994; National Science Foundation, 1997).

Findings

Participant Characteristics

A total of 15 individuals participated in the two focus groups: seven in the first group and eight in the second. Because of an oversight by one participant (by neglecting to turn over the questionnaire to the second page), some information is missing for one participant. Tables 1 through 6 provide additional information on focus group participants.

Table 1. Education Level (N = 14)

Education	Percent
High school education	21.4%
Technical school or some college	50.0%
College graduates	21.4%
Postcollege degree	7.1%

Table 2. Retailers Used to Purchase Hardware (N = 15)

Retailer	Percent
Lowe's	73.3%
Home Depot	66.7%
Other	13.3%

Table 3. Smoke Detector Installation (N = 15)

Installation Arrangement	Percent
Detector was preinstalled	20%
Detector was installed by participant	40%

Storm Preparations

Participants experience a number of different storms that cause power outages at their homes. The most common types of storms are snowstorms, ice storms, and windstorms. However, some participants also experience severe rain storms, thunderstorms, and flooding, which also cause power outages.

Participants described making several preparations in advance of these winter storms. Many individuals purchase supplies, such as groceries, bottled water, gasoline, candles, batteries, and flashlights. Most individuals also fuel their vehicles and, in advance of the storm, use any appliances that will stop working during power outages (i.e., filling containers with water if on a

well). Others ensure that electronic equipment, such as TVs and stereos, is raised off the ground in case of flooding, and some even take precautions to try to prevent power outages, such as trimming tree limbs that hang over power lines.

In addition, many participants start up their generator in advance of needing it. They want to ensure that the generator is working properly, especially if they anticipate a power outage, and want to make sure the fuel is “fresh.” Some participants cited the need to run generators occasionally throughout the year, regardless of power outages, and said they run their generator once every few months outside of storm season.

Reasons for Using Generator/Key Items Powered

We asked participants at what point they typically decide to activate their generator and what factors drive that decision. Almost all participants wait to start their generator until after power is lost, and during winter storms, most activate the generator within 1 to 2 hours. Some individuals also contact the power company to learn the extent of storm damage and to estimate when power will be restored. If the outage will be quick (2 to 5 hours), individuals may decide against using their generator. Most individuals also wait until a storm has fully passed before turning on their generator, and several said they would not initiate it after dark, because they need sufficient light to turn it on safely.

Not surprising, heat is a major issue during winter storms, and most individuals who rely on electric heat cite it as the primary motivation for starting the generator. Consequently, participants stated that the lower outdoor temperatures are, the lower their tolerance for waiting out a power outage. Fear of food spoilage is also an issue, although a few participants said that they would simply store food outside during winter if the freezer or refrigerator lost power. Finally, if individuals need to attend work during a power outage, they are more likely to start their generator sooner, because they want hot water and personal appliances (i.e., hair dryers, electric razors) to be available.

Participants agreed that several appliances were important to power: furnaces and central heaters, freezers and refrigerators, water heaters, water pumps, lights, and communication devices like TVs, radios, and computers. Heaters are essential for keeping warm during winter storms, freezers and refrigerators are critical to preserving food, and communication devices help individuals learn about the extent of storm damage. Several participants also rely on electricity to keep water pipes from freezing (their pipes are embedded with heated electric strips), and a few participants cited sewer pumps and stoves as important items to operate after a storm.

Participants rely on several sources of information during winter storms and power outages. Many use televisions and battery-powered radios. Others use computers—powered by either a generator or a laptop battery—to access online news sites. Most individuals also use cell phones and text messaging to contact friends, neighbors, and utility companies to assess the extent of storm damage and estimate when power will be restored.

Generator Placement

Almost all participants have a standard, predetermined location for their generator, but these locations vary widely. Many participants place their generator on an attached porch or patio with a roof or overhang. Others place the generator in an outdoor shed or detached garage, and a

few set up the generator in the back or side yard, ranging from 2 to 30 feet from the house. Some participants also place their generator in an attached garage, basement, and sunroom.

Noise and exhaust are the most common determinants of generator placement. Most individuals said they chose the generator's location to minimize its noise and to keep generator exhaust and fumes from entering the house. When discussing exhaust and fumes, a few individuals—without prompting from the moderator—mentioned having a CO detector. Several participants also selected a location that would protect the generator from winter weather (i.e., structure with roof or overhang), and a few individuals cited cord length and the risk of a generator fire as additional considerations. Interestingly, theft is not a major concern, and many individuals feel a running generator is safe in their yard or on their porch. The few participants who are concerned about theft simply chain their generator to another structure.

When asked where they would *not* place a generator, most individuals agreed they would not operate one indoors or inside the home. Individuals did not appear to notice a conflict between this belief and their behavior of placing generators on covered porches or in detached sheds. In addition, a few participants said they would not place a generator under open windows. Participants disagreed about whether placing a generator inside a garage—attached or detached—was safe. Some stated operating a generator in a garage is fine if the door is open and the structure is well ventilated. Others said they would never do so.

We also asked participants to describe their generator setup. Most respondents use extension cords (“drop cords”) and run them to individual appliances, such as freezers or heaters. However, a few participants connect the generator to the central power box, thus running power to their entire house. They then switch off the power breakers for the rooms or appliances they do not wish to operate.

Overnight Generator Usage

Very few participants run their generator at night. Most individuals said they do not require overnight power and, thus, feel it is too expensive and wasteful to use the generator. Instead, many participants power key appliances, such as freezers and refrigerators, until going to bed and restart the generator in the morning. Those who do run the generator overnight cited lighting, heat, and communication devices (i.e., TV, computer) as the main reasons.

For all participants, overnight generator placement is identical to daytime placement. No one moves or stores their generator at night; they simply shut it down until morning. Nighttime theft is not a concern for participants, and many stated their generator is too heavy, big, and awkward for someone to steal easily.

Perceived Risks of Generators

Electrical safety and possible electrocution are participants' biggest concerns when using a generator. Many individuals worry about the risk of electric shock or electrical overload, and a few individuals fear accidentally shocking power line workers by sending electricity backward from their generator. In addition, participants see fuel spillage and gasoline fires as potential risks, especially when refueling the generator, and several individuals mentioned the need to keep the generator out of contact with water and winter weather.

Ventilation, exhaust, and fumes are a second common concern, although only a few participants raised this issue before being asked about it by the moderator. Individuals see exhaust exposure as serious and potentially fatal, and several individuals take precautions to avoid it (i.e., placing the generator downwind, pointing the generator exhaust pipe away from the house). Two individuals also mentioned having CO detectors—without moderator prompting—to prevent exhaust poisoning.

When asked what they do to avoid or minimize these risks, most participants discussed electrical safety. Specifically, participants use proper extension cords, purchase surge protectors, and ensure extension cords are in limited contact with snow, ice, and rain. A few participants also said they make sure the generator is well ventilated. When asked what “well ventilated” means, participants offered various definitions, including placing a generator outdoors or in a garage with an open door. Others defined ventilated as being in a space with air circulation, being in a structure with two to three open sides (i.e., covered porch), or being kept away from people and pets. Proximity to the house was not mentioned as a factor.

CO Knowledge

Most participants are somewhat familiar with CO and had heard about CO poisoning. Some participants knew that CO is odorless, potentially fatal, and leads to poisoning if trapped in an enclosed area, and many were able to list at least one CO symptom, such as sleepiness, headache, dizziness, and nausea. A few participants also proactively mentioned CO detectors, and most participants echoed the comments about the importance of detectors.

When asked, participants easily named several sources of CO, including generators, oil and gas furnaces, gas and charcoal grills, kerosene heaters, automobiles, fireplaces, wood stoves, and other gas appliances. Almost all participants are aware of the connection between CO and generators, although a few admitted that they had not made the connection or “didn’t give it much thought.” (Conversely, one individual said he believed CO caused more generator-related deaths than electrocution.)

Concern about CO

When prompted, almost all participants said that CO was a legitimate concern during storms and power outages. However, most participants thought by not placing a generator indoors they were adequately protected, and many are less worried about CO if their generator is located outside (including on covered porches and in attached garages). Despite earlier comments about CO poisoning symptoms, a few individuals suggested, half jokingly, that unconscious birds or animals would give an early warning of CO exposure.

CO Detectors: Awareness, Ownership, and Maintenance

Every participant is aware of CO detectors and their purpose, and about half of participants have them in their home. Individuals recalled hearing about CO detectors primarily through word of mouth and local news stories. All individuals know they could purchase CO detectors from hardware stores, such as Home Depot, Lowes, and Ace, and several said they would likely purchase them at Wal-Mart, eBay.com, or Amazon.com as well.

All participants understand the difference between CO detectors and smoke alarms, and a few are aware of joint smoke/CO detector units. Participants generally thought CO detector installation was easy (especially for plug-in units), but they were unclear about where detectors

should be placed. Most individuals thought CO detectors should be near gas appliances, such as furnaces and stoves. Others thought placing the detectors in bedrooms was ideal or that CO detectors should be near smoke alarms. Participants are also confused about the proper height of CO detectors: some thought they should be installed on the ceiling while others thought a lower installation, such as outlet level, was correct.

Participants have mixed opinions about when to change the batteries in smoke alarms and CO detectors. Several individuals recognized that batteries should be changed every 6 months, but others thought that newer detectors would chirp when power is low and, thus, do not require regular battery changes. Regardless, most individuals actually change smoke alarm batteries when they chirp. (Several people reasoned that, because the detectors are hardwired and rely on batteries only during power outages, there is no need to change them more frequently.)

Individuals change CO detector batteries even less frequently. Some participants change the batteries every 1 to 2 years, but others admitted that they had not thought about battery changes because the detectors are plug-in units.

Hypothetical Reaction to CO

We asked participants how they would hypothetically respond if they discovered CO in their home. Most participants said they would evacuate the home, and many said they would try to ventilate it by opening windows and doors. Several participants also said they would contact the fire department or another expert to locate the source of CO, although some individuals would try to do it themselves.

Preventing CO Poisoning

A few individuals see CO detectors as the primary way to prevent CO poisoning, but most suggested personally checking and regularly maintaining fuel-burning appliances, such as stoves and heating systems. In particular, participants thought ensuring that gas stoves and fireplaces were turned off at night was a key prevention strategy. A few participants also suggested less appropriate strategies, such as cleaning the ductwork and vacuuming furnace basins.

In contrast to earlier statements, most participants are unconcerned about the risk of CO poisoning when using a generator. Despite a number of individuals placing generators on porches and in garages, many feel they are already using their generator in an open, ventilated space and could do little else to prevent CO poisoning. However, some did propose proper generator maintenance as a prevention strategy.

Sources of CO Information

Most participants recalled seeing or hearing information about carbon monoxide, and many cited TV and radio news stories as the source. The most common experience: Participants saw a news story on a fatal or near-fatal poisoning. In many cases, the stories covered generator poisonings after hurricanes or charcoal grill poisonings during winter; however, no participant recalled coverage of generator poisonings after winter storms.

In addition to news stories, a few participants recalled seeing public service announcements, commercials for CO detectors, or safety messages on the Weather Channel and other TV stations. However, proactive safety messages were usually tied to hurricanes rather than winter

storms. One individual also participated in a first responder class in which CO was addressed. In general, participants did not alter their behavior after hearing about carbon monoxide. A few individuals purchased CO detectors, but most saw the information as a reminder of CO safety and said it reinforced their current behavior.

Promoting CO Detectors

Focus group participants offered several ideas for promoting carbon monoxide safety and CO detectors. Many suggested emphasizing family safety or tying the issue to environmentalism. Several also suggested selling CO detectors alongside or in combination with generators, selling joint smoke/CO detectors, and providing discounts on homeowners' insurance for having CO detectors. Many participants even thought fire departments or city governments could provide free detectors to homeowners.

Participants also recommended several educational outlets. Many thought including information about CO in utility bills would be effective, and several suggested promoting detectors through schools or health departments. (One rationale: If children learn about CO, they may nag their parents to buy a CO detector.) Others suggested placing advertisements or public service announcements on TV, radio, and billboards, and several individuals mentioned the Weather Channel as an effective media outlet. Participants also thought schools, supermarkets, and hardware stores would be good locations for educational displays.

Finally, respondents identified several reasons people may not have or want a CO detector. Most participants thought being unaware of CO and its severity was the biggest obstacle. Several participants also thought cost, or even perceived cost, was a barrier and that many individuals simply don't believe CO poisoning could happen to them. When asked why they purchased CO detectors, individuals said they often used in-home gas appliances and were concerned about fumes, but none cited a source for learning about CO poisoning.

Future Generator Usage

We closed the focus groups by asking participants if they intended to use their generators any differently in the future. Despite many individuals placing generators on covered porches or near the house, most individuals said they would continue using their generators as before. However, one individual said he/she would likely check the generator more frequently during power outages, and another said he/she would purchase CO detectors.

Recommendations

Based on the findings above, we've outlined several recommendations for educating consumers about generator safety and for promoting carbon monoxide detectors:

- Gas stations may be a good outlet for promoting CO safety and CO detectors, as consumers tend to gas up vehicles prior to a storm and because they tend to test generators before a storm hits.
- Grocery stores may be another strategic outlet for promoting CO safety. Many individuals purchase groceries and supplies before a winter storm.
- Target individuals who place generators on covered porches and patios. These seem to be the most common "dangerous locations" for generators, so targeting these individuals

may have the biggest impact. Emphasize that any attached building or porch with a roof is not ventilated enough.

- Include CO safety messages on utility company hotlines during power outages. After a storm, individuals often call the hotline to estimate when power will be restored.
- Clearly define well ventilated for consumers. Individuals want to make sure the generator is well ventilated; they're just not sure what "well ventilated" means and how they achieve it. Many believe covered or semi-enclosed areas are still ventilated.
- Dovetail CO safety with electrical safety. Individuals are concerned about electrical safety when using generators and appear willing to learn more about it. If we combine electrical and CO safety messages, individuals may be more likely to listen.
- Noise is a major factor in generator placement and may be useful in reinforcing the need to locate the generator away from the house.
- Propose safe ways for individuals to protect their generator from winter weather. This is a major concern, which often leads individuals to place generators in covered areas.
- Educate individuals about CO detector placement. Few individuals placed CO detectors in bedrooms, common areas, or garages; most stuck them near furnaces or other gas appliances.
- Deliver safety messages explicitly about generators and winter storms. Currently, most safety announcements focus on hurricane generator usage or winter storm charcoal usage.
- Explore innovative routes for CO safety education—school demonstrations, supermarket displays, gas/utility bill notices, etc.
- Explore innovative methods for CO detector promotion—homeowner insurance discounts, fire department distribution, combination generator / detector sales, etc.

Appendix E—Field Test Findings

RTI and the Centers for Disease Control and Prevention (CDC)

Executive Summary and Recommendations

July 20–21, 2010

Introduction

The following summarizes findings from four focus groups led by Vanguard Communications—two held in Buffalo, N.Y., and two held in Virginia Beach, Va., on behalf of RTI and the Centers for Disease Control and Prevention (CDC). The goal was to learn how best to inform people about ways to prevent carbon monoxide poisoning by testing the effectiveness and motivational quality of various types of CO materials.

Methodology

The first focus group in Buffalo, N.Y., consisted of 10 homeowners ages 52–76 that use a gas furnace as a primary source of heating. The second group consisted of 10 homeowners ages 35–49 that use a gas furnace as a primary source of heating. Both groups were evenly split between men and women; similarly, in each group, two of the respondents in each group identified themselves as African-American, one of them as Hispanic, and seven as White.

The first focus group in Virginia Beach, Va., consisted of 11 homeowners ages 30–67 that use a gas furnace as a primary source of heating. The group was evenly split between men and women. Four of the respondents identified themselves as African-American and seven as white. The second group consisted of 10 homeowners ages 26–70. Every participant in the group had a generator, and a majority also had furnaces. This group was evenly split between men and women. Five of the respondents identified themselves as African-American and five as white.

Each group lasted approximately two hours. The focus groups were held in Buffalo's Survey Service, Inc. facility and Virginia Beach's Martin Focus Group Services facility.

Recruitment and Eligibility

To be eligible to participate in the Buffalo groups, individuals had to own a single-family home that uses either a gas or oil-burning furnace for heating. To be eligible to participate in the Virginia Beach groups, individuals had to own a portable gasoline-powered generator and have used it during a storm-related power outage, such as one caused by a summer storm. Participants also had to be the primary person responsible for operating the generator during an outage. While not eligibility criteria, we aimed for diversity in race and ethnicity across participants as well.

Potential participants were contacted by telephone, administered a verbal consent, and screened for eligibility. If eligible, individuals were enrolled in a focus group and subsequently reminded of the focus group scheduled time 48 hours in advance.

Data Collection

When participants arrived at the focus group facility, facility staff welcomed them and administered a written informed consent form and a written questionnaire. A trained Vanguard Communications moderator and core project team member moderated each focus group using a semi-structured guide, and a dedicated notetaker documented the conversation. In addition, we audio-recorded the focus groups. At the conclusion of the focus groups, we provided each participant with a \$75 incentive.

Participant Characteristics

A total of 41 individuals participated in the four focus groups: 10 people in each of three groups and 11 people in one group. Participants ranged in age from 30 to 76 years old.

Findings and Recommendations

Beyond comments specific to draft materials being tested in the focus groups, the following recommendations for educating consumers about CO safety and for promoting the proper use of carbon monoxide detectors were derived from the participants' responses.

Generator, Furnace, and Alarm Use

- A majority of respondents had heard information about the safe use of generators, furnaces, and CO alarms.
- All respondents said that "CO alarms" should be referred to as "CO detectors."
- The main source of information overall was the news.

Generators

- A majority of participants said that they heard about the safe use of generators after big storms, like the "October storm" in Buffalo and when hurricanes are approaching in Virginia Beach.
- Participants expected to find information about the safe use of generators at hardware stores, Home Depot, Loews, BJ's, Sam's Value, grocery stores, the health department, home insurance companies, owner's manuals, a tag on the cord or sticker on the generator, CDC, fire department, and Google.

Furnaces

- Respondents noted hearing information about the safe use of furnaces from the media, companies that service furnaces, service vendors' commercials, local gas company, PSA, local energy company, word of mouth, and the local fire department.
- Participants would expect to find information about the safe use of furnaces on a sticker on the furnace or on the installer's Web site.

CO detectors

- Participants had heard information about the safe use of CO detectors from Senior Services, the county Department of Health, local fire department, pediatrician, billboard featuring a local family who lost their sons to CO poisoning, state law, flyer from security system provider, and a PSA during fire prevention month.
- The respondents expected to hear information about CO detectors at the local hardware store, on the CO detector box, on appliances that could emit dangerous levels of CO, Consumer Reports, schools, and CO detector manufacturers' commercials.

Developing Materials

- “CO alarms” should be referred to as “CO detectors.”
- Participants liked the use of red in all materials and disliked blue.
- Participants were attracted to messages that created a sense of “urgency” and brought the issue “close to home.”
- The terms “family,” “home,” “you,” “killer,” and “silent killer” attracted participants to messages.
- Participants like very specific information so they know exactly what they need to do to protect their home and loved ones from CO poisoning.
- CO should always be spelled out first instead of just using “CO.”
- Information about the safe use of CO detectors, furnaces, and generators should be included in the box with the CO detector.

Carbon Monoxide Prevention Materials Testing

Introduction

The following summarizes findings from four focus groups—two held in Miami, Fla., on August 24, 2010, with portable generator owners and two held in Buffalo, N.Y., on August 25, 2010, with owners of homes with fuel-burning furnaces. The goal of the focus groups was to test the effectiveness and motivational quality of various types of Carbon Monoxide (CO) materials that were developed on behalf of the Centers for Disease Control and Prevention (CDC) with the input of the previous focus groups held in Buffalo and Virginia Beach, Va., in July 2010.

Methodology

The Miami focus groups were conducted by Vanguard Communications. The participants were segmented by age—one group of adults ages 28 to 50 and another group of adults ages 51 and older—to examine differences in knowledge and practice by experienced and newer homeowners. The Buffalo focus groups also were segmented by age with one group of adults ages 31 to 50 and another group of adults ages 51 and older.

Recruitment and Eligibility

To be eligible to participate in the Buffalo groups, individuals had to own a single-family home that uses either a gas or oil-burning furnace for heating. To be eligible to participate in the Miami groups, individuals had to own a portable gasoline-powered generator and have used it during a storm-related power outage, such as one caused by a summer storm. Participants also had to be the primary person responsible for operating the generator during an outage. While not eligibility criteria, we aimed for diversity in race and ethnicity across participants as well.

Potential participants were contacted by telephone, administered a verbal consent, and screened for eligibility. If eligible, individuals were enrolled in a focus group and subsequently reminded of the focus group scheduled time 48 hours in advance.

Data Collection

When participants arrived at the focus group facility, facility staff welcomed them and administered a written informed consent form and a written questionnaire. A trained Vanguard Communications moderator and core project team member moderated each focus group using a semi-structured guide, and a dedicated notetaker documented the conversation. In addition, we audio-recorded the focus groups. At the conclusion of the focus groups, we provided each participant with a \$75 incentive.

Participant Characteristics

A total of 40 individuals participated in the four focus groups: 10 people in each group. Participants ranged in age from 28 to 78 years old.

Findings and Recommendations

Beyond comments specific to draft materials being tested in the focus groups, the following recommendations for educating consumers about CO safety and for promoting the proper use of carbon monoxide detectors were derived from the participants' responses.

Generator, Furnace, and Alarm Use

Generator use

- Participants noted having heard a lot of information about the safe use of generators on television news, during and after a big storm. The news media also reports heavily on the safe use of generators after someone in the area dies from CO poisoning linked to a generator.
- Several participants suggested that hardware stores like Home Depot and Lowes should hold free workshops on how to properly run a generator.
- People expected to find information about the safe use of generators on the news, in the newspaper, on the radio, at churches, through local government, where they buy generators, in hardware stores, and inside the generator box.
- One participant thought that when buying a generator, customers should have to go through all of the safety information before being permitted to take it home.
- Another respondent explained that when people are rushing to get generators during storm season, they are less likely to pay attention to messages about CO. The participant suggested including the information in the box with the generator or on the generator itself.

Furnace use

- People heard recommendations about the use of furnaces from private commercial companies' advertisements that talk about maintenance and the dangers of not having the maintenance done annually. Some respondents said that they question the information because of the source.
- Respondents said that they hear about the dangers of not properly maintaining a furnace on the news when people in the area die from CO poisoning.

CO alarm use

- Many respondents said that CO alarms should be near bedrooms, in the kitchen, and in hallways so that they are easily heard, but some people said they were not sure exactly where the alarms should be installed.
- Some respondents said that they have heard information about CO alarms in the news, typically during and before storms or when there has been a local incident of CO poisoning.

Developing Materials

- Participants felt that the CDC was a credible source for the information presented and thought that the CDC logo should be bigger to emphasize the source of the information. CO poisoning information should be attached to furnaces and generators, as well as included in the equipment's packaging and user's guide.
- Respondents stressed the importance of making the text as brief as possible.
- The words "poison," "death," or "kills" should be in the first reference on each material to show the danger of CO poisoning to people that are unaware, i.e., "poisonous carbon monoxide." Each first reference to carbon monoxide should also be shown as "carbon monoxide (CO)."

- Materials should include graphic and design elements in red and the word “danger” to capture people’s attention.
- If possible, any radio or television PSA should attribute the source of the information to CDC and begin with “the following announcement is a public service message from the Centers for Disease Control and Prevention.”
- Respondents recommended including a “bill stuffer” or a magnet in utility bills, as utility bills capture their attention. Some added that magnets attract more attention than a bill stuffer.