Incidents, Deaths, and In-Depth Investigations Associated with Non-Fire Carbon Monoxide from Engine-Driven Generators and Other Engine-Driven Tools, 1999–2010

CPSA 6(b)(1) CLEARED for PUBLIC
NO MFRS/PRVTLBLRS OR PRODUCTS IDENTIFIED
7/29/11
EXCEPTED BY: PETITION RULEMAKING ADMIN. PRCDG
WITH PORTIONS REMOVED: _____

Matthew V. Hnatov
U.S. Consumer Product Safety Commission
Directorate for Epidemiology
Division of Hazard Analysis
4330 East West Highway
Bethesda, MD 20814
July 2011

This analysis was prepared by the CPSC staff and has not been reviewed or approved by, and may not necessarily reflect the views of, the Commission.

Contents

Executive Summary

This report summarizes non-fire carbon monoxide (CO) incidents associated with engine-driven generators and other engine-driven tools that occurred between 1999 and 2010, and were reported to the U.S. Consumer Product Safety Commission (CPSC) staff as of Feb. 17, 2011. It should be noted that this report's cut-off date for incidents reported to the CPSC is months earlier than in prior reports due to an earlier release date of this year's annual report. Therefore, it is likely to be even less complete for the two most recent years than were previous reports. Throughout this report, the number of deaths represents a count of the fatalities reported to CPSC staff associated with generators and other engine-driven tools, such as power lawn mowers, garden tractors, portable pumps, power sprayers and washers, snow blowers, and concrete saws. Also included in this report are summaries of fatal, non-fire CO incidents, where an engine-driven tool (EDT) and one or more other fuel-burning consumer products[1] also may have been involved and the EDT was believed to be, at least, a contributing factor to the fatal levels of CO. These fatalities are characterized in the "Multiple Product" category. This report also provides a more detailed summary of fatal, non-fire CO poisoning incidents associated with engine-driven tools based on information found in the CPSC's In-depth Investigation (INDP) File.

Some of the findings of this report are provided below.

CO Fatalities Associated with All EDTs and by EDT Product Type:

- The total fatalities for 1999 through 2010 increased by 64 from the 676 fatalities summarized in the September 2010 report, which reported fatalities for the period 1999 through 2009.
- Seven hundred and forty fatalities from 568 fatal incidents were associated with the use of engine-driven tools, or engine-driven tools used in conjunction with another potentially CO-emitting consumer product, from 1999 through 2010.
- There were 39 non-fire CO fatalities in 2010, from 28 reported incidents. Twenty-nine of these deaths (21 incidents) were associated with a generator; 6 deaths (4 incidents) were associated with a non-generator other engine-driven tool (OEDT); and 4 deaths (3 incidents) were associated with multiple fuel-burning consumer products, one of which was a generator.
- Five hundred and ninety-one (80%) of these 740 fatalities from 434 incidents were associated with generators; 97 fatalities (13%) from 94 incidents were associated with other engine-driven tools; and 52 fatalities (7%) from 40 incidents involved multiple fuel-burning consumer products, one of which was a generator (47 of 52 deaths) or OEDT (4 of 52 deaths) or both a generator and an OEDT (1 of 52 deaths).
- Of the 40 incidents that involved multiple consumer products, all but one incident involved a heating or cooking product, most commonly a portable LP- or kerosene-fueled portable heater. One incident involved a generator and another EDT (a lawnmower).
- Twenty-seven percent of generator-related, non-fire CO incidents caused multiple fatalities, while all but three of the other engine-driven tool-related incidents (97 percent) involved a single fatality. Twenty-five percent of multiple product-related, non-fire CO incidents caused multiple fatalities.
- More than two-thirds (436 of 639) of generator-related fatalities detailed in this report (including fatalities involving multiple products where one product was a generator) occurred between 2005 and 2010.

Socio-demographic Characteristics of Victims and EDT Use Patterns:

- Eighty percent of generator-related victims were 25 years old or older, while 99 percent of other engine-driven tool-related victims were 25 years old or older.

---

[1] Combustion consumer products produce heat or energy by burning a fuel source. It should be noted that all fuel-burning consumer products create gases with CO because CO is a by-product of incomplete combustion.

- Nearly three-quarters of the generator-related non-fire CO victims were male, while all but three of the other engine-driven tool-related fatalities were male (97 percent).
- Nearly half of generator-related, non-fire CO fatalities (284 of 591) occurred in the four colder months of the year (November through February), while CO fatalities associated with OEDT were only slightly more prevalent in the colder months (41 percent) than the transitional and warm months (35 percent and 24 percent, respectively).
- Seventy-two percent of the generator-related fatalities and 79 percent of fatalities from multiple products, where one was a generator, occurred in fixed structure homes, while 52 percent of OEDT fatalities occurred in fixed structure homes.
- Eighty-three percent of the generator-related fatalities are known to have occurred in urban or large rural areas, and another 17 percent occurred in small rural and isolated areas.

CO Alarm Usage:

- A CO alarm was reported to have been present in only 14 of 232 incidents where alarm presence was known, which accounted for 19 of 317 (6 percent) EDT-related CO fatalities. In seven of the incidents (10 deaths), the alarm was inoperable due to no batteries or no electric current. The alarm sounded in four incidents (four deaths), and in two incidents (two deaths), the alarm was powered, but did not sound. Nine of the 10 fatality cases (six of seven incidents) with inoperable alarms were associated with generator usage.

Hazard Patterns Associated with Generators:

- Thirty percent of all generator-related, non-fire CO deaths (194 of 639) were associated with power outages. Of these 194 fatalities, 53 (27 percent) occurred in 2005. Thirty-one of the 2005 fatalities were related to hurricanes or tropical storms, and another 20 were related to ice or snow storms. (Additionally, one fatality was associated with a thunderstorm; and for one fatality, it could not be determined what caused the power outage.)
- Four hundred and sixty-three non-fire CO fatalities that occurred in fixed-structure homes were associated with a generator or a generator in use with another CO-generating consumer product. Seventy-one percent (327 of 439) occurred when the generator was placed inside the living area of the home, including the basement, closets, and doorways, but excluding the attached garage, enclosed carport, or attached barn.
- In recent years, the most common location of generators associated with CO fatalities has shifted from the basement to the non-basement living space of the home. From 2004 through 2010, 40 percent of CO fatalities in the home occurred with a generator placed in the non-basement living space of the home, compared to only 21 percent of non-basement use of generators from 1999 through 2003.
- Sixty-seven percent (173 of 259) of generator-related non-fire CO fatalities in fixed structure homes (in which information on ventilation of the generator was available) occurred when no ventilation of the generator was attempted.
- Sixty-one percent (172 of 283) of generator-related non-fire CO fatalities in fixed structure homes, where the size of the home was known and the generator was not located in an external structure, occurred in houses less than 1,500 square feet in size; 81 percent (229 of 283) occurred in houses less than 2,000 square feet in size.
- More than two-thirds (68 percent) of CO fatalities were associated with generators in the 3500 to 6499 watt range, and nearly half (47 percent) were associated with generators in the 5000 to 6499 watt range.

Carboxyhemoglobin Levels in CO Fatality Victims:

- More than 82 percent of the engine-driven tools-related CO fatality victims had carboxyhemoglobin (COHb) levels above the 50 percent level.

Note: Throughout this report, the years 2009 and 2010 are italicized in table headings, indicating that incident and death counts may change as additional information is received.

Introduction

The following CPSC databases were searched to prepare the statistics recorded in this report: the In-depth Investigation (INDP) File, the Injury or Potential Injury Incident (IPII) File, and the Death Certificate (DTHS) File. See Appendix A for the codes and keywords used in the database searches. The data records were combined and collated to develop the most complete records possible in a single database. At this stage, each record was reviewed to determine if the incident was in scope for this report and to correct any discrepancies between information from the different sources. It should be noted that reporting may not be complete, and this report reflects only those incidents reported and entered into CPSC databases on or before Feb. 17, 2011. All fatal, non-fire carbon monoxide (CO) incidents associated with engine-driven tools (EDTs) found during the database search that were determined to be in scope were included.

CPSC records contain information on 740 non-fire CO fatalities associated with EDTs during the years 1999 through 2010. This is an increase of 64 fatalities from the 676 fatalities reported in the September 2010 report on non-fire CO fatalities associated with EDTs.[2] Thirty-nine of these fatalities occurred in 2010, while the remaining 25 occurred in previous years but were reported in 2010. Thirty-five of these 39 fatalities were associated with generators or other engine-driven tools (OEDT) as the only known source of the CO. Four additional fatalities were associated with multiple, combustion –fuel burning consumer products, one of which was an EDT, and classified in the "Multiple Products" category. Incidents associated with generators that were specifically reported as integral parts of recreational vehicles (RVs), motor homes, or boats are not within the jurisdiction of the CPSC, and thus were considered out of scope and were not included. For example, generators that were reported as mounted to the bottom of an RV were not included, nor were boat generators that were installed by the boat manufacturer. Since incidents in recreational vehicles and boats can be associated with a portable generator or an integral generator, those incidents in which the type of generator could not be determined were also excluded from the analysis.

Any incident that was determined to be other than accidental in nature was considered to be out of scope, as were work-related incidents, which are not within the jurisdiction of the CPSC.

This report is divided into four sections:

I. Reported Numbers of Fatalities by EDT Product Type. This presents an overall picture of CO fatalities associated with engine-driven tools.
II. Socio-demographics of Victims and EDT Use Patterns. This presents various socio-demographic summaries helpful in identifying specific characteristics of CO fatality victims and usage patterns, such as when and where fatalities occurred.
III. Alarm Usage. This presents information on CO alarm usage during fatal CO events.
IV. Hazard Patterns Associated with Generators. This presents data specific to generator usage patterns that may lead to fatal CO poisoning events.

Additionally, Appendix B presents summary findings on carboxyhemoglobin levels in the blood of victims of CO poisoning involving EDT use, which are helpful in assessing the hazard presented by the product and the speed of onset of harm.

---

[2] Hnatov, M. V. *Incidents, Deaths, and In-Depth Investigations Associated with Non-Fire Carbon Monoxide from Engine-Driven Generators and Other Engine-Driven Tools, 1999–2009. U.S. Consumer Product Safety Commission. September 2010.*

I. Reported Numbers of Fatalities by EDT Product Type

As of Feb. 17, 2011, CPSC staff had records indicating that there were 28 fatal, non-fire carbon monoxide (CO) exposure incidents involving engine-driven tools between Jan. 1, 2010 and Dec. 31, 2010. Thirty-nine deaths occurred in these 28 fatal CO incidents. Table 1 presents the reported fatal incidents and the number of deaths in 2010, along with a summary of CO incidents and fatalities associated with engine-driven tools for the 12-year period from 1999 through 2010. The table records the number of incidents and deaths by the broad categories of "Generators," "Other Engine-Driven Tools," and "Multiple Products." Multiple product incidents are fatal CO poisonings that involved multiple fuel-burning consumer products that generate CO, at least one being an EDT, or in which investigating authorities could not determine which of multiple consumer products in use at the time of the incident was the source of the CO. CPSC staff is aware of 52 fatalities associated with multiple consumer products occurring between 1999 and 2010; four of these fatalities occurred in 2010. Incidents involving an EDT and a product that generates CO, but is not under the CPSC's jurisdiction, such as automobiles, boats, or recreational vehicles, were determined to be out of scope and are not included in this report.

It should be noted that fatality and incident counts from years prior to 2010 may have changed from the previous report. The changes are due primarily to the addition of new data that were made available to CPSC staff. New to this report are 25 reported fatalities that occurred before 2010, and 39 fatalities that occurred in 2010.

One other change was made for this report that affects only three cases and subsequent yearly counts. In prior reports, date of death was used for the yearly totals. Since publication of the previous report, it has been determined that a more meaningful date is the date of the fatal incident because, occasionally, victims of fatal CO poisoning incidents pass away weeks or months after the poisoning event, which can sometimes be in the next calendar year. The three cases include:

1. an individual who died in March 2004, six months after being hospitalized for CO poisoning in September 2003 (this incident involved two fatalities, with one of the victims dying on the day of the incident);
2. an individual who died in January 2005, three weeks after being hospitalized for CO poisoning in December 2004; and
3. an individual who died in January 2007, five weeks after being hospitalized for CO poisoning in December 2006 (this incident involved five fatalities, with four of the victims dying on the day of the incident).

Within each broad category, the frequency of reports is summarized by product type. Staff is aware of 568 incidents with a total of 740 deaths due to non-fire CO exposure that occurred between 1999 and 2010, involving engine-driven tools.

In Table 1, the product type "welder" appears in both the "Generator" and "Other Engine-Driven Tool" categories. Some welding equipment is designed to be used as a welder or as an electric generator. Two of the fatal, non-fire CO incidents associated with the use of welding equipment, which occurred between 1999 and 2010, involved the use of the welder as a generator during a power outage. Each of these two incidents involved a single death. There were five fatal, non-fire CO incidents between 1999 and 2010 associated with the use of welder equipment, where it was not specifically identified as being used as a generator. Of these five incidents, one incident (involving two deaths) occurred when the welder was being used as a source of heat, and, in the other four incidents (five deaths: three single fatality incidents and one two-fatality incident), when the welder was being used for welding purposes or the method of usage could not be ascertained. These latter five incidents were included in the "Other Engine-Driven Tools" category because there was no evidence that indicated that the welders were being used as generators.

All but one of the 52 non-fire CO fatalities in the "Multiple Products" category involved a heating- or cooking-related consumer product other than an EDT. This single incident involved a generator and a lawn tractor being run in a closed garage.

Table 1: Number of Reported Fatal Non-Fire Carbon Monoxide Exposure Incidents and Deaths Associated with Engine-Driven Tools, 1999–*2010*

Product	*2010*		Total: 1999–*2010*	
	Number of Incidents	***Number of Deaths***	**Number of Incidents**	**Number of Deaths**
Total Engine-Driven Tools	***28***	***39***	**568**	**740**
Generators	***21***	***29***	**434**	**591**
Generator	*21*	*29*	432	589
Welder (used as a generator)[1]	*0*	*0*	2	2
Other Engine-Driven Tools (OEDT)	***4***	***6***	**94**	**97**
Riding Lawn Mower/Garden Tractor	*1*	*1*	50	50
Push Lawn Mower	*0*	*0*	2	2
Powered lawn mower, unspecified type	*0*	*0*	4	4
Power washer/sprayer	*0*	*0*	7	7
Snow blower	*1*	*1*	9	9
All-terrain vehicle	*1*	*2*	5	6
Welder (used as welder or other reason)[1]	*1*	*2*	5	7
Water pump	*0*	*0*	3	3
Concrete saw	*0*	*0*	3	3
Air compressor	*0*	*0*	2	2
Paint Sprayer	*0*	*0*	1	1
Snowmobile	*0*	*0*	1	1
Go-Cart	*0*	*0*	1	1
Small Engine (unknown use)	*0*	*0*	1	1
Multiple Products[2]	***3***	***4***	**40**	**52**
Generator + Other Consumer Products (excluding OEDTs)	*3*	*4*	35	47
OEDT + Other Consumer Products	*0*	*0*	4	4
Generator + OEDT	*0*	*0*	1	1

1 Some welding equipment is designed to be used as either a welder or a generator.

2 "Multiple Products" includes incidents involving generators or OEDTs with other combustion fuel-burning consumer products. "Other Consumer Products" includes one or more of the following: portable LP-fueled heaters, portable kerosene-fueled heaters, camp stoves, lanterns, outdoor cookers, furnaces, and wood stoves, and one case with a generator and an OEDT (lawn mower) in operation.

Note: Italicized numbers indicate that reporting of incidents is ongoing. Counts may change in subsequent reports.

Source: U. S. Consumer Product Safety Commission, Directorate for Epidemiology, 2011.

Four hundred thirty-four of the 568 incidents reported to CPSC staff were associated with a generator and accounted for 591 of the 740 CO deaths (80%). Additionally, 48 other CO fatalities from 36 incidents were associated with use of a generator and another combustion consumer product—most commonly an LP- or kerosene-fueled heater. One of these fatalities involved a generator and another engine-driven tool (lawn tractor). For the rest of this report, this incident will be included in the tables and discussions in the

category *Multiple Products* involving a generator. Throughout the remainder of this report, incidents associated with all non-generator engine-driven tools are reported as a group. In addition, because the majority of incidents were associated with generators, characteristics of these incidents are reported separately in Section IV. Nearly two-thirds of the non-fire, non-generator CO fatalities (57 of 102) involved a garden tractor or other powered lawn mower (including multiple product incidents). Deaths associated with powered lawn mowers were often associated with an individual repairing or working on the product in an enclosed space.

CPSC staff examined the number of deaths associated with each fatal incident (Table 2). Of the 568 fatal incidents, 77 percent involved a single fatality. Seventy-three percent (318 of 434) of fatal generator-related incidents involved a single fatality. One incident involving a generator resulted in the deaths of six individuals, and another incident involved five fatalities. Of the 94 fatal incidents in the "Other Engine-Driven Tools" category, three incidents resulted in more than one fatality. Twenty-five percent of multiple product, fatal CO incidents resulted in multiple fatalities.

Table 2: Number of Reported Fatal Non-Fire Carbon Monoxide Exposure Incidents and Deaths Associated with Engine-Driven Tools by Number of Deaths per Incident, 1999–*2010*

Number of Deaths Reported in Incident[1]	Total		Generator		Other Engine-Driven Tools		Multiple Products[2,3]	
All Incidents	**568**	**100%**	**434**	**100%**	**94**	**100%**	**40 (36)**	**100%**
1	439	77%	318	73%	91	97%	30 (26)	75%
2	96	17%	85	20%	3	3%	8 (8)	20%
3	25	4%	23	5%	0	0%	2 (2)	5%
4	6	1%	6	1%	0	0%	0 (0)	0%
5	1	< 1%	1	< 1%	0	0%	0 (0)	0%
6	1	< 1%	1	< 1%	0	0%	0 (0)	0%

1 SPECIAL NOTE ABOUT COUNTS IN THIS TABLE ONLY: One incident included in this table involved an in-scope, generator-related death and an out-of-scope death (work-related). Because two fatalities were involved in the incident, this incident is included as a two-fatality incident. The out-of-scope fatality is not included elsewhere in the report. Therefore, in this table only, there is one additional fatality reported. The fatality was a generator-related fatality, so it is included in the "Generator" and "Total" columns.

2 "Multiple Products" includes incidents involving generators or OEDTs with other combustion fuel-burning consumer products. "Other Consumer Products" includes one or more of the following: portable LP-fueled heaters, portable kerosene-fueled heaters, camp stoves, lanterns, outdoor cookers, furnaces, and wood stoves, and one case with a generator and another engine-driven tool (lawn mower) in operation.

3 Numbers in parentheses indicate incidents involving a generator and another product, including a case where a generator and an OEDT (lawn mower) were used concurrently.

Notes: Totals may not add to 100 percent due to rounding.
Italicized numbers indicate that reporting of incidents is ongoing. Counts may change in subsequent reports.

Source: U. S. Consumer Product Safety Commission, Directorate for Epidemiology, 2011.

CPSC staff summarized the number of reported deaths associated with engine-driven tools by year of death (Table 3). It should be noted that the values in Table 3 represent the number of deaths reported to CPSC staff as of Feb. 17, 2011. Some deaths are reported to CPSC staff shortly after an incident occurs, while other deaths are reported to CPSC staff months or even years after an incident occurs. Therefore, counts for more recent years may not be as complete as counts for earlier years and may change in the future. For the 12 years covered by this report, nearly two-thirds (488 of 740) of the deaths were reported in the most recent six years (2005 through 2010).

The average number of non-fire CO fatalities associated with both generators and other engine-driven tools for years 2006 through 2008 is also presented in Table 3. These three years represent the most recent years for which CPSC staff believes reporting is substantially complete. Due to reporting delays, these averages may change slightly in the future when data are complete. Figure 1 illustrates the trend in generator-related, non-fire CO fatalities since 1999.

Table 3: Number of Reported Fatal Non-Fire Carbon Monoxide Exposure Incidents and Deaths Associated with Engine-Driven Tools by Year, 1999–*2010*

Year	Total		Generators		Other Engine-Driven Tools		Multiple Products[1,2]	
	Incidents	Deaths	Incidents	Deaths	Incidents	Deaths	Incidents	Deaths
Total	***568***	***740***	***434***	***591***	***94***	***97***	***40 (36)***	***52 (48)***
1999	12	12	6	6	5	5	1 (0)	1 (0)
2000	22	28	14	20	7	7	1 (1)	1 (1)
2001	19	25	14	17	2	2	3 (3)	6 (6)
2002	47	58	34	42	8	9	5 (4)	7 (6)
2003	51	67	38	52	9	9	4 (3)	6 (5)
2004	50	62	34	46	14	14	2 (1)	2 (1)
2005	93	116	73	94	13	13	7 (7)	9 (9)
2006	79	108	60	89	16	16	3 (3)	3 (3)
2007	56	69	46	58	6	6	4 (4)	5 (5)
2008	67	92	59	83	3	3	5 (5)	6 (6)
2009	*44*	*64*	*35*	*55*	*7*	*7*	*2 (2)*	*2 (2)*
2010	*28*	*39*	*21*	*29*	*4*	*6*	*3 (3)*	*4 (4)*
Average: 2006–2008	67	90	55	77	8	8	4	5 (5)

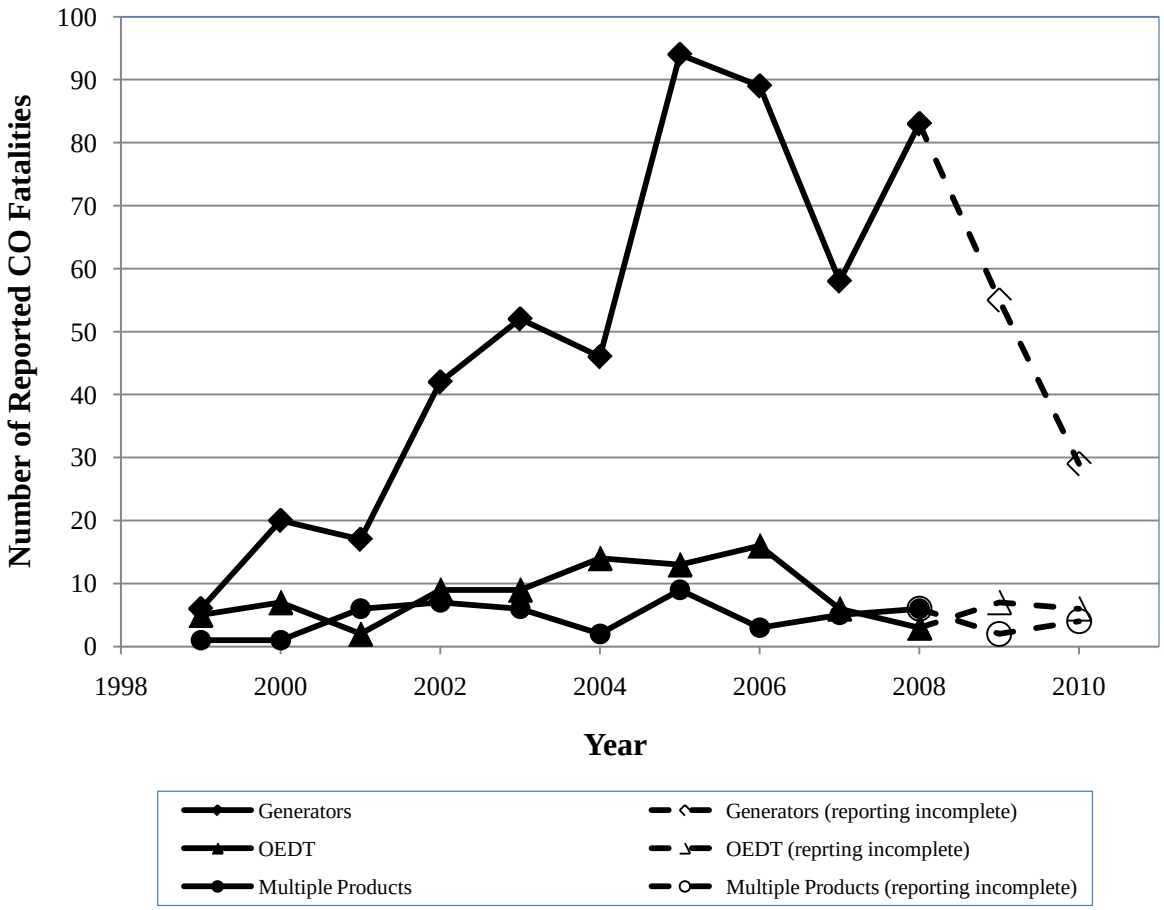
1 "Multiple Products" includes incidents involving generators or OEDTs with other CO generating consumer products. "Other Consumer Products" includes one or more of the following: portable LP-fueled heaters, portable kerosene-fueled heaters, camp stoves, lanterns, outdoor cookers, furnaces, and wood stoves, and one case with a generator and another engine-driven tool (lawn mower) in operation.

2 Numbers in parentheses indicate incidents involving a generator and another product, including the case where a generator and an OEDT (lawn mower) were used concurrently.

Notes: Detail averages may not sum to total average due to rounding.
Italicized numbers indicate that reporting of incidents is ongoing. Counts may change in subsequent reports.

Source: U. S. Consumer Product Safety Commission, Directorate for Epidemiology, 2011.

Figure 1: Number of Reported Fatal Non-Fire Carbon Monoxide Exposure Incidents and Deaths Associated with Engine-Driven Tools, 1999–*2010*



II. Socio-Demographic Characteristics of Victims and EDT Use Patterns

This section presents socio-demographic information about the victims of reported fatal CO incidents associated with engine-driven tools (EDTs). Tables 4 and 5 present the distribution of age and gender of the victims, respectively. Table 4 shows that victims aged 25 years or older accounted for about 83 percent (615 of 740) of reported non-fire CO poisoning deaths associated with all engine-driven tools. Victims with a reported age of 25 years or older accounted for about 80 percent (473 of 591) of non-fire CO poisoning deaths associated with generators and accounted for all deaths associated with other engine-driven tools. Eighty-two percent of the non-fire CO fatalities associated with non-generator engine-driven tools (80 of 97) involved victims age 45 or older, with only one reported fatality of an individual younger than 25. Male victims accounted for 78 percent of the deaths associated with all engine-driven tools. Male victims comprised 74 percent of the deaths associated with generators and 97 percent of non-generator engine-driven tool fatalities (Table 5).

Table 4: Number of Reported Fatal Non-Fire Carbon Monoxide Exposure Incidents and Deaths Associated with Engine-Driven Tools by Age of Victim, 1999–*2010*

Age	Number of Deaths Reported to CPSC							
	All Engine-Driven Tools		Generators		Other Engine-Driven Tools		Multiple Products[1,2]	
Total	**740**	**100%**	**591**	**100%**	**97**	**100%**	**52 (48)**	**100%**
Under 5	14	2%	14	2%	0	0%	0 (0)	0%
5–14	25	3%	25	4%	0	0%	0 (0)	0%
15–24	78	11%	71	12%	1	1%	6 (6)	12%
25–44	225	30%	195	33%	16	16%	14 (14)	27%
45–64	274	37%	197	33%	53	55%	24 (22)	46%
65 and over	116	16%	81	14%	27	28%	8 (6)	15%
Adult, age unknown	6	1%	6	1%	0	0%	0 (0)	0%
Unknown age	2	< 1%	2	< 1%	0	0%	0 (0)	0%

1 "Multiple Products" includes incidents involving generators or OEDTs with other CO generating consumer products. "Other Consumer Products" includes one or more of the following: portable LP-fueled heaters, portable kerosene-fueled heaters, camp stoves, lanterns, outdoor cookers, furnaces, and wood stoves, and one case with a generator and another engine-driven tool (lawn mower) in operation.

2 Numbers in parentheses indicate incidents involving a generator and another product, including the case where a generator and an OEDT (lawn mower) were used concurrently.

Notes: Totals may not add to 100 percent due to rounding.
Italicized numbers indicate that reporting of incidents is ongoing. Counts may change in subsequent reports.

Source: U. S. Consumer Product Safety Commission, Directorate for Epidemiology, 2011.

Table 5: Number of Reported Fatal Non-Fire Carbon Monoxide Exposure Incidents and Deaths Associated with Engine-Driven Tools by Gender of Victim, 1999–*2010*

Gender	Number of Deaths Reported to CPSC							
	All Engine-Driven Tools		Generators		All Other Engine-Driven Tools		Multiple Products[1,2]	
Total	**740**	**100%**	**591**	**100%**	**97**	**100%**	**52 (48)**	**100%**
Male	574	78%	435	74%	94	97%	45 (41)	87%
Female	162	22%	152	26%	3	3%	7 (7)	13%
Unknown	4	1%	4	1%	0	0%	0 (0)	0%

1 "Multiple Products" includes incidents involving generators or OEDTs with other CO generating consumer products. "Other Consumer Products" includes one or more of the following: portable LP-fueled heaters, portable kerosene-fueled heaters, camp stoves, lanterns, outdoor cookers, furnaces, and wood stoves, and one case with a generator and another engine-driven tool (lawn mower) in operation.

2 Numbers in parentheses indicate incidents involving a generator and another product, including the case where a generator and an OEDT (lawn mower) were used concurrently.

Notes: Totals may not add to 100 percent due to rounding.
Italicized numbers indicate that reporting of incidents is ongoing. Counts may change in subsequent reports.

Source: U. S. Consumer Product Safety Commission, Directorate for Epidemiology, 2011.

Staff examined reported deaths associated with engine-driven tools by the time of year that the incident occurred (Table 6). The non-fire CO fatalities were classified into one of three categories depending on the month in which the incident occurred: Cold months, Warm months, and Transitional months. "Cold months" are defined as November, December, January, and February; "Warm months" as May, June, July, and August; and "Transitional months" as March, April, September, and October.

Nearly half (48%) of the non-fire CO deaths associated with generators occurred in the cold months of November through February. Many of the fatalities can be directly associated with the use of generators during power outages due to weather conditions such as ice or snow storms. Thirty percent of the generator-related CO deaths occurred in the transitional months of March, April, September, and October. A large portion of the non-fire CO fatalities in the transitional months can be directly associated with the use of generators during power outages due to hurricanes and tropical storms, many of which occurred in September and, to a lesser extent, October. Further details on this issue are presented in Section IV of this report.

For OEDTs, CO fatalities were only slightly more prevalent in the cold months (41%) than the transitional months (35%) and warm months (24%). The *Multiple Products* category had a very large proportion of fatalities in the cold months (75%), with the remaining 25percent in the transitional months and no fatalities occurring in the warm months. This large percentage of fatalities in the cold months can be explained by examining the other fuel burning consumer products in use at the time of the deaths. Of the 52 CO fatalities that involved multiple consumer products, 48 involved the use of a generator, and all but one involved a heating or cooking product, most commonly a portable LP- or kerosene-fueled portable heater. Heaters are used almost exclusively in the cold and transitional months.

Table 6: Number of Reported Fatal Non-Fire Carbon Monoxide Exposure Incidents and Deaths Associated with Engine-Driven Tools by Season, 1999–*2010*

Season Incident Occurred	Number of Deaths Reported to CPSC							
	All Engine-Driven Tools		Generators		Other Engine-Driven Tools		Multiple Products[1,2]	
Total	**740**	**100%**	**591**	**100%**	**97**	**100%**	**52 (48)**	**100%**
Cold months	362	49%	284	48%	40	41%	38 (36)	73%
Transitional months	226	31%	178	30%	34	35%	14 (12)	27%
Warm months	152	21%	129	22%	23	24%	0 (0)	0%

1 "Multiple Products" includes incidents involving generators or OEDTs with other CO generating consumer products. "Other Consumer Products" includes one or more of the following: portable LP-fueled heaters, portable kerosene-fueled heaters, camp stoves, lanterns, outdoor cookers, furnaces, and wood stoves, and one case with a generator and another engine-driven tool (lawn mower) in operation.

2 Numbers in parentheses indicate incidents involving a generator and another product, including the case where a generator and an OEDT (lawn mower) were being used concurrently.

Notes: Totals may not add to 100 percent due to rounding.
Italicized numbers indicate that reporting of incidents is ongoing. Counts may change in subsequent reports.

Source: U. S. Consumer Product Safety Commission, Directorate for Epidemiology, 2011.

Incidents involving deaths are further summarized in Table 7 by the location where the death occurred. The majority of non-fire CO poisoning deaths (614 of 740, or 83%) reported to CPSC staff associated with engine-driven tools occurred at home locations. Sixty-nine percent of the deaths occurred at fixed structure residences, which includes single-family homes, apartments, townhouses, and mobile homes. Another 11 percent occurred in external structures at home locations, such as detached garages or sheds. And another three percent occurred in nontraditional homes, such as travel trailers, houseboats, or storage sheds used as permanent residences. The "Temporary shelter" category includes incidents in which victims died from CO poisoning from portable generators or other engine-driven tools while the victims were temporarily occupying trailers, horse trailers, recreational vehicles (RVs), cabins (used a temporary shelter), tents, and campers. Incidents that occurred in a temporary shelter, where the generator was an integral part of the temporary shelter, such as built-in generators or generators built specifically for use in an RV, were determined to be out of scope for this report and were excluded. The "Boat/Vehicle" category only includes incidents in which a generator or other engine-driven tool was not an integral part of the boat— but was brought onto the boat—and incidents where an EDT was brought into a vehicle, such as a van. As with temporary shelters, incidents involving generators that were built-in or specifically designed for a boat are not considered in scope and are not included in this report. The "Other" category includes incidents that occurred in the following locations: office buildings, utility buildings, and storage sheds (offsite from home).

Table 7: Number of Non-Fire Carbon Monoxide Poisoning Deaths Reported to CPSC Staff and Associated with Engine-Driven Tools by Location, 1999-*2010*

Location	Number of Deaths Reported to CPSC							
	All Engine-Driven Tools		Generators		Other Engine-Driven Tools		Multiple Products[1,2]	
Total	**740**	**100%**	**591**	**100%**	**97**	**100%**	**52 (48)**	**100%**
Home, fixed Structure[3]	514	69%	425	72%	50	52%	39 (38)	75%
Home, detached Structure[4]	81	11%	39	7%	38	39%	4 (1)	8%
Home, non-house[5]	19	3%	14	2%	4	4%	1 (1)	2%
Temporary shelter	84	11%	76	13%	2	2%	6 (6)	12%
Boat/Vehicle	20	3%	16	3%	2	2%	2 (2)	4%
Other	13	2%	13	2%	0	0%	0 (0)	0%
Not reported	9	1%	8	1%	1	1%	0 (0)	0%

1 'Multiple Products' includes incidents involving generators or OEDTs with other CO generating consumer products. Other consumer products include one or more of the following: portable LP-fueled heaters, portable kerosene-fueled heaters, camp stoves, lanterns, outdoor cookers, furnaces, and wood stoves, and one case with both a generator and another engine-driven tool (lawn mower) in operation.

2 Numbers in parentheses indicate incidents involving a generator and another product including the case where both a generator and an OEDT (lawn mower) were being used concurrently.

3 This refers to a fixed location structure used as a residence including houses, mobile homes, apartments, townhouses, etc. and attached structures to the house such as an attached garage.

4 This refers to detached structures at home locations including detached garages, sheds, etc.

5 This refers to non-fixed location residences including travel trailers, houseboats, etc.

Notes: Totals may not add to 100% due to rounding.
Italicized numbers indicate that reporting of incidents is ongoing. Counts may change in subsequent reports.

Source: U. S. Consumer Product Safety Commission, Directorate for Epidemiology, 2011.

Table 8 presents the number of non-fire CO poisoning deaths reported to CPSC staff and associated with EDTs categorized by the population density of the place of death. All fatal incidents were assigned to one of four rural/urban categories based on the Rural-Urban Commuting Area (RUCA) codes developed by the Economic Research Service (ERS) of the United States Department of Agriculture (USDA). The four broad categories are Urban, Large Rural, Small Rural, and Isolated.

Details on the process of determining population density, or rurality, can be found at the U.S. Department of Agriculture website at the following URL: http://www.ers.usda.gov/briefing/Rurality/. Additional information regarding the cross referencing of zip codes to RUCA codes can be obtained from the University of Washington, WWAMI[1] Rural Health Research Center website at the following URL: http://depts.washington.edu/uwruca/.

Eighty-three percent (492 of 591) of CO fatalities associated with the use of generators and reported to CPSC staff occurred in urban and large rural areas. The estimated proportion of the U.S. population living in urban and large rural areas is 91%. There appears to be an unusually high proportion of fatalities in small rural and isolated areas. Eighteen percent (130 of 740) of the CO fatalities known to CPSC staff to be associated with EDTs occurred in small rural and isolated areas where only an estimated 9% of the U.S. population live.

[1] The WWAMI name is derived from the first letter of each of the five cooperating states in a partnership between the University of Washington School of Medicine and the states of Wyoming, Alaska, Montana, and Idaho.

Table 8: Number of Reported Fatal Non-Fire Carbon Monoxide Exposure Incidents and Deaths Associated with Engine-Driven Tools by Population Density of Place of Death, 1999–*2010*

Population Density	Estimated Percentage of U.S. Population[1]	Number of Deaths Reported to CPSC							
		All Engine-Driven Tools		Generators		Other Engine-Driven Tools		Multiple Products[2,3]	
Total	**100%**	**740**	**100%**	**591**	**100%**	**97**	**100%**	**52 (48)**	**100%**
Urban	81%	515	70%	421	71%	59	61%	35 (32)	67%
Large Rural	10%	95	13%	71	12%	17	18%	7 (6)	13%
Small Rural	5%	57	8%	40	7%	11	11%	6 (6)	12%
Isolated	4%	73	10%	59	10%	10	10%	4 (4)	8%

1 Estimated 2008 U.S. population categorized by RUCA designation. The 2008 population estimates by RUCA classification are the most recent available. U.S. population estimates by RUCA classification was obtained from a Health Resources and Services Administration report, 2009.

2 "Multiple Products" includes incidents involving generators or OEDTs with other CO generating consumer products. "Other Consumer "Products" includes one or more of the following: portable LP-fueled heaters, portable kerosene-fueled heaters, camp stoves, lanterns, outdoor cookers, furnaces, and wood stoves, and one case with a generator and another engine-driven tool (lawn mower) in operation.

3 Numbers in parentheses indicate incidents involving a generator and another product, including the case where a generator and an OEDT (lawn mower) were being used concurrently.

Notes: Totals may not add to 100 percent due to rounding.
Italicized numbers indicate that reporting of incidents is ongoing. Counts may change in subsequent reports.

Source: U. S. Consumer Product Safety Commission, Directorate for Epidemiology, 2011.
WWAMI Rural Research Center at the University of Washington
Economic Research Group, USDA.
Health Resources and Services Administration, 2009.

III. Alarm Usage

Table 9 presents a summary of CO fatalities known to CPSC staff characterized by CO alarm usage and alarm status. In 59 percent of the fatal incidents (336 of 568) and 57 percent of reported CO poisoning deaths (423 of 740), the presence of a CO alarm at the location of the incident was unknown or unreported. Of the 232 fatal incidents (317 CO fatalities) associated with engine-driven tools in which it was known whether a CO alarm was present or not, a CO alarm was present in only 14 incidents (6%) involving 19 CO fatalities. Of these 14 fatal incidents, the alarm was known to be inoperable in seven incidents (10 fatalities) due to missing batteries from a battery powered alarm (non-plug-in type) or because the alarm was a plug-in type and power was out at the location of the incident. Six of the seven fatal incidents (nine fatalities) with inoperable alarms were associated with generator usage.

For the remaining seven fatal incidents (nine fatalities) where an alarm was known to be present, the alarm was known to have sounded in only four incidents (four deaths). Three of the four incidents occurred in an attached garage of a home with the alarm sounding inside the house. In the fourth incident, the victim's family reportedly did not understand that the alarm sounding pattern (sounding every few minutes) was indicating CO present in the home and thought it simply meant that the alarm was working. In an additional two CO deaths from two separate incidents, an apparently operable CO alarm failed to sound, even though lethal levels of CO were present in the home. There were also three deaths in one incident in which a CO alarm was present in the house, but it was unknown whether it sounded or if it was even operable.

Table 9: Carbon Monoxide Alarm Usage Associated with Engine-Driven Tools Non-Fire Carbon Monoxide Poisoning Deaths, 1999–*2010*

CO Alarm Status	Number of Deaths and Percentage of Deaths when Alarm Status was Known							
	All Engine-Driven Tools		Generators		Other Engine-Driven Tools		Multiple Products[1,2]	
Total	**740**	**-**	**591**	**-**	**97**	**-**	**52 (48)**	**-**
Alarm Status Known	**317**	**100%**	**265**	**100%**	**31**	**100%**	**21 (18)**	**100%**
No Alarm	**298**	**94%**	**250**	**94%**	**29**	**94%**	**19 (17)**	**90%**
Alarm Present	**19**	**6%**	**15**	**6%**	**2**	**6%**	**2 (1)**	**10%**
Alarmed	4	1%	1	< 1%	2	6%	1 (1)	5%
Did not alarm, batteries removed	2	1%	2	1%	0	0%	0 (0)	0%
Did not alarm, plug-in type, no power	8	3%	7	3%	0	0%	1 (0)	5%
Did not alarm, though powered	2	1%	2	1%	0	0%	0 (0)	0%
Alarm present, Unknown if it alarmed	3	1%	3	1%	0	0%	0 (0)	0%
Alarm Status Unknown	**423**	**-**	**326**	**-**	**66**	**-**	**31 (30)**	**-**

1 "Multiple Products" includes incidents involving generators or OEDTs with other CO generating consumer products. "Other Consumer Products" includes one or more of the following: portable LP-fueled heaters, portable kerosene-fueled heaters, camp stoves, lanterns, outdoor cookers, furnaces, and wood stoves, and one case with a generator and another engine-driven tool (lawn mower) in operation.

2 Numbers in parentheses indicate incidents involving a generator and another product, including the case where both a generator and an OEDT (lawn mower) were used concurrently.

Notes: Totals may not add to 100 percent due to rounding.
Italicized numbers indicate that reporting of incidents is ongoing. Counts may change in subsequent reports.

Source: U. S. Consumer Product Safety Commission, Directorate for Epidemiology, 2011.

IV. Hazard Patterns Associated with Generators

This section presents information about the usage patterns associated with fatal CO poisoning specific to generators, as well as information about the homes where fatal generator incidents occurred. As of Feb. 17, 2011, CPSC staff is aware of 470 generator-related incidents in 1999 through 2010, which resulted in non-fire CO fatalities. Four hundred-thirty four of these incidents involved only a generator. The remaining 36 incidents involved a generator and another combustion fuel-burning consumer product, including one that was another engine-driven tool. Staff completed In-depth Investigations (IDIs) for 444 of 470 (94%) fatal CO incidents associated with generators that occurred from 1999 through 2010. For the remaining 26 incidents in which an IDI was not performed, attempts were made to augment the data from reports of the incident in the Injury and Potential Injury Incidents (IPII) records or from death certificate information. Summaries of generator-related incidents in this section also include incidents where multiple fuel-burning consumer products were involved, including a generator.

A review of records for the 639 generator-related non-fire CO deaths reported to CPSC staff, which includes 591 fatalities involving a generator alone and 48 involving a generator and another CO-producing consumer product, suggests two main reasons reported for using a generator. One reason cited was to provide electricity to a location that did not have electricity due to a temporary situation (*e.g.*, a power outage), and the other was to provide power to a temporary location. Table 10 provides a breakdown by year listing the reasons why a generator was in use at the time of the incident. Thirty percent (194 of the 639 reported deaths) of the generator-related, non-fire CO fatalities involved the use of generators during a temporary power outage stemming from a weather problem or a problem with power distribution. More than one-sixth (18% or 114 deaths) of the fatalities were associated with the use of generators after power was shut off to the residence by the utility company due to bill dispute or nonpayment. For 100 of the reported fatalities (16%), it could not be determined why the generator was in use or why there was no electricity at the location of the incident.

Table 10: Number of Reported Fatal Non-Fire Carbon Monoxide Exposure Incidents and Deaths Associated with Engine-Driven Tools Generators[1] by Reason for Use, 1999–*2010*

Reason for Use	Total	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	*2009*	*2010*
Total	**639**	**6**	**21**	**23**	**48**	**57**	**47**	**103**	**92**	**63**	**89**	***57***	***33***
Power outage due to weather, or problem with power distribution	194	3	1	3	16	20	11	53	17	23	25	*16*	*6*
Electricity turned off by power company due to bill dispute or nonpayment	114	0	2	1	13	5	6	12	23	15	18	*8*	*11*
Provide power to storage shed, trailer, boat, camper, cabin, campsite	102	0	11	9	7	10	4	11	21	9	7	*8*	*5*
New home or homeowner, and power not yet turned on, home under construction or renovation	65	0	1	3	1	8	14	6	9	2	12	*5*	*4*
Provide power to home or mobile home that normally does not have electricity	35	0	1	5	1	1	4	6	5	5	4	*2*	*1*
Working on or preparing a home for predicted storm	7	1	0	0	0	1	0	0	1	0	4	*0*	*0*
Provide power to a shed or garage that normally does not have electricity	5	0	1	1	1	0	0	0	0	0	1	*0*	*1*
Other (previous fire in house, power shut off by owners, servicing power supply, or other usage)	17	1	3	1	4	0	0	1	1	0	3	*2*	*1*
Unknown why electricity off	100	1	1	0	5	12	8	14	15	9	15	*16*	*4*

1 Number of deaths associated with generators includes incidents where other consumer products may also have been involved. Other products include one or more of the following: lawn mowers, portable LP-fueled heaters, portable kerosene-fueled heaters, camp stoves, lanterns, outdoor cookers, furnaces, and wood stoves.

Notes: Totals may not add to 100 percent due to rounding.
Italicized numbers indicate that reporting of incidents is ongoing. Counts may change in subsequent reports.

Source: U. S. Consumer Product Safety Commission, Directorate for Epidemiology, 2011.

For the 194 fatalities associated with a power outage due to weather or a problem with power distribution, Table 11 provides a further breakdown by year and cause of the power outage. Ninety percent (175 of 194) of the fatalities associated with power outages were due to outages caused by specific weather conditions. Ice or snow storms are associated with the largest percentage of weather-related CO fatalities (46%). Hurricanes are also associated with a large percentage of CO fatalities (29%). Table 11 suggests the spike in fatalities in 2005 (shown in Table 10), from 47 in 2004 to 103 in 2005, appears to be due primarily to unusually severe weather. In 2004, there were 11 power outage-related CO fatalities, 10 of these were known to be weather-related. In 2005, the number of power outage-related fatalities jumped to 53, with 52 known to be weather-related. The 52 fatalities associated with weather-related power outages in 2005 were due primarily to hurricanes in September in the Gulf states, ice/snow storms in January in the Midwest, and ice storms in December in the Carolinas. CPSC staff is aware of 31 hurricane- or tropical storm-related, non-fire CO fatalities in 2005, more CO deaths than for any other year in this report for all weather-related outages combined. An additional 20 fatalities were associated with the use of generators during ice- or snow-related power outages in 2005. Both the hurricane- and ice/snow-related fatality counts in 2005 are higher than any other year in this report. Over the 12-year period covered by this report, more than one quarter (26%, 51 of 194) of the power outage-related, non-fire CO fatalities occurred during hurricane- or winter storm-related power outages in 2005. Figure 2 illustrates the impact of the power outages in 2005, relative to other years.

Table 11: Number of Reported Fatal Non-Fire Carbon Monoxide Exposure Incidents and Deaths Associated with Engine-Driven Tools Generators[1] by Reason for Power Outage, 1999–*2010*

Reason for Power Outage	Total	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	*2009*	*2010*
Total	**194**	**3**	**1**	**3**	**16**	**20**	**11**	**53**	**17**	**23**	**25**	***16***	***6***
Ice or snow storm	90	0	0	0	14	7	2	20	8	13	9	*13*	*4*
Hurricane or tropical storm	57	0	0	0	1	9	8	31	1	0	7	*0*	*0*
Wind storm	9	0	0	1	0	0	0	0	6	1	1	*0*	*0*
Thunderstorm or rainstorm	11	0	0	1	0	2	0	1	2	1	2	*0*	*2*
Tornado	3	0	0	0	0	0	0	0	0	0	3	*0*	*0*
Storm, unspecified	5	0	0	0	0	0	0	0	0	4	1	*0*	*0*
Unknown or other reason for outage	19	3	1	1	1	2	1	1	0	4	2	*3*	*0*

1 Number of deaths associated with generators includes incidents where other consumer products may also have been involved. Other products include one or more of the following: lawn mowers, portable LP-fueled heaters, portable kerosene-fueled heaters, camp stoves, lanterns, outdoor cookers, furnaces, and wood stoves.

Note: Italicized numbers indicate that reporting of incidents is ongoing. Counts may change in subsequent reports.

Source: U.S. Consumer Product Safety Commission, Directorate for Epidemiology, 2011.

Figure 2: Number of Reported Fatal Non-Fire Carbon Monoxide Exposure Incidents and Deaths Associated with Engine-Driven Tools with Generators During Power Outages

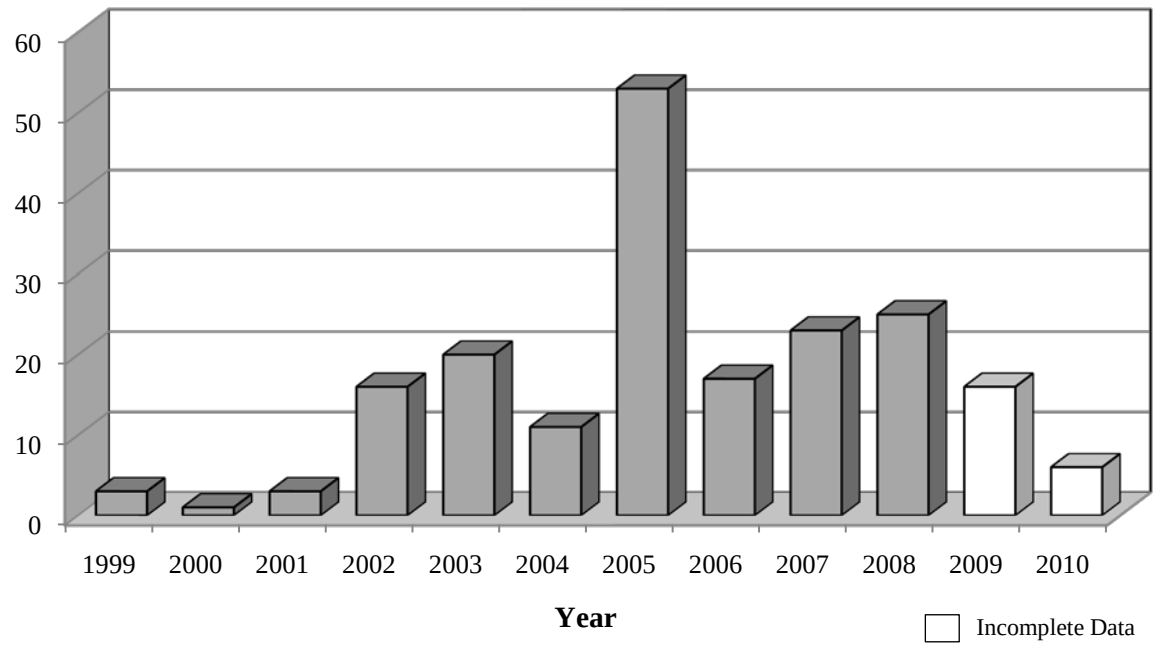


Table 7 shows 425 generator-related, non-fire CO fatalities that occurred in a fixed structure home. For this characterization, a fixed structure home is defined as a permanent, fixed residential structure, including detached and attached houses, apartments, fixed mobile homes, and cabins used as a permanent residence. Travel trailers, campers, and RVs are not included in this classification. Additionally, 38 of the 39 multiple product-related fatalities involved a generator. Of these 463 generator-related fatalities that occurred in a fixed structure home, information was available for 391 deaths (84%) regarding the victim's location in relation to the generator. Eighty-eight of these 391 fatalities (23%) occurred in the same room or space as the generator.

The 463 deaths that occurred in a fixed structure home were further classified by the specific location of the generator (Table 12) within the home. The category "Living space" includes rooms reported as bedrooms, bathrooms, dens, living rooms, landings, home offices, rear rooms, enclosed porches, and converted garages. This category does not include attached garages or basements. The category "Outside home" includes incidents where the generator was placed outside a home but near an open window, door, or vent of the home. Seventy-one percent (327 of 463) of the CO deaths at home locations occurred when a generator was placed inside the home, including the living space (145), a basement (127), closet (12), doorway (6), or inside the house, with no further information provided (37). Another 24% (110 of 463) occurred when the generator was placed in an attached garage, enclosed carport, or attached barn. More than half of the CO fatalities (237 of 463) occurred when the generator was placed in an attached structure (110) or in the basement or crawlspace (127).

Review of the yearly fatal incident data in Table 12 suggests that since 2004, more fatalities were related to generators in living areas of the home. Included in the definition of "non-basement living area of the home" are the categories "Living space," "Closet of home," and "Doorway of home." Not included here is the category "Inside house, no further information reported" because this could be in the living area or the basement of the house. From 2000 through 2003, there were more CO fatalities reported where the

generator was placed in the basement or crawl space than in the non-basement living areas (in 1999, there were an equal number of fatalities reported where generators were placed in the basement and the living area). For each of the years 2004 through 2010, more reported CO fatalities were associated with generators in non-basement living areas than in basement or crawl space locations. Of the 109 generator-associated fatalities between 1999 and 2003, the basement was the predominant location of the generator in the fatal CO poisoning incidents (48 of 109, or 44%) followed by living areas (23 of 109, or 21%), including living space (17), closets (2), and doorways (4) and attached garages and other attached structures (22 of 109, or 20%). From 2004 onward, there have been 354 reported CO fatalities in the home associated with the use of generators. More CO fatalities occurred with the generators placed in the non-basement living areas (140 of 354, or 40%, including living space (128), closets (10), and doorways (2)), followed by an attached garage or other structure (88 of 354, or 25%), and then the basement (79 of 354, or 22%). It is unclear why there has been a shift from the basement to the living space, but this may indicate a lack of knowledge by consumers about the severity of the CO dangers associated with the use of generators inside the home.

Table 12: Non-Fire Carbon Monoxide Poisoning Deaths in the Fixed Structure Home Location[1] by Location of the Generator[2], 1999–*2010*

Generator Location	Total	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	*2009*	*2010*
Total	**463**	**5**	**7**	**10**	**41**	**46**	**38**	**70**	**57**	**51**	**67**	***46***	***25***
Living space (non-basement)	145	2	1	2	5	7	18	23	17	19	26	*17*	*8*
Garage/enclosed carport/attached barn	110	0	2	2	10	8	8	18	20	15	13	*11*	*3*
Basement/crawlspace	127	2	4	4	18	20	7	15	11	10	20	*9*	*7*
Inside house, no further information reported	37	1	0	1	4	7	2	2	4	5	4	*5*	*2*
Closet in home	12	0	0	0	2	0	0	6	3	1	0	*0*	*0*
Outside home	11	0	0	1	0	2	2	4	0	1	0	*0*	*1*
Doorway to home	6	0	0	0	2	2	0	0	2	0	0	*0*	*0*
Unknown location, but at home	15	0	0	0	0	0	1	2	0	0	4	*4*	*4*

1 This refers to a fixed location structure used as a residence, including houses, mobile homes, apartments, townhouses, and structures attached to the house, such as an attached garage. Not included here are incidents that occurred in detached structures at home locations (*e.g.*, detached garages, sheds) or at non-fixed location residences (*e.g.*, travel trailers, houseboats)

2 Number of deaths associated with generators includes incidents where other consumer products may also have been involved. Other products include one or more of the following: lawn mowers, portable LP-fueled heaters, portable kerosene-fueled heaters, camp stoves, lanterns, outdoor cookers, furnaces, and wood stoves.

Notes: Totals may not add to 100 percent due to rounding.
Italicized numbers indicate that reporting of incidents is ongoing. Counts may change in subsequent reports.

Source: U. S. Consumer Product Safety Commission, Directorate for Epidemiology, 2011.

Table 13 presents a summary of non-fire CO fatalities that occurred in the fixed location structure home characterized by ventilation status. Many of the incidents of generator-associated fatalities in the home (204 of the 463 deaths) did not contain information about the ventilation of the generator. In 173 of the 259 deaths (67%) in which information on ventilation of the generator was available, the generators were not vented at the time of the incident. In four of these deaths, a window or door was open during some period of use but later closed. There were 86 deaths associated with generators in which it was reported that some type of ventilation was employed. Of these 86 deaths, 63 non-fire CO deaths were associated

with incidents in which it was reported that there was an open or partially open window, door, garage door, or a combination of these. Eleven deaths were associated with generators that were placed outside the home near open windows, doors, or vents, where carbon monoxide entered the home. In 11 deaths, consumers actively attempted to vent generator exhaust outside through a window or door or through the use of a fan, but these measures failed to adequately vent the CO from the victims' location. And in one fatal incident in the "No ventilation" category, the victim placed the generator outside his apartment door in the unventilated hallway of the building.

Table 13: Non-Fire CO Fatalities in the Fixed Location Structure Home[1] Reported to CPSC Staff and Associated with Generators[2] Categorized by Status of Ventilation, 1999–*2010*

Ventilation Status	Number of Incidents	Number of Deaths	Percentage of Deaths	Percentage of Deaths Where Ventilation is Known
Non-fire CO fatalities in the home	**340**	**463**	**100%**	**100%**
Some ventilation attempted	**67**	**85**	**18%**	**33%**
Open window(s), open door(s), an open garage door, or a combination of these	51	63	14%	24%
Actively trying to vent either by fans or by directing exhaust out a window or door	6	11	2%	4%
Placed outside, but near a window, door or A/C unit[3]	10	11	2%	5%
No ventilation	**130**	**174**	**38%**	**67%**
Open windows or doors closed sometime later	3	4	1%	2%
No ventilation attempted[4]	127	170	37%	65%
Unknown ventilation	**143**	**204**	**44%**	**-**

1 This refers to a fixed location structure used as a residence, including houses, mobile homes, apartments, and townhouses, as well as structures attached to the house, such as an attached garage. Not included here are incidents that occurred in detached structures at home locations (*e.g.,* detached garages and sheds) or at non-fixed location residences (*e.g.*, travel trailers and houseboats).

2 Number of deaths associated with generators includes incidents where other consumer products may also have been involved. Other products include one or more of the following: lawn mowers, portable LP fueled heaters, portable kerosene fueled heaters, camp stoves, lanterns, outdoor cookers, furnaces, and wood stoves.

3 One incident involved alternately moving the generator outside then inside after the generator would shut off, presumably because of weather conditions. After a warm-up period, the generator was again placed outside until it failed again.

4 One death that occurred when a generator was placed outside an apartment in an unvented hallway and one that occurred when the generator was placed outside a trailer that was located inside an enclosed, unvented garage.

Source: U. S. Consumer Product Safety Commission, Directorate for Epidemiology, 2011.

Note: Italicized numbers indicate that reporting of incidents is ongoing. Counts may change in subsequent reports.

Table 14 presents a summary of the fatal CO incidents and fatalities characterized by the size of the home in which the fatalities occurred. For 39 percent (180 of 463) of the deaths (133 of 340 fatal incidents), CPSC staff could not ascertain the size of the home. Home size information was available for 283 of the 463 deaths (207 of 340 fatal incidents). Information regarding the size of the home reported in this document is from one of two sources. The first source is the CPSC In-depth Investigations (IDIs), which

include information gathered from police, fire department, or public records. The second source is one of two Internet databases of real estate information, which contain public record data: *Cyberhomes.com* and *Zillow.com*. In most cases, the two databases agree on the size of the home because both databases are based on public records from the county, state, or municipality. Occasionally, the records in the databases do not agree. In that situation, the average of the two sizes was used because it could not be determined which database had the more accurate figure.

Sixty-one percent (172 of 283) of the reported CO fatalities (from 124 or 207 fatal incidents) associated with generators that occurred in the home, where the size of the structure was known, occurred in homes that were less than 1,500 square feet, and 81 percent (229 of 283 deaths from 170 or 207 incidents) occurred in houses that were less than 2,000 square feet. This portion of the fatal incident location includes most incidents that occurred in apartments and mobile homes. Fatal incidents that occurred in a detached structure are not included in this figure. The median home size involved in fatal CO poisoning deaths, where home size information is known, was 1,350 square feet. As a point of reference, according to the U.S. Census Bureau's *American Housing Survey for the United States: 2009*, the median housing unit as of 2009 was 1,736 square feet. Comparing the percentages of deaths by home size to the U.S. Census figures, it appears that the CO fatalities are skewed toward smaller homes. Whether this is due to economic reasons or that smaller volume structures are more quickly filled by deadly carbon monoxide is unclear. Perhaps it is a combination of the two factors or some yet unidentified reason.

Table 14: Non-Fire CO Fatalities in the Fixed Location Structure Home[1] Reported to CPSC Staff and Associated with Generators[2] Categorized by Size of Home, 1999–*2010*

Home Size (in sq. feet)[2]	Number of Incidents	Number of Deaths	Percentage of Deaths	Percentage of Deaths Where Size is Known	Estimated Percentage of U.S. Housing Units (2009)
Total	**340**	**463**	**100%**	**100%**	**100%**
Under 500	2	2	< 1%	1%	1%
500–999	56	73	16%	26%	10%
1,000–1,499	66	97	21%	34%	25%
1,500–1,999	46	57	12%	20%	24%
2,000–2,499	26	41	9%	14%	17%
2,500–2,999	5	6	1%	2%	9%
3,000 or Larger	6	7	2%	2%	14%
Unknown	133	180	39%	-	-

1 This refers to a fixed location structure used as a residence, including houses, mobile homes, apartments, and townhouses and structures attached to the house, such as an attached garage. Not included here are incidents that occurred in detached structures at home locations (*e.g.*, detached garages and sheds) or at non-fixed location residences (*e.g.*, travel trailers and houseboats)

2 Number of deaths associated with generators includes incidents where other consumer products may also have been involved. Other products include one or more of the following: lawn mowers, portable LP-fueled heaters, portable kerosene-fueled heaters, camp stoves, lanterns, outdoor cookers, furnaces, and wood stoves.

3 Home size based on CPSC IDIs or from the Internet real estate databases *Cyberhomes.com* and *Zillow.com.*

Source: U. S. Consumer Product Safety Commission, Directorate for Epidemiology, 2011.
U.S. Census Bureau, American Housing Survey for the United States: 2009.

Note: Italicized numbers indicate that reporting of incidents is ongoing. Counts may change in subsequent reports

The size of the generator and the fuel used with the generator were both examined. The size of the generator was examined by the wattage rating (Table 15). In most cases, the advertised running wattage rating was used to categorize the generator. In some instances, however, a wattage rating was obtained, but it could not be determined whether this rating was the rated running wattage or maximum/surge

wattage. When the wattage rating of the generator was known or could be determined (309 investigated deaths), 211 deaths (68%) were associated with a generator in the 3500 to 6499 watt rating range. Nearly half (47%) of the CO fatalities, where the generator size was known, were associated with generators in the 5000 to 6499 watt range. Generator sales data available to CPSC staff[4] indicate that during the time period 2003 through 2005, 56 percent of portable generators sold to consumers were in the 3500 to 6499 watt range; 23 percent of units sold had outputs below 3500 watts; and 21 percent had outputs of 6500 watts or greater. During this same period, generator size is available for incidents associated with 92 fatalities. Seventy-eight percent (72 of 92) of the CO fatalities were associated with generators in the 3500 to 6499 watt range; 20 percent (18 of 92) were associated with units with outputs below 3500 watts; and 2 percent (2 of 92) were associated with units with outputs of 6500 watts or greater. In the time period following the sales data (2006 through 2010), there were 158 fatalities in which the generator size is known. Of these, 64 percent (101 of 158) of CO fatalities were associated with generators in the 3500 to 6499 watt range; 30 percent (47 of 158) were associated with units with outputs below 3500 watts; and 6 percent (10 of 158) were associated with units with outputs of 6500 watts or greater. Assessments of trends or patterns using direct comparisons of sales data and CO fatality data should be made with caution. Sales figures only reflect the proportion of newly purchased generators in each category and do not reflect the proportions of existing generators in the consumer population. Although many CO fatalities are associated with first-time users of newly purchased generators, many are also associated with older generators originally purchased for other uses or borrowed when a need for power presented itself.

Almost all of the generators that were involved in the CO poisoning incidents identified in this report were referred to as gas- or gasoline-fueled generators. One generator was identified as a propane-fueled generator, and one was identified as a natural gas-fueled generator.

Table 15: Number of Reported Fatal Non-Fire Carbon Monoxide Exposure Incidents and Deaths Associated with Generators[1] Categorized by Generator Wattage Rating, 1999–*2010*

Wattage Rating (in Watts)	Total	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	*2009*	*2010*
Total	**639**	**6**	**21**	**23**	**48**	**57**	**47**	**103**	**92**	**63**	**89**	***57***	***33***
Under 2000	19	0	2	0	3	0	2	3	1	5	1	*1*	*1*
2000–3499	66	0	5	3	7	3	2	8	17	6	8	*6*	*1*
3500–4999	67	0	2	8	1	5	2	13	11	7	11	*2*	*5*
5000–6499	144	1	3	4	19	14	18	20	20	8	18	*10*	*9*
6500–7999	8	0	0	0	0	0	0	1	0	2	4	*0*	*1*
8000 and larger	5	0	0	0	1	0	1	0	1	0	1	*1*	*0*
Not reported	330	5	9	8	17	35	22	58	42	35	46	*37*	*16*

1 Number of deaths associated with generators includes incidents where other consumer products may also have been involved. Other products include one or more of the following: lawn mowers, portable LP-fueled heaters, portable kerosene-fueled heaters, camp stoves, lanterns, outdoor cookers, furnaces, and wood stoves.

Source: U. S. Consumer Product Safety Commission, Directorate for Epidemiology, 2011.

Note: Italicized numbers indicate that reporting of incidents is ongoing. Counts may change in subsequent reports.

[4] Smith, Charles L. *Portable Electric Generator Sets for Consumer Use: Additional Data on Annual Sales, Number in Use, and Societal Costs.* Memorandum to Janet Buyer, Project Manager, ESFS. August 24, 2006.

Conclusion

Between 1999 and 2010, there were 740 non-fire CO poisoning deaths reported to CPSC staff that were associated with engine-driven tools. The majority of these deaths (591) involved generators. Another 48 fatalities were associated with both a generator and another consumer product (one involved both a generator and another engine-driven tool). Other engine-driven tools, including garden tractors, lawn mowers, power washers or sprayers, and others, were associated with a much smaller number of deaths. The majority of fatal incidents reported to CPSC staff involved a single fatality. Most reported deaths occurred while an individual was at home.

Victims age 25 years and older accounted for about 80 percent of the non-fire CO poisoning deaths that were associated with generators reported to CPSC staff, and the majority (74%) of the victims were male. Seventy-two percent of the reported deaths associated with generators (including deaths associated with the use of a generator and another consumer product) occurred at fixed structure home locations. Seventy-one percent of the fatalities known to have occurred in the home involving generators occurred when a generator was placed in the living area or basement of the home. Another 24 percent occurred when a generator was used inside an attached garage or shed. Generators were often used as alternative sources of electricity due to temporary power outages or as power sources for temporary shelters. Power outages, most commonly weather-related, were the single most common reason for generator usage that resulted in a non-fire CO fatality, accounting for at least 194 of the 639 fatalities (30%). Generators were often used with little or no ventilation. In only about 6 percent of the fatalities was it known that there was a CO alarm installed—and most of these were inoperable at the time of the fatal incident. Conclusions about why consumers used generators indoors or determinations about whether users were aware of the potential non-fire CO poisoning hazard are difficult to make with the available information.

Victims age 25 years and older accounted for 99 percent (100 of 101) of the non-fire CO poisoning deaths reported to CPSC staff that were associated with other engine-driven tools. Males accounted for 97 percent (98 of 101) of the deaths associated with other engine-driven tools. Deaths associated with garden tractors and lawn mowers were often associated with an individual repairing or working on the product in an enclosed space.

Visit the CPSC's Carbon Monoxide Information Center—www.cpsc.gov/info/co/index.html—for the latest information on recalls, safety tips, safety standards, CO alarms, and downloadable injury prevention materials.

References

Hnatov, Matthew V. *Incidents, Deaths, and In-Depth Investigations Associated with Non-Fire Carbon Monoxide from Engine-Driven Generators and Other Engine-Driven Tools, 1999-2009*. U.S. Consumer Product Safety Commission. September 2010.

Hnatov, Matthew V. *Non-Fire Carbon Monoxide Deaths Associated with the Use of Consumer Products: 2007 Annual Estimates*. U.S. Consumer Product Safety Commission. January 2011.

Smith, Charles L. *Portable Electric Generator Sets for Consumer Use: Additional Data on Annual Sales, Number in Use, and Societal Costs.* Memorandum to Janet Buyer, Project Manager, Directorate for Engineering Sciences, Division of Combustion and Fire Sciences. August 24, 2006.

U.S. Census Bureau. American Housing Survey for the United States: 2009.

U.S. Department of Agriculture. Briefing Rooms: Measuring Rurality. 7 Nov. 2008 <http://www.ers.usda.gov/briefing/Rurality/>

University of Washington, WWAMI Rural Health Research Center. Rural-Urban Commuting Area Codes (version 2.0). 5 Jan. 2009 <http://depts.washington.edu/uwruca/>

Goodman, David C., *2008 Population Estimates for Zip Code Tabulation Areas (ZCTAs) and Primary Care Service Areas (PCSAs)*. Health Resources and Services Administration. 1 May 2009

Appendix A: Epidemiology Data Retrieval Specifics

The queries below were submitted through EPIR (EPIdemiology Retrieval), the CPSC staff's epidemiology data access application. Query results were reviewed to include only carbon monoxide poisoning incidents and to exclude duplicates and out-of-scope cases, which were cases that did not involve an incident that was associated with a non-fire carbon monoxide exposure and an engine-driven tool. Records from the three databases that were used in this report (the In-depth Investigation database (INDP), the Injury or Potential Injury Incident database (IPII), and the Death Certificate database (DTHS)) were then manually matched up to provide the most complete record and to eliminate additional duplicates. Work-related cases were also excluded.

Date of Queries: 02/17/2011

Incident Dates: 1/1/99-12/31/10
Product Codes: 113, 606, 800-899, 1062, 1400-1464, 3285-3287
Diagnosis Codes: 65 (Anoxia), 68 (Poisoning) – (INDP only)
ICD10 Code: X47x, Y17x – (DTHS only)
Narrative/Text Contains: 'CARB' or 'MONO'

Appendix B: Carboxyhemoglobin Levels Present In CO Fatalities

Carboxyhemoglobin (COHb) is a complex of carbon monoxide and hemoglobin that forms in red blood cells when carbon monoxide is inhaled. COHb poisoning can be fatal in large doses as it hinders delivery of oxygen to the body. Carboxyhemoglobin data is helpful in estimating the concentration of CO in the product exhaust and the lethality of the product which affects the speed of onset of harm. This information may be used by CPSC staff to assist in determining how best to address the CO hazard presented by generators and other engine-driven tools.

In healthy adults, a COHb level of 40–50 percent in the blood approximately correlates with symptoms of confusion, unconsciousness, coma, and possible death; a level of 50–70 percent approximately correlates with symptoms of coma, brain damage, seizure, and death; and a level greater than 70 percent is typically fatal.[5] COHb levels were available for 418 of the 740 fatalities (56% of the CO fatalities). Table B-1 shows the frequency of reports by COHb level categories. Percentages in the table are the category proportions of reported COHb levels. Eighty-two percent (341 of the 418) of fatalities had reported COHb levels of 50 percent or greater.

Table B-1: Carboxyhemoglobin Levels Associated with Engine-Driven Tools Non-Fire Carbon Monoxide Poisoning Deaths, 1999–*2010*

COHb Level	Number of Deaths[1]							
	All Engine-Driven Tools		Generators		Other Engine-Driven Tools		Multiple Products[2,3]	
Total	**740**	**-**	**591**	**-**	**97**	**-**	**52 (48)**	**-**
Reported Levels	**418**	**100%**	**328**	**100%**	**57**	**100%**	**33 (29)**	**100%**
Less than 30%	15	4%	12	4%	1	2%	2 (2)	6%
30–39.9%	26	6%	21	6%	4	7%	1 (1)	3%
40–49.9%	36	9%	29	9%	7	12%	0 (0)	0%
50–59.9%	82	20%	68	21%	7	12%	7 (7)	21%
60–69.9%	110	26%	87	27%	14	25%	9 (6)	27%
70–79.9%	116	28%	87	27%	16	28%	13 (12)	39%
80–89.9%	30	7%	21	6%	8	14%	1 (1)	3%
90–99.9%	3	1%	3	1%	0	0%	0 (0)	0%
Not reported	322	-	263	-	40	-	19 (19)	-

1 Percentages shown are the percentage of reported COHb levels per category.

2 "Multiple Products" includes incidents involving generators or OEDTs with other CO generating consumer products. Other consumer products include one or more of the following: portable LP fueled heaters, portable kerosene fueled heaters, camp stoves, lanterns, outdoor cookers, furnaces, and wood stoves, and one case with both a generator and another engine-driven tool (lawn mower) in operation.

3 Numbers in parentheses indicate incidents involving a generator and another product, including the case where a generator and an OEDT (lawn mower) were used concurrently.

Notes: Totals may not add to 100 percent due to rounding.
Italicized numbers indicate that reporting of incidents is ongoing. Counts may change in subsequent reports.

Source: U. S. Consumer Product Safety Commission, Directorate for Epidemiology, 2011.

[5] Inkster S.E. *Health hazard assessment of CO poisoning associated with emissions from a portable, 5.5 Kilowatt, gasoline-powered generator*. Washington, D.C.: U.S. Consumer Product Safety Commission. 2004.