



Incidents, Deaths, and In-Depth Investigations Associated with Non-Fire Carbon Monoxide from Engine-Driven Generators and Other Engine-Driven Tools, 2004–2013

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Executive Summary

This report summarizes non-fire carbon monoxide (CO) incidents associated with engine-driven generators and other engine-driven tools that occurred between 2004 and 2013, and were reported to U.S. Consumer Product Safety Commission (CPSC) staff as of May 1, 2014. It should be noted that due to incident reporting delays, statistics for the most recent years should be considered incomplete, as data collection is still ongoing. In this report, the two most recent years, 2012 and 2013, are identified as being incomplete because the numbers for these years most likely will increase in future reports. Throughout this report, the number of deaths represents a count of the fatalities 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 that were reported to CPSC staff. Additionally 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 products¹ 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, with particular emphasis on cases involving generator use, 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:

- From 2004 through 2013, 808 fatalities from 629 incidents were associated with the use of engine-driven tools, or engine-driven tools used in conjunction with another potentially CO-emitting consumer product.
- The total number of reported fatalities for 2004 through 2013 increased by 67 from the 741 fatalities summarized in the August 2013 report, including 47 deaths in 2013, plus 12 deaths for 2012 and 8 for 2011 that were previously not reported.
- As of May 1, 2014, there were 47 reported non-fire CO fatalities in 2013, from a total of 36 incidents. Forty-one of these deaths (30 incidents) involved only a generator and no other product; four deaths (four incidents) were associated with a non-generator other engine-driven tool (OEDT); and two deaths (two incidents) were associated with multiple fuel-burning consumer products, one of which was a generator.
- From 2004 to 2013, of the 808 fatalities from 629 incidents:
 - 657 fatalities (81%) from 489 incidents were associated with generators;
 - 103 fatalities (13%) from 101 incidents involved other engine-driven tools; and
 - 48 fatalities (6%) from 39 incidents involved multiple fuel-burning consumer products, where one product was either a generator (46 of 48 deaths) or an OEDT (2 of 48 deaths), and the other product was a non-EDT.

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

- Of the 39 incidents that involved multiple consumer products, all involved either a heating or cooking product as the second product. Most commonly, the second product was a portable LP- or kerosene-fueled portable heater.
- Twenty-five percent of generator-related, non-fire CO incidents caused multiple fatalities, while only two of the OEDT-related incidents (2%) involved multiple fatalities.

Socio-Demographic Characteristics of Victims and EDT-Use Patterns:

- Eighty-three percent of generator-related victims were known to be 25 years old or older. By contrast, 99 percent of OEDT-related victims (all but one) were 25 years old or older.
- Three-quarters of the generator-related, non-fire CO victims were male; while 97 percent (all but three) of the OEDT-related fatalities were male.
- Twenty-four percent of generator-related, non-fire CO fatalities were non-Hispanic Black or African American, double the combined non-Hispanic Black and African American proportion of the U.S. population. Eighty-nine percent of other engine-driven tool-related, non-fire CO fatalities were non-Hispanic White, much higher than the non-Hispanic White proportion (65%) of the U.S. population.
- Nearly half of generator-related, non-fire CO fatalities (349 of 703) occurred in the four cold months of the year (November through February); while CO fatalities associated with OEDTs were only slightly more prevalent in the cold months (37%) than in the transitional and warm months (32% and 30%, respectively).
- Seventy-five percent of the generator-related fatalities occurred in fixed-structure homes; while 70 percent of OEDT fatalities occurred in fixed-structure homes.
- Fifty-eight percent of the EDT-related fatalities are known to have occurred in urban areas. Sixteen percent occurred in small rural and isolated areas, nearly double the proportion of the U.S. population that lives in such areas.

CO Alarm Usage:

- A CO alarm was reported to have been present in only 19 of 250 incidents where alarm presence was known, which accounted for 29 of 346 (8%) EDT-related CO fatalities. In seven of the incidents (14 deaths), the alarm was inoperable due to no batteries, batteries inserted incorrectly, probable drained batteries, or no electric current. The alarm sounded in six incidents (seven deaths), but the signal was either misunderstood, the alarm was subsequently disarmed (batteries removed after alarming), or the alarm sounded inside the house while the fatality occurred inside an attached garage (presumably, the death occurred in the garage before CO levels increased inside the house sufficient to set off the CO alarm). Additionally, there were six incidents (eight deaths) in which the presence of a CO alarm was noted, but it is unknown if the alarm sounded during the event.

Hazard Patterns Associated with Generators:

- Twenty-nine percent of all generator-related, non-fire CO deaths (206 of 703) from 2004 through 2013 were associated with power outages, mostly due to weather-related issues. The two most common causes of weather-related outages leading to fatal incidents were ice/snow storms (71 incidents, 95 deaths) and hurricanes/tropical storms (42 incidents, 61 deaths). The second most common reason for generator usage in the reported CO fatalities

was due to power shut-off, accounting for 20 percent (141 deaths from 107 incidents) of the all reported fatalities.

- Five hundred twenty-eight non-fire CO fatalities (395 incidents) that occurred in fixed-structure homes were associated with a generator or a generator in use with another potential CO-generating consumer product. Sixty-seven percent (354 deaths, 258 incidents) 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.
- Two-thirds of generator-related, non-fire fatal CO incidents in fixed-structure homes (for which information on ventilation of the generator was available) occurred when no ventilation of the generator was attempted.
- Fifty-nine percent of the generator-related, non-fire fatal CO incidents 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; 85 percent occurred in houses less than 2,000 square feet in size.
- Sixty-three percent (150 of 240) of fatal CO incidents, where the size of the generator was known, were associated with generators in the 3,500 to 6,499 watt range; 44% (105 of 240) were associated with generators in the 5,000 to 6,499 watt range.

Carboxyhemoglobin Levels in CO Fatality Victims:

- Of the CO fatality victims associated with engine-driven tools, 79 percent had carboxyhemoglobin (COHb) levels at or above the 50 percent level when the COHb level was known.²

Note: Throughout this report, the years 2012 and 2013 are italicized in table headings, indicating that incident and death counts may change as additional information is received due to reporting delays. Incident and death counts may change for other years, but to a much smaller extent.

² As levels rise above 40 percent COHb, death is possible in healthy individuals and becomes increasingly likely with prolonged exposures that maintain levels in the 40 percent to 60 percent range.

Introduction

The following U.S. Consumer Product Safety Commission (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 whether the incident was in scope for this report and to correct any discrepancies between information from the different sources. (See Appendix A for the specifics of scope determination.) 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 May 1, 2014. All fatal, unintentional, 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 808 non-fire CO fatalities associated with EDTs during the years 2004 through 2013. Last year's report, dated August 2013, contained summary information and analyses for the 14-year period, 1999–2012. The current report limits the reporting period to 10 years, 2004–2013. Since the last report in 2013, there have been 67 new CO fatalities associated with engine-driven tools reported to CPSC. This is an increase of 67 fatalities from the 741 fatalities over the period of 2004–2012 reported in the August 2013 report on non-fire CO fatalities associated with EDTs, which included data entered into CPSC databases as of April 23, 2013.³

Changes to previous report:

- 2011 – Eight new single-fatality incidents added.
- 2012 – Eleven new incidents added, accounting for 12 deaths.
- 2013 – Thirty-six new incidents added, accounting for 47 deaths.

Forty-five of the 47 fatalities reported to CPSC that occurred in 2013 were associated with generators or other engine-driven tools (OEDT) as the only known sources of the CO. Two additional fatalities were associated with the use of a generator and a portable LP heater. 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, these incidents were considered out of scope and were not included. For example, generators that were reportedly mounted to an RV were not included, nor were boat generators that were installed by the boat manufacturer. Because 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 unintentional in nature was considered to be out of scope, as were work-related incidents, which are not within the jurisdiction of the CPSC.

³ Hnatov, M. V. *Incidents, Deaths, and In-Depth Investigations Associated with Non-Fire Carbon Monoxide from Engine-Driven Generators and Other Engine-Driven Tools, 1999–2012*. U.S. Consumer Product Safety Commission. August 2013.

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.

I. Reported Numbers of Fatalities by Engine-Driven Tool (EDT) Product Type

As of May 1, 2014, CPSC staff had records indicating that there were 36 fatal, non-fire carbon monoxide (CO) exposure incidents involving engine-driven tools between January 1, 2013 and December 31, 2013. Forty-seven deaths occurred in these 36 fatal CO incidents. Table 1 presents the reported fatal incidents and the number of deaths in 2013, along with a summary of CO incidents and fatalities associated with engine-driven tools for the 10-year period from 2004 through 2013. 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 48 fatalities associated with multiple consumer products, occurring between 2004 and 2013; two of these fatalities occurred in 2013. Multiple product incidents, where one of the sources of CO 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. Following Table 1, Multiple Product incidents will be included in the summary for the involved engine-driven tool type, either “Generators” or “Other Engine-Driven Tools.”

Within each broad category, the frequency of reports is summarized by product type. Staff is aware of 629 incidents with a total of 808 deaths due to non-fire CO exposure that occurred between 2004 and 2013, 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 that occurred between 2004 and 2013, involved the use of the welder as a generator during a power outage. Each of these two incidents involved a single death. There were three fatal, non-fire CO incidents between 2004 and 2013, which were associated with the use of welder equipment, where it was not specifically identified as being used as a generator. Of these three incidents, one incident involved two deaths.

All but one of the 48 non-fire, CO fatalities in the “Multiple Products” category for 2004–2013 involved a heating- or cooking-related consumer product other than an EDT. The one incident not involving a heating- or cooking-related consumer product involved a gasoline-fueled, walk-behind mower and a gasoline-fueled trimmer, also running in a closed garage.

Table 1: Number of Reported Fatal Non-Fire Carbon Monoxide Exposure Incidents and Deaths Associated with Engine-Driven Tools, 2004–2013

Product	2012		2013		Total: 2004–2013	
	Number of Incidents	Number of Deaths	Number of Incidents	Number of Deaths	Number of Incidents	Number of Deaths
Total Engine-Driven Tools	43	49	36	47	629	808
Generators	37	43	30	41	489	657
Generator, portable	37	43	30	41	484	650
Generator, fixed	0	0	0	0	3	5
Welder (used as a generator) ¹	0	0	0	0	2	2
Other Engine-Driven Tools (OEDT)	5	5	4	4	101	103
Lawn mowers	4	4	2	2	54	54
Riding lawn mower/Garden tractor	4	4	2	2	47	47
Push lawn mower	0	0	0	0	2	2
Powered lawn mower, unspecified type	0	0	0	0	5	5
Power washer/sprayer	0	0	0	0	11	11
Snow blower	0	0	0	0	10	10
All-terrain vehicle	1	1	0	0	7	8
Welder (used as welder or other reason) ¹	0	0	0	0	3	4
Water pump	0	0	1	1	5	5
Concrete saw	0	0	0	0	2	2
Air compressor	0	0	0	0	2	2
Paint sprayer	0	0	0	0	1	1
Snowmobile	0	0	0	0	1	1
Go-cart	0	0	0	0	1	1
Tiller	0	0	0	0	1	1
Small engine (unknown use)	0	0	0	0	1	1
Edger	0	0	0	0	1	1
Stump Grinder	0	0	1	1	1	1
Multiple Products²	1	1	2	2	39	48
Generator + Other Consumer Product	1	1	2	2	37	46
OEDT + Other Consumer Product ³	0	0	0	0	2	2

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.

3 The two incidents associated with an OEDT and another consumer product include the following engine-driven tools: one incident involved two gasoline-fueled lawn mowers and an LP heater, and the other incident involving a gasoline-fueled lawn mower and a gasoline-fueled trimmer.

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, 2014.

Four hundred eighty-nine of the 629 incidents reported to CPSC staff during the 2004–2013 period were associated with a generator and accounted for 657 of the 808 CO deaths (81%). Additionally, 46 other CO fatalities from 37 incidents were associated with the use of a generator and another combustion consumer product—most commonly an LP- or kerosene-fueled heater. 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. More than half of the non-fire, non-generator CO fatalities (56 of 105, 53%) involved a garden tractor or other powered lawn mower (including both of the 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 629 fatal incidents, 79 percent involved a single fatality. Seventy-five percent (396 of 526) of the fatal generator-related incidents involved a single fatality. One incident involving a generator resulted in the deaths of six individuals, and two others involved five fatalities. Of the 103 fatal incidents in the “Other Engine-Driven Tools” category, two incidents resulted in more than one fatality.

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, 2004–2013

Number of Deaths Reported in Incident ¹	All Engine-Driven Tools (EDTs)		Generator		Other Engine-Driven Tools (OEDTs)	
	Count	Percentage	Count	Percentage	Count	Percentage
All Incidents	629	100%	526	100%	103	100%
1	497	79%	396	75%	101	98%
2	99	16%	97	18%	2	2%
3	22	3%	22	4%	0	0%
4	8	1%	8	2%	0	0%
5	2	< 1%	2	< 1%	0	0%
6	1	< 1%	1	< 1%	0	0%

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 in-scope fatality was a generator-related fatality, so it is included in the “Generator” and “Total” columns.

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, 2014.

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 May 1, 2014. 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. Thirty percent (20 of 67) of the reported fatalities new to the report were for years prior to 2013.

The average number of non-fire CO fatalities associated with both generators and other engine-driven tools for years 2009 through 2011 is also presented in Table 3. These 3 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 in Appendix C illustrates the historical trend in engine-driven, tool-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, 2004–2013

Year	All Engine-Driven Tools (EDTs)		Generators		Other Engine-Driven Tools (OEDTs)	
	Incidents	Deaths	Incidents	Deaths	Incidents	Deaths
<i>Total</i>	<i>629</i>	<i>808</i>	<i>526</i>	<i>703</i>	<i>103</i>	<i>105</i>
2004	50	62	35	47	15	15
2005	93	116	80	103	13	13
2006	79	109	63	93	16	16
2007	69	82	58	71	11	11
2008	77	102	70	95	7	7
2009	55	76	45	66	10	10
2010	46	57	36	45	10	12
2011	81	108	69	96	12	12
<i>2012</i>	<i>43</i>	<i>49</i>	<i>38</i>	<i>44</i>	<i>5</i>	<i>5</i>
<i>2013</i>	<i>36</i>	<i>47</i>	<i>32</i>	<i>43</i>	<i>4</i>	<i>4</i>
Average: 2009–2011	61	80	50	69	11	11

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, 2014.

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, 5, and 6 present summaries of socio-demographic characteristics of the victims. Table 4 presents the distribution of ages of the victims. Victims age 25 years or older accounted for about 86 percent (687 of 802) of reported non-fire, CO poisoning deaths associated with all engine-driven tools, where the victim's age is known. Victims with a reported age of 25 years or older accounted for about 84 percent (583 of the 697 victims where the age was known) of non-fire CO poisoning deaths associated with generators and accounted for all but one of the deaths (104 of 105) associated with other engine-driven tools. Eighty-eight percent of the non-fire CO fatalities associated with non-generator, engine-driven tools (92 of 105) involved victims age 45 or older.

It appears from the data summary that EDT-related CO fatalities have been occurring at a higher rate to older consumers. Fifty-six percent of the CO fatalities were over the age of 44, while only 39 percent of the U.S. population was above 44 years of age during this time period. By contrast, only 14 percent of EDT-related victims were below the age of 25, while 34 percent of the U.S. population was below 25 years of age during this time period.

Table 4: Number of Reported Non-Fire Carbon Monoxide Fatalities Associated with Engine-Driven Tools by Age of Victim, 2004–2013

Age	Percentage of Mid-Point Estimated U.S. Resident Population ¹	All Engine-Driven Tools (EDTs)		Generators		Other Engine-Driven Tools (OEDTs)	
		Deaths	Percentage	Deaths	Percentage	Deaths	Percentage
Total	100%	808	100%	703	100%	105	100%
Under 5	7%	11	1%	11	2%	0	0%
5–14	13%	29	4%	29	4%	0	0%
15–24	14%	75	9%	74	10%	1	1%
25–44	27%	235	29%	223	32%	12	12%
45–64	26%	310	38%	257	37%	53	50%
65 and over	13%	142	18%	103	15%	39	37%
Adult, age unknown	-	6	1%	6	1%	0	0%

¹ This percentage represents the average 2008/2009 mid-point percentage of the 10-year period 2004 through 2013.

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, 2014.

Table 5 presents the distribution of the gender of the victims. Male victims accounted for 78 percent of the deaths associated with all engine-driven tools when the gender of the victim is known. Male victims comprised 75 percent of the deaths associated with generators and 97 percent of non-generator, engine-driven tool fatalities.

Table 5: Number of Reported Non-Fire Carbon Monoxide Fatalities Associated with Engine-Driven Tools by Gender of Victim, 2004–2013

Gender	All Engine-Driven Tools (EDTs)		Generators		All Other Engine-Driven Tools (OEDTs)	
	Deaths	Percentage	Deaths	Percentage	Deaths	Percentage
Total	808	100%	703	100%	105	100%
Male	632	78%	530	75%	102	97%
Female	174	22%	171	24%	3	3%
Unknown	2	< 1%	2	< 1%	0	0%

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, 2014.

Table 6 presents a summary of the race/ethnicity of the reported CO fatalities associated with engine-driven tools. The percentage of generator-related CO fatalities identified as “Black/African American” (24% of deaths) was double the proportion classified by the U.S. Census Bureau as “Black/African Americans” in the U.S. population (an estimated 12%). The percentage of the non-generator, engine drive tools-related CO fatalities identified as “White” (89% of deaths) was much higher than proportion classified as “White” by of the U.S. Census Bureau (an estimated 65% of the U.S. population).

Table 6: Number of Reported Non-Fire Carbon Monoxide Fatalities Associated with Engine-Driven Tools by Race/Ethnicity of Victim, 2004–2013

Race / Ethnicity	Percentage of Mid-Point Estimated U.S. Resident Population ¹	All Engine-Driven Tools (EDTs)		Generators		All Other Engine-Driven Tools (OEDTs)	
		Deaths	Percentage	Deaths	Percentage	Deaths	Percentage
Total		808	100%	703	100%	105	100%
White	65%	498	62%	405	58%	93	89%
Black/African American	12%	171	21%	169	24%	2	2%
Hispanic (any race)	15%	82	10%	80	11%	2	2%
Asian	4%	14	2%	13	2%	1	1%
Native American	1%	6	1%	6	1%	0	0%
Other / Unknown	< 1%	37	5%	30	4%	7	7%

² This percentage represents the average 2008/2009 mid-point percentage of the 10-year period 2004 through 2013. All categories, with the exception of “Hispanic (any race)” are non-Hispanic averages.

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.

Sources: U. S. Consumer Product Safety Commission, Directorate for Epidemiology, 2014.

U. S. Census Department, The 2012 Statistical Abstract - The National Data Book, Table 6.

Staff examined reported deaths associated with engine-driven tools by the time of year that the incident occurred (Table 7). 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 November, December, January, and February; “Warm months” are May, June, July, and August; and “Transitional months” are March, April, September, and October.

Half (50%) 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. Additional 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 (37%) than the transitional months (32%) and warm months (30%).

Table 7: Number of Reported Non-Fire Carbon Monoxide Incidents and Fatalities Associated with Engine-Driven Tools by Season, 2004–2013

Season Incident Occurred		All Engine-Driven Tools (EDTs)		Generators		Other Engine-Driven Tools (OEDTs)	
Total	Incidents	629	100%	526	100%	103	100%
	Deaths	808	100%	703	100%	105	100%
Cold months	Incidents	306	49%	268	51%	38	37%
	Deaths	388	48%	349	50%	39	37%
Transitional months	Incidents	182	29%	149	28%	33	32%
	Deaths	245	30%	211	30%	34	32%
Warm months	Incidents	141	22%	109	21%	32	31%
	Deaths	175	22%	143	20%	32	30%

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, 2014.

Incidents involving deaths are further summarized in Table 8 by the location where the death occurred. The majority of non-fire, CO poisoning deaths (687 of 808, or 85%) reported to CPSC staff associated with engine-driven tools occurred at home locations. Seventy-four percent of the deaths occurred at fixed-structure used as a residence, which include houses, mobile homes, apartments, townhouses, and structures attached to the house, such as an attached garage. Another 8 percent occurred in external or detached structures at home locations, such as detached garages or

sheds. A large portion of these external structure fatalities were related to OEDTs, such as lawnmowers running in sheds or detached garages. Thirty-five percent (23 of 65) of fatalities occurring in external structures at the home involved OEDTs. In fact, 23 percent of all deaths involving OEDTs occurred in external structures at the home, compared to only six percent of all generator deaths.

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 as 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, are not within the purview of the CPSC; and thus, they are out of scope for this report and were excluded from the analyses. 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 within the purview of CPSC 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 8: Number of Reported Non-Fire Carbon Monoxide Incidents and Fatalities Associated with Engine-Driven Tools by Location, 2004–2013

Location		All Engine-Driven Tools (EDTs)		Generators		Other Engine-Driven Tools (OEDTs)	
Total	Incidents	629	100%	526	100%	103	100%
	Deaths	808	100%	703	100%	105	100%
Home, fixed Structure ¹	Incidents	467	74%	395	75%	72	70%
	Deaths	601	74%	528	75%	73	70%
Home, detached Structure ²	Incidents	63	10%	40	8%	23	22%
	Deaths	65	8%	42	6%	23	22%
Home, non-house ³	Incidents	18	3%	14	3%	4	4%
	Deaths	21	3%	17	2%	4	4%
Temporary shelter	Incidents	46	7%	46	9%	0	0%
	Deaths	72	9%	72	10%	0	0%
Boat/Vehicle	Incidents	19	3%	18	3%	1	1%
	Deaths	25	3%	23	3%	2	2%
Other	Incidents	13	2%	11	2%	2	2%
	Deaths	16	2%	14	2%	2	2%
Not reported	Incidents	3	< 1%	2	< 1%	1	1%
	Deaths	8	1%	7	1%	1	1%

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

2 This refers to detached structures at home locations, including detached garages and sheds.

3 This refers to non-fixed location residences, including travel trailers and houseboats.

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, 2014.

Table 9 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 U.S. Department of Agriculture (USDA). Recently, the four urban/rural categories were changed to delineate further the large urban category. Formerly, the four broad categories were: “Urban,” “Large Rural,” “Small Rural,” and “Isolated.” In the newer categorization, the “Urban” category was divided into “Urban Core” and “Sub-Urban.” Additionally, the “Small Rural” and “Isolated” categories are now combined into the “Small Rural/Isolated” category. Details on the process of determining population density or rurality can be found at the USDA website at: <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, WWAMI⁴ Rural Health Research Center website at: <http://depts.washington.edu/uwruca/>.

Fifty-eight percent (471 of 808) of CO fatalities associated with the use of engine-driven tools reported to CPSC staff occurred in urban areas, while the estimated proportion of the U.S. population living in urban core areas is 71 percent. Forty-two percent (337 of 808) of CO fatalities occurred in non-urban core areas (sub-urban, large rural, and small rural/isolated areas), where an estimated 29 percent of the U.S. population lives. There appears to be an unusually high proportion of fatalities in small rural/isolated areas. Sixteen percent (128 of 808) of the CO fatalities known to CPSC staff to be associated with EDTs occurred in small rural and isolated areas, where only an estimated nine percent of the U.S. population lives. The high proportion of fatalities in small rural/isolated areas can be explained partly by the fact that 20 percent (25 of 128) of these occurred in temporary or boat/vehicle locations and not at home locations.

Table 9: Number of Reported Non-Fire Carbon Monoxide Fatalities Associated with Engine-Driven Tools by Population Density of Place of Death, 2004–2013

Population Density		Estimated Percentage of U.S. Population ¹	All Engine-Driven Tools (EDTs)		Generators		Other Engine-Driven Tools (OEDTs)	
Total	Incident	100%	629	100%	526	100%	103	100%
	Deaths		808	100%	703	100%	105	100%
Urban Core	Incident	71%	358	57%	304	58%	54	52%
	Deaths		471	58%	416	59%	55	52%
Sub-Urban	Incident	10%	84	13%	69	13%	15	15%
	Deaths		107	13%	92	13%	15	14%
Large Rural	Incident	10%	86	14%	66	13%	20	19%
	Deaths		102	13%	81	12%	21	20%
Small Rural /Isolated	Incident	9%	101	16%	87	17%	14	14%
	Deaths		128	16%	114	16%	14	13%

¹ Percentages are determined from the estimated 2010 U.S. population categorized by RUCA designation. U.S. population estimates by RUCA classification were determined by cross-referencing the WWAMI RUCA zip code table with the 2010 U.S. Census population estimates by zip code area, the most current census data available by zip code area.

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, 2014.

WWAMI Rural Research Center at the University of Washington Economic Research Group, USDA.

U.S. Census Bureau, 2011.

⁴ 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 Wyoming, Alaska, Montana, and Idaho.

III. Alarm Usage

Table 10 presents a summary of known CO fatalities characterized by CO alarm usage and alarm status. In 60 percent of the fatal incidents (379 of 629) and 57 percent of reported CO poisoning deaths (462 of 808), the presence of a CO alarm at the location of the incident was unknown or unreported. Of the 250 fatal incidents (346 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 19 incidents (8%) involving 29 CO fatalities. Of these 19 fatal incidents, the alarm was known to be inoperable in seven incidents (14 fatalities) due to missing, improperly installed, or possibly drained batteries in 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. All seven fatal incidents (14 fatalities) with inoperable alarms were associated with generator usage.

For the remaining 12 fatal incidents (15 fatalities) where an alarm was known to be present, the alarm was known to have sounded in only six incidents (seven deaths):

- Two incidents (one death each) occurred in an attached garage of a home with the alarm sounding inside the house. It is unclear from the incident reports, but, presumably, the death occurred in the garage before CO levels increased inside the house sufficient to set off the CO alarm.
- In one 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; they thought the alarm sounding simply meant that the alarm was working.
- In one fatal incident the victims thought the "beeping" meant that the batteries were low so they replaced the batteries. The batteries were inserted incorrectly, thus disabling the alarm. One family member died and two survived.
- In one incident the alarm sounded, and the victim removed the batteries, thus disabling it. The victim was transported to the hospital but was pronounced dead.
- In another incident, two victims were found in a home where a CO alarm was sounding. It is unclear if the alarm triggered after the victims became incapacitated by CO poisoning or if the victims simply misunderstood or ignored the signal.

There were also eight deaths from six incidents in which a CO alarm was present in the house, but it was unknown whether it sounded or if it was operable.

Table 10: Carbon Monoxide Alarm Usage Associated with Engine-Driven Tools Non-Fire Carbon Monoxide Poisoning Deaths, 2004–2013

CO Alarm Status	Number of Deaths and Percentage of Deaths when Alarm Status was Known								
	All Engine-Driven Tools (EDTs)			Generators			Other Engine-Driven Tools (OEDTs)		
	Incidents	Deaths	% of Deaths	Incidents	Deaths	% of Deaths	Incidents	Deaths	% of Deaths
Total	629	808	-	526	703	-	103	105	-
Alarm Status Known	250	346	100%	221	315	100%	29	31	100%
No Alarm	231	317	92%	205	289	92%	26	28	90%
Alarm Present	19	29	8%	16	26	8%	3	3	10%
Alarmed	6	7	2%	4	5	2%	2	2	6%
Did not alarm, batteries removed, incorrectly inserted, or drained	4	9	3%	4	9	3%	0	0	0%
Did not alarm, plug-in type, no power	3	5	1%	3	5	2%	0	0	0%
Alarm present, Unknown if it alarmed	6	8	2%	5	7	2%	1	1	3%
Alarm Status Unknown	379	462	-	305	388	-	74	74	-

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, 2014.

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 May 1, 2014, CPSC staff is aware of 526 generator-related incidents from 2004 through 2013, which resulted in non-fire CO fatalities. Staff completed In-Depth Investigations (IDIs) for 499 of 526 (95%) fatal CO incidents associated with generators that occurred from 2004 through 2013. For the remaining 27 incidents in which an IDI was not performed or was not completed by the May 1, 2014 cut-off date, 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 526 incidents resulting in 703 generator-related, non-fire CO deaths reported to CPSC staff suggests two primary 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 after a shutoff to the residence by the utility company due to bill dispute or nonpayment. Table 11 provides a breakdown by year, listing the reasons why a generator was in use at the time of the incident. Twenty-eight percent of the incidents (29 percent of the reported deaths) involving generator-related, non-fire CO fatalities were associated with the use of generators during a temporary power outage stemming from a weather problem or a problem with power distribution. Twenty percent of the fatal incidents (20 percent of deaths) were associated with the use of generators after a power shutoff by the utility company for nonpayment of a bill or a bill dispute. For 19 percent of the fatal incidents (17 percent of deaths), it could not be determined why the generator was in use, or why there was no electricity at the location of the incident.

Table 11: Number of Reported Non-Fire Carbon Monoxide Fatalities for Incidents that Occurred at a Fixed-Structure Home Associated with Generators¹ by Reason for Use, 2004–2013

Reason for Use		Total	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Total	Incidents	526	35	80	63	58	70	45	36	69	38	32
	Deaths	703	47	103	93	71	95	66	45	96	44	43
Power outage due to weather, or problem with power distribution	Incidents	147	7	37	11	15	19	10	5	19	15	9
	Deaths	206	11	53	17	23	26	17	6	27	16	10
Electricity turned off by power company due to bill dispute or nonpayment	Incidents	107	6	11	17	13	13	6	12	17	5	7
	Deaths	141	6	12	23	16	19	9	16	25	6	9
Provide power to storage shed, trailer, boat, camper, cabin, campsite	Incidents	63	3	8	13	8	5	8	2	8	5	3
	Deaths	88	4	11	19	9	7	11	5	13	6	3
New home or homeowner, and power not yet turned on, home under construction or renovation	Incidents	56	10	4	6	5	7	5	5	5	3	6
	Deaths	83	14	6	9	5	13	6	5	10	4	11
Provide power to home or mobile home that normally does not have electricity	Incidents	34	3	6	3	4	4	3	3	4	4	0
	Deaths	45	4	6	5	5	5	7	3	4	6	0
Working on or preparing a home for predicted storm	Incidents	5	0	0	1	0	4	0	0	0	0	0
	Deaths	5	0	0	1	0	4	0	0	0	0	0
Provide power to a shed or garage that normally does not have electricity	Incidents	6	0	0	0	0	2	0	1	2	1	0
	Deaths	6	0	0	0	0	2	0	1	2	1	0
Other (previous fire in house, power shut off by owners, servicing power supply, or other usage)	Incidents	10	0	1	1	0	3	2	1	1	0	1
	Deaths	12	0	1	1	0	3	2	1	2	0	2
Unknown why electricity off	Incidents	98	6	13	11	13	13	11	7	13	5	6
	Deaths	117	8	14	18	13	16	14	8	13	5	8

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, 2014.

For the 147 fatal incidents associated with a power outage due to weather or a problem with power distribution, Table 12 provides a further breakdown by year and cause of the power outage. Ninety-four percent of the fatal incidents associated with power outages were due to specific weather conditions. Ice or snow storms are associated with the largest percentage of weather-related CO fatal incidents accounting for nearly half (48%) of the power outage-related incidents. Hurricanes and tropical storms are also associated with a large percentage of CO fatal incidents (29%) over the 10-year period from 2004 to 2013. Nearly half (48%) of the hurricane- or tropical storm-related fatal incidents (20 of 42) occurred in 2005.

Table 12: Number of Reported Non-Fire Carbon Monoxide Fatalities for Incidents that Occurred at a Fixed-Structure Home Associated with Generators¹ by Reason for Power Outage, 2004–2013

Reason for Power Outage		Total	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Total	Incidents	147	7	37	11	15	19	10	5	19	15	9
	Deaths	206	11	53	17	23	26	17	6	27	16	10
Ice or snow storm	Incidents	71	1	15	6	9	7	9	3	10	5	6
	Deaths	95	2	20	8	13	9	14	4	14	5	6
Hurricane or tropical storm	Incidents	42	5	20	1	0	6	0	0	3	7	0
	Deaths	61	8	31	1	0	8	0	0	5	8	0
Wind storm	Incidents	6	0	0	2	1	1	0	0	1	1	0
	Deaths	10	0	0	6	1	1	0	0	1	1	0
Thunderstorm or rainstorm	Incidents	9	0	1	2	1	1	0	2	2	0	0
	Deaths	11	0	1	2	1	2	0	2	3	0	0
Tornado	Incidents	3	0	0	0	0	2	0	0	1	0	0
	Deaths	5	0	0	0	0	3	0	0	2	0	0
Storm, unspecified	Incidents	7	0	0	0	2	1	0	0	1	2	1
	Deaths	9	0	0	0	4	1	0	0	1	2	1
Unknown or other reason for outage	Incidents	9	1	1	0	2	1	1	0	1	0	2
	Deaths	15	1	1	0	4	2	3	0	1	0	3

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, 2014.

As shown in Table 8 above, 526 generator-related, non-fire CO fatalities occurred in a fixed-structure home. The category “fixed-structure home” is defined as a permanent, fixed-structure used as a residence, including: houses, mobile homes, apartments, townhouses, and structures attached to the house, such as an attached garage. Travel trailers, campers, and RVs are not included in this classification, nor are external structures at the home, such as detached garages or sheds.

Of these 526 generator-related deaths that occurred in a fixed-structure home, information was available for 445 deaths (85%) regarding the victim’s location in relation to the generator. One hundred-two of these 445 fatalities (23%) occurred in the same room or space as the generator.

The 526 deaths that occurred in a fixed-structure home were the result of 393 incidents (Table 13). These incidents were further classified by the specific location of the generator within the home. The category “Living Space (non-basement)” 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 the home” includes incidents where the generator was placed outside a home but near an open window, door, or vent of the home. Sixty-six percent (258 of 393) of the CO fatal incidents at home locations occurred when a generator was placed inside the home, including the living space (133), a basement (89), closet (4), doorway (2), or inside the house, with no further information provided (30). Another 27 percent of the fatal incidents (106 of 393) occurred when the generator was placed in an attached garage, enclosed carport, or attached barn. Nearly half (50%) of the fatal incidents (195 of 393) occurred when the generator was placed in an attached structure (106) or in the basement or crawlspace (89).

Fifteen deaths from 11 incidents were associated with the use of a generator placed outside the home.⁵ Usually, this involved placing the generator too near an open window or vent. This category also includes an incident where a generator was running outside the home but inside a building (*e.g.*, outside an apartment but still inside the building).

⁵ During the time period covered by this report, there were a total of 38 fatalities from 29 incidents known to have been caused by a generator being used either outdoors or outside the victims location but inside a building. For non-fixed-structure home locations, the most common scenario was when a generator was placed outside nearby a camper or RV and the CO infiltrated into the enclosed space where the victims were located.

Table 13: Non-Fire Carbon Monoxide Poisoning Deaths in the Fixed-Structure Home Location¹ by Location of the Generator,² 2004–2013

Generator Location		Total	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Total	Incidents	393	28	55	40	44	52	35	29	54	31	25
	Deaths	526	38	70	57	56	71	52	35	76	36	35
Living space (non-basement)	Incidents	133	12	17	12	15	20	14	13	17	9	4
	Deaths	180	18	23	17	19	27	20	13	24	13	6
Garage / enclosed carport / attached barn	Incidents	106	6	17	13	10	13	8	5	13	13	8
	Deaths	136	8	18	20	15	15	11	6	18	13	12
Basement / crawlspace	Incidents	89	6	12	9	9	11	6	4	16	6	10
	Deaths	127	7	15	11	12	20	11	7	25	6	13
Inside house, no further information reported	Incidents	30	1	2	4	6	5	3	1	4	2	2
	Deaths	33	1	2	4	6	5	5	2	4	2	2
Closet in home	Incidents	4	0	1	1	1	0	1	0	0	0	0
	Deaths	11	0	6	3	1	0	1	0	0	0	0
Outside the home	Incidents	11	1	4	0	2	0	0	1	1	1	1
	Deaths	15	2	4	0	2	0	0	1	2	2	2
Doorway to home	Incidents	2	1	0	1	0	0	0	0	0	0	0
	Deaths	3	1	0	2	0	0	0	0	0	0	0
Unknown location, but at home	Incidents	18	1	2	0	1	3	3	5	3	0	0
	Deaths	21	1	2	0	1	4	4	6	3	0	0

1 This refers to a fixed-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, 2014.

Table 14 presents a summary of non-fire CO fatalities that occurred in the fixed-structure home characterized by ventilation status. Many of the incidents with generator-associated fatalities in the home (174 of the 393 incidents) did not contain information about the ventilation of the generator. In 145 of the 219 incidents (66%), accounting for 201 deaths, in which information on ventilation of the generator was available, there was no ventilation being provided when the incident occurred. In

five of these fatal incidents (seven deaths), a window or door was open during some period of use but later closed. There were 74 incidents associated with generators in which it was reported that some type of ventilation was employed. Of these 74 incidents, 52 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, accounting for 64 CO deaths. As noted here and in Table 13, ten incidents (13 deaths) were associated with generators that were placed outside the home near open windows, doors, or vents, where carbon monoxide entered the home. In eleven incidents (22 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. An additional fatality occurred when a victim placed a generator outside of an apartment in the unventilated hallway of a building.

Table 14: Non-Fire CO Fatalities in the Fixed-Structure Home¹ Reported to CPSC Staff and Associated with Generators² Categorized by Status of Ventilation, 2004–2013

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	393	526	100%	100%
Some ventilation attempted	74	100	19%	33%
Open window(s), open door(s), an open garage door, or a combination of these	52	64	12%	21%
Actively trying to vent either by fans or by directing exhaust out a window or door	11	22	4%	7%
Placed outside, but near a window, door or A/C unit ³	10	13	2%	4%
Placed outside apartment, but inside building	1	1	< 1%	< 1%
No ventilation	145	201	38%	67%
Open windows or doors closed sometime later	5	7	1%	2%
No ventilation attempted ⁴	140	194	37%	64%
Unknown ventilation	174	225	43%	-

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 occurred when a generator was placed outside an apartment in an unvented hallway and one 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, 2014.

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

Table 15 presents a summary of the fatal CO incidents and fatalities characterized by the size of the home in which the fatalities occurred. For 40 percent (159 of 393) of the fatal incidents (205 of 526 deaths), CPSC staff could not ascertain the size of the home. Home size information was available for 234 of 393 fatal incidents (321 of the 526 deaths). 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 from Internet databases of real estate information, which contain public record data, such as *Cyberhomes.com* and *Zillow.com*. In most cases, Internet 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 or more sizes was used because it could not be determined which database had the more accurate figure.

Fifty-nine percent (137 of 234) of the reported fatal incidents (189 of 321 CO fatalities) 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 85 percent (198 of 234) of the reported incidents (272 of 321 deaths) 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 generator-related CO poisoning deaths, where home size information is known, was 1,328 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 fatal incidents by home size to the U.S. Census figures, it appears that the fatal CO incidents are skewed toward smaller homes. Whether this is due to economic reasons or because smaller-volume structures are filled more quickly by deadly carbon monoxide, is unclear. Perhaps it is a combination of the two factors, or some yet unidentified reason.

Table 15: Non-Fire CO Fatalities in the Fixed-Structure Home¹ Reported to CPSC Staff and Associated with Generators² Categorized by Size of Home, 2004–2013

Home Size (in sq. feet) ²	Number of Incidents	Number of Deaths	Percentage of Incidents	Percentage of Incidents Where Home Size is Known	Estimated Percentage of U.S. Housing Units (2009) ⁴
Total	393	526	100%	100%	100%
Under 500	1	1	< 1%	< 1%	1%
500–999	54	70	14%	23%	10%
1,000–1,499	82	118	21%	35%	25%
1,500–1,999	61	83	16%	26%	24%
2,000–2,499	21	32	5%	9%	17%
2,500–2,999	8	9	2%	3%	9%
3,000 or Larger	7	8	2%	3%	14%
Unknown	159	205	40%	-	-

- 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*.
- 4 The 2009 housing unit figures are the most current figures available.

Source: U. S. Consumer Product Safety Commission, Directorate for Epidemiology, 2014.

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 16). Note that this table presents a summary of all incidents known to CPSC at all locations, not just fixed-structure home locations. In most cases, the advertised running wattage rating was used to categorize the generator. In some instances, however, a wattage rating was used in which it could not be determined whether it was the rated running wattage or maximum/surge wattage. When the wattage rating of the generator was known or could be determined (347 investigated deaths from 240 incidents), 63 percent of the incidents (150 incidents, 216 deaths) were associated with a generator in the 3500 to 6499 watt rating range. Forty-four percent of the incidents (105 incidents, 151 deaths) involving CO fatalities, where the generator size was known, were associated with generators in the 5000 to 6499 watt range.

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. Three incidents (five deaths) identify a propane-fueled generator as the source of the CO. In all three of these incidents, the generator was identified as non-portable, backup generator.

Table 16: Number of Reported Non-Fire Carbon Monoxide Fatalities Associated with Generators¹ Categorized by Generator Wattage Rating, 2004–2013

Wattage Rating (in Watts)		Total	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Total	Incidents	526	35	80	63	58	70	45	36	69	38	32
	Deaths	703	47	103	93	71	95	66	45	96	44	43
Under 2000	Incidents	20	2	4	1	2	2	1	2	1	4	1
	Deaths	24	2	4	1	5	2	1	2	1	5	1
2000–3499	Incidents	52	2	6	11	6	5	3	3	7	3	6
	Deaths	81	2	8	19	7	8	6	3	12	5	11
3500–4999	Incidents	45	2	11	6	5	9	2	3	6	1	0
	Deaths	65	2	14	11	8	11	2	5	11	1	0
5000–6499	Incidents	105	12	12	15	11	14	8	11	11	3	8
	Deaths	151	19	20	20	13	20	15	13	17	4	10
6500–7999	Incidents	12	0	1	0	1	3	1	1	3	1	1
	Deaths	16	0	1	0	2	4	1	1	5	1	1
8000 and larger	Incidents	6	1	0	1	0	1	1	0	1	0	1
	Deaths	10	1	0	1	0	1	1	0	5	0	1
Not reported	Incidents	286	16	46	29	33	36	29	16	40	26	15
	Deaths	356	21	56	41	36	49	40	21	45	28	19

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, 2014.

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

Table 17 presents a summary of all incidents at fixed-structure home locations categorized by generator size (Watts) and home size (square feet). There does not appear to be any correlation between home size and the size of the generator used. The most commonly involved generator size (5000 to 6499 Watts) is the most commonly used in all but the largest home category. It should be noted that the numbers of incidents where the size of the generator is known at the smallest house category (0 to 499 sq. ft., [one incident]) and the two largest categories (2500 to 2999 sq. ft. [2 incidents] and 3000 sq. ft. or larger [3 incidents]) are probably too small to make meaningful conclusions.

Table 17: Number of Reported Non-Fire Carbon Monoxide Fatalities for Incidents that Occurred at a Fixed-Structure Home Associated with Generators¹ Categorized by Generator Wattage Rating and Home Size, 2004–2013

Wattage Rating (in Watts)		Total	Home Size (in square feet)							Unknown
			0 - 499	500 - 999	1000 - 1499	1500 - 1999	2000 - 2499	2500 - 2999	3000 or larger	
Total	Incidents	393	1	54	82	61	21	8	7	159
	Deaths	526	1	70	118	83	32	9	8	205
Under 2000	Incidents	18	0	2	8	3	0	0	0	5
	Deaths	22	0	2	10	4	0	0	0	6
2000–3499	Incidents	37	0	5	9	8	2	0	1	12
	Deaths	62	0	8	16	17	6	0	1	14
3500–4999	Incidents	35	0	5	7	6	3	0	2	12
	Deaths	49	0	7	12	8	3	0	2	17
5000–6499	Incidents	83	1	9	20	17	4	2	0	30
	Deaths	122	1	14	31	22	7	2	0	45
6500–7999	Incidents	10	0	1	2	3	0	0	0	4
	Deaths	13	0	1	3	3	0	0	0	6
8000 and larger	Incidents	3	0	1	1	0	0	0	0	1
	Deaths	3	0	1	1	0	0	0	0	1
Not reported	Incidents	207	0	31	35	24	12	6	4	95
	Deaths	255	0	37	45	29	16	7	5	116

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, 2014.

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

Conclusion

Between 2004 and 2013, 808 non-fire CO poisoning deaths from 629 incidents were reported to CPSC staff that was associated with engine-driven tools. The majority of these deaths (703) involved generators or both a generator and another consumer product. 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 84 percent of the non-fire CO poisoning deaths that were associated with generators reported to CPSC staff, and the majority (75 percent) of the victims were male. Seventy-five percent of the reported deaths associated with generators occurred at fixed-structure home locations. Sixty-six percent of the fatal incidents known to have occurred in the home and involving generators occurred when a generator was placed in the living area or basement of the home. Another 27 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 206 of the 703 fatalities (29 percent). Generators were often used with little or no ventilation. In only about eight 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 were not possible to make with the available information.

Victims age 25 years and older accounted for 99 percent of the non-fire CO poisoning deaths reported to CPSC staff that were associated with other engine-driven tools. Males accounted for 97 percent 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—<http://www.cpsc.gov/en/Safety-Education/Safety-Education-Centers/Carbon-Monoxide-Information-Center/>—for the latest information on recalls, safety tips, safety standards, CO alarms, and downloadable injury prevention materials.

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Appendix A: Epidemiology Data Retrieval Specifics

The queries below were submitted through EPIR (EPIde miology Retrieval), 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.

For this report, a fatal incident was deemed in scope if none of the following criteria were violated:

- Carbon monoxide was the primary or contributing factor in the fatality.
- The carbon monoxide was not fire-related.
- The source of the CO was an engine-driven tool, or an engine-driven tool used in conjunction with another non-fire-related CO generating source.
- The fatal injury was unintentional in nature.
- The engine-driven tool involved was a consumer product.
- The incident was not work-related.

Date of Queries: 05/01/2013

Incident Dates: 1/1/04-12/31/13

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 are 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 the best way 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.⁶ COHb levels were available for 451 of the 808 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. Seventy-nine percent (357 of the 451) 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, 2004–2013¹

COHb Level	All Engine-Driven Tools (EDTs)		Generators		Other Engine-Driven Tools (OEDTs)	
Total	808	-	703	-	105	-
Reported Levels	451	100%	394	100%	57	100%
Less than 30%	24	5%	22	6%	2	4%
30–39.9%	28	6%	24	6%	4	7%
40–49.9%	42	9%	34	9%	8	14%
50–59.9%	96	21%	89	23%	7	12%
60–69.9%	121	27%	107	27%	14	25%
70–79.9%	107	24%	90	23%	17	30%
80–89.9%	28	6%	23	6%	5	9%
90–99.9%	5	1%	5	1%	0	0%
Not reported	357	-	309	-	48	-

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

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, 2014.

⁶ 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.

Appendix C: Historical Data

Figure 1 illustrates the trend in the number of non-fire CO fatalities associated with the use of generators and other engine-driven tools from 1999 to 2013. The number of generator-related fatalities increased at a steady rate from six in 1999 to 103 in 2005. After which, the number of yearly fatalities has oscillated between 40 and 100 fatalities per year. It should be noted that, due to reporting delays, fatality counts reported in future annual reports for the most recent years are likely to increase. Over the last six reports, including this one, the most recent year's counts have increased by about an average of 27 percent from the previous report. Two years back, the average increase, report to report, is about another 8 percent.

The number of CO fatalities associated with the use of non-generators engine-driven tools has been relatively steady over the period 1999 through 2013.

Figure 1: Number of Reported Non-Fire Carbon Monoxide Fatalities Associated with Engine-Driven Tools, 1999–2013

