



Incidents, Deaths, and In-Depth Investigations Associated with Non-Fire Carbon Monoxide from Engine-Driven Generators and Other Engine-Driven Tools, 2005–2016

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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 2005 and 2016, and were reported to U.S. Consumer Product Safety Commission (CPSC) staff as of June 14, 2017. It should be noted that due to incident reporting delays, statistics for the most recent years should be considered incomplete because data collection is still ongoing. In this report, the two most recent years, 2015 and 2016, 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 that were reported to CPSC staff. The generators and other engine-driven tools were power lawn mowers, garden tractors, portable pumps, power sprayers and washers, snow blowers, and concrete saws. 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:

- As of June 14, 2017, for the 12-year period 2005 through 2016, 965 fatalities from 743 incidents were associated with the use of engine-driven tools, or engine-driven tools used in conjunction with another potentially CO-emitting consumer product.
- This updated report increases the total number of reported fatalities for the 12-year period 2005 through 2016 by 85 from last year’s report covering the 11-year period 2005 through 2015. The 85 additional reported death include:
 - 57 reported deaths occurred in 2016;and based on information obtained since the previous report,
 - 21 additional deaths in 2015;
 - 2 additional deaths in 2014;
 - 4 additional deaths in 2013; and
 - 1 additional death in 2012.
- The 57 reported non-fire engine-driven tool-related CO fatalities in 2016 were a result of 41 separate incidents. Forty-four of these deaths (31 incidents) involved a portable generator and no other product; four deaths involved some type of gasoline-fueled lawn mower; one death involved a gas-powered pressure washer; and one death involved a concrete saw.

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.

Additionally, seven deaths (four incidents) were associated with a generator and some other fuel-burning consumer product.

- From 2005 through 2016, of the 965 fatalities from 743 incidents:
 - 788 fatalities (82%) from 581 incidents were associated with generators (including five fatalities from three incidents involving fixed location, permanently installed stationary generators) and no other CO producing product;
 - 114 fatalities (12%) from 112 incidents involved other engine-driven tools and no other CO producing product; and
 - 63 fatalities (7%) from 50 incidents involved multiple fuel-burning consumer products, where one product was either a generator (61 of 63 deaths) or an Other Engine-Driven Tools (OEDT) (2 of 63 deaths), and the other product was a non-EDT.
- In 48 of the 50 incidents that involved multiple consumer products, the second product involved was either a heating or cooking product. Most commonly, the second product was a portable liquid propane (LP)- or kerosene-fueled portable heater. One incident not associated with a heating or cooking product involved a gas-fueled lawn mower and a gas-fueled hedge trimmer. The other incident not associated with a heating or cooking product involved a generator and a vehicle of unspecified type.
- Twenty-five percent of the generator-related, non-fire CO incidents (155 of 629) caused multiple fatalities; while only two of the 114 OEDT-related incidents (2%) involved multiple fatalities.

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

- Eighty-two percent of generator-related victims were known to be 25 years old or older. In contrast, 99 percent of OEDT-related victims (all but one) were 25 years old or older.
- More than three-quarters (76%) of the generator-related, non-fire CO victims were male; while 97 percent (all but four) of the OEDT-related fatalities were male.
- Twenty-five percent of generator-related, non-fire CO fatalities were non-Hispanic Black or African American, nearly double the non-Hispanic Black or African American proportion (13%) of the U.S. population. Eighty-seven 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 (414 of 849) occurred in the four cold months of the year (November through February); while CO fatalities associated with OEDTs were more evenly distributed across the year with the cold months (40%) slightly higher than in the transition and warm months (33% and 28%, respectively).
- Seventy-five percent of the generator-related fatalities occurred in fixed-structure homes; while 69 percent of OEDT fatalities occurred in fixed-structure homes.
- Fifty-six percent of the EDT-related fatalities are known to have occurred in urban areas. Eighteen percent occurred in small rural and isolated areas, double the proportion of the U.S. population that lives in such areas.

CO Alarm Usage:

- A CO alarm was reportedly present in only 25 of 262 incidents where alarm presence was known; these 25 incidents accounted for 36 of 376 (10%) EDT-related CO fatalities. In nine of the incidents (17 deaths), the alarm was inoperable due to no batteries, batteries inserted incorrectly, probable drained batteries, or no electric current. The alarm sounded in nine incidents (10 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 seven incidents (nine 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-six percent of all generator-related, non-fire CO deaths (220 of 849) from 2005 through 2016 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 (77 incidents, 102 deaths) and hurricanes/tropical storms (38 incidents, 54 deaths). The second most common reason for generator usage in the reported CO fatalities was due to power shut-off, accounting for 21 percent (179 deaths from 129 incidents) of the all reported fatalities. This latter scenario included an incident where a father and seven children died in 2015.
- Six hundred thirty-five non-fire CO fatalities (465 incidents) that occurred in fixed-structure homes were associated with a generator, or a generator in use with another potential CO-generating consumer product. Seventy-one percent (450 deaths, 322 incidents) of those 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.
- The second most common location of generators associated with fatal CO poisoning incidents at a fixed-structure home was in an attached structure to the house like an attached garage, enclosed carport, or attached barn where 113 incidents involving 148 deaths were reported.
- Two-thirds of generator-related, non-fire fatal CO incidents (67%) in fixed-structure homes (for which information on ventilation of the generator was available) occurred when no apparent ventilation of the generator exhaust was attempted.
- Sixty-four 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; 87 percent occurred in houses less than 2,000 square feet in size.

Engine Class of Generators Involved in Fatal CO Incidents

- The vast majority of generator-related fatal CO incidents involved generators equipped with either Class I or Class II, Single Cylinder engines. Of the 629 fatal generator incidents between 2005 and 2016, the generator engine class could only be determined in 279 cases. Ninety-seven percent of the 279 incidents involved a generator with a Class

I engine (98 incidents) or Class II, Single-Cylinder (172 incidents). [Note that one of the Class II, Single-Cylinder equipped incidents also involved a Class I equipped generator.]

Fatal CO Incidents Where Generator Was Located Outside the Victim Location:

- Seven percent of CO fatalities were associated with generators being used either outdoors situated too close to windows, air conditioners, or other locations where CO infiltrated into an enclosed space or where a generator was placed outside of the victims location but still within an enclosed space like outside of an apartment in the building's hallway or outside a travel trailer but inside a garage in which it was parked.

Carboxyhemoglobin Levels in CO Fatality Victims:

- Of the CO fatality victims associated with engine-driven tools, 81 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 2015 and 2016 are italicized in table headings, indicating that incident and death counts are likely to 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 incidents reported and entered into CPSC databases on or before June 14, 2017. 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 965 non-fire CO fatalities associated with EDTs during the years 2005 through 2016. Last year's report, dated June 2016, contained summary information and analyses for the 11-year period, 2005–2015. This updated report adds information on 85 CO fatalities associated with engine-driven tools, reported to CPSC since the last report.

Changes to previous report:

- 2012 – One incident added, accounting for one death.
- 2013 – Three incidents added, accounting for four deaths.
- 2014 – Two incidents added, accounting for two deaths.
- 2015 – Nineteen incidents added, accounting for 21 deaths.
- 2016 – Forty incidents added, accounting for 57 deaths.

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. 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 and was also excluded from the analysis, 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 focused on 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 (COHb) 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 June 14, 2017, CPSC staff had records indicating that there were 41 fatal, non-fire CO exposure incidents involving EDTs between January 1, 2016 and December 31, 2016. Fifty-seven deaths occurred in these 41 fatal CO incidents. Table 1 presents the reported fatal incidents and the number of deaths in 2016, along with a summary of CO incidents and fatalities associated with engine-driven tools for the 12-year period from 2005 through 2016. The table records the number of incidents and deaths by the broad categories of “Generators,” OEDTs 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 63 fatalities associated with multiple consumer products, occurring in the 2005 through 2016 time period; seven of these fatalities occurred in 2016. 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. Thus, this report may underestimate the incidents of CO fatalities. Following Table 1, Multiple Product incidents will be included in the summary for the involved engine-driven tool type, either “Generators” or OEDTs.

Within each broad category, the frequency of reports is summarized by product type. Staff is aware of 743 incidents with a total of 965 deaths due to non-fire CO exposure that occurred between 2005 and 2016, involving EDTs.

In Table 1, the product type “welder” appears in both the “Generator” and OEDT categories. Some welding equipment is designed to be used as a welder or as an electric generator. Three of the fatal, non-fire CO incidents associated with the use of welding equipment that occurred between 2005 and 2016, involved the use of the welder as a generator during a power outage. Each of these three incidents involved a single death. There were four fatal, non-fire CO incidents between 2005 and 2016, which were associated with the use of welding equipment, where it was not specifically identified as being used as a generator. Of these four incidents, one incident involved two deaths.

All but two of the 48 non-fire CO fatalities in the “Multiple Products” category for 2005–2016 involved a heating- or cooking-related consumer product other than an EDT. 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. The other multi-product incident not associated with a heating or cooking product involved a generator and a vehicle of unspecified type being used in a shed.

Table 1: Number of Reported Fatal Non-Fire Carbon Monoxide Exposure Incidents and Deaths Associated with Engine-Driven Tools, 2005–2016

Product	2015		2016		Total: 2005–2016	
	Number of Incidents	Number of Deaths	Number of Incidents	Number of Deaths	Number of Incidents	Number of Deaths
Total Engine-Driven Tools	55	80	41	57	743	965
Generators	44	69	31	44	581	788
Generator, portable	44	69	31	44	575	780
Generator, fixed	0	0	0	0	3	5
Welder (used as a generator) ¹	0	0	0	0	3	3
Other Engine-Driven Tools (OEDT)	7	7	6	6	112	114
Lawn mowers	2	2	4	4	57	57
Riding lawn mower/Garden tractor	1	1	2	2	46	46
Push lawn mower	0	0	1	1	2	2
Powered lawn mower, unspecified type	1	1	1	1	9	9
Power washer/sprayer	1	1	1	1	13	13
Snow blower	1	1	0	0	13	13
All-terrain vehicle	0	0	0	0	7	8
Welder (used as welder or other reason) ¹	1	1	0	0	4	5
Water pump	1	1	0	0	5	5
Wood Splitter	0	0	0	0	2	2
Concrete saw	0	0	1	1	2	2
Small Engine	0	0	0	0	1	1
Air compressor	0	0	0	0	1	1
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
Edger	0	0	0	0	1	1
Stump Grinder	0	0	0	0	1	1
Leaf Blower	1	1	0	0	1	1
Multiple Products²	4	4	4	7	50	63
Generator + Other Consumer Product	4	4	4	7	48	61
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. One incident involved a vehicle of indeterminate type.

3 The two incidents associated with an OEDT and another consumer product includes 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, 2017.

Five hundred and eighty-one of the 743 incidents (78%) reported to CPSC staff during the 2005–2016 period were associated with a generator and accounted for 788 of the 965 CO deaths (82%). Additionally, 61 other CO fatalities from 48 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. Half of the non-fire, non-generator engine-drive tool-related CO incidents (57 of 112) 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 otherwise working on the product in an enclosed space.

CPSC staff examined the number of deaths associated with each fatal incident (Table 2). Of the 743 fatal incidents, 79 percent involved a single fatality. Seventy-five percent (474 of 629) of the fatal generator-related incidents involved a single fatality. One incident in 2015, which involved a generator, resulted in the deaths of eight people (a single father and his seven children); and another incident in 2005, resulted in six fatalities. In 2016, another incident resulted in six deaths. This incident involved an LP-fueled generator. Of the 112 fatal incidents in the OEDTs category, only 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, 2005–2016

Number of Deaths Reported in Incident ¹	All Engine-Driven Tools (EDTs)		Generator		Other Engine-Driven Tools (OEDTs)	
	743	100%	629	100%	114	100%
1	586	79%	474	75%	112	98%
2	118	16%	116	18%	2	2%
3	22	3%	22	3%	0	0%
4	12	2%	12	2%	0	0%
5	2	< 1%	2	< 1%	0	0%
6	2	< 1%	2	< 1%	0	0%
7	0	0%	0	0%	0	0%
8	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, 2017.

CPSC staff summarized the number of reported deaths associated with EDTs 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 June 14, 2017. 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-four percent (29 of 85) of the reported fatalities new to the report were for years before 2016.

The average number of non-fire CO fatalities associated with both generators and OEDTs for years 2012 through 2014, is also presented in Table 3. These 3 years represent the most recent years for which CPSC staff believes reporting are substantially complete. Due to reporting delays, these averages may change slightly in the future, when data are complete. Figure 1 in Appendix D illustrates the historical trend in EDT-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, 2005–2016

Year	All Engine-Driven Tools (EDTs)		Generators		Other Engine-Driven Tools (OEDTs)	
	Incidents	Deaths	Incidents	Deaths	Incidents	Deaths
<i>Total</i>	<i>743</i>	<i>965</i>	<i>629</i>	<i>849</i>	<i>114</i>	<i>116</i>
2005	93	116	80	103	13	13
2006	79	109	63	93	16	16
2007	68	83	57	72	11	11
2008	77	102	70	95	7	7
2009	55	76	45	66	10	10
2010	47	58	37	46	10	12
2011	81	108	69	96	12	12
2012	48	54	43	49	5	5
2013	56	69	46	59	10	10
2014	43	53	36	46	7	7
<i>2015</i>	<i>55</i>	<i>80</i>	<i>48</i>	<i>73</i>	<i>7</i>	<i>7</i>
<i>2016</i>	<i>41</i>	<i>57</i>	<i>35</i>	<i>51</i>	<i>6</i>	<i>6</i>
Average: 2012–2014	49	59	42	51	7	7

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, 2017.

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 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 84 percent (814 of 965 where the age was known) of reported non-fire, CO poisoning deaths associated with all EDTs. By comparison, according to the 2010 Census (the approximate mid-point of this data summary), 66 percent of the U.S. population is over 25 years old. Victims with a reported age of 25 years or older accounted for about 82 percent (699 of the 849 victims where the age was known) of non-fire CO poisoning deaths associated with generators and accounted for all but one of the deaths (115 of 116) associated with other EDTs. Eighty-six percent of the non-fire CO fatalities associated with non-generator, EDTs (100 of 116) involved victims age 45 or older.

It appears from the data summary that EDT-related CO fatalities have been occurring to older consumers at a higher rate. Fifty-six percent of the CO fatalities (where the age was known) 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 15 percent of EDT-related victims (of known age) 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, 2005–2016

Age	2010 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%	965	100%	849	100%	116	100%
Under 5	7%	11	1%	11	1%	0	0%
5–14	13%	42	4%	42	5%	0	0%
15–24	14%	90	9%	89	10%	1	1%
25–44	27%	281	29%	266	31%	15	13%
45–64	26%	371	38%	317	37%	54	47%
65 and over	13%	162	17%	116	14%	46	40%
Adult, age unknown	-	8	1%	8	1%	0	0%

This percentage represents the 2010 Census-estimated percentage of the U.S. population, the approximate mid-point of the 10-year range. Note: 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, 2017.

U.S. Census Department, Annual Estimates of the Resident Population by Sex, Age, Race, and Hispanic Origin for the United States and States: April 1, 2010 to July 1, 2015

Table 5 presents the distribution of the gender of the victims. Male victims accounted for 78 percent of the deaths associated with all EDTs. Male victims comprised 76 percent of the deaths associated with generators and 97 percent of non-generator, EDT fatalities.

Table 5: Number of Reported Non-Fire Carbon Monoxide Fatalities Associated with Engine-Driven Tools by Gender of Victim, 2005–2016

Gender	All Engine-Driven Tools (EDTs)		Generators		All Other Engine-Driven Tools (OEDTs)	
	Deaths	Percentage	Deaths	Percentage	Deaths	Percentage
Total	965	100%	849	100%	116	100%
Male	756	78%	644	76%	112	97%
Female	207	21%	203	24%	4	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, 2017.

Table 6 presents a summary of the race/ethnicity of the reported CO fatalities associated with EDTs. The percentage of generator-related CO fatalities identified as “Black/African American” (25% of deaths) was nearly double the proportion classified by the U.S. Census Bureau as “Black/African Americans” in the U.S. population (an estimated 13%). The percentage of the non-generator, EDT-related CO fatalities identified as non-Hispanic “White” (87% of deaths) was much higher than the proportion classified as non-Hispanic “White” by of the U.S. Census Bureau (an estimated 64% 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, 2005–2016

Race / Ethnicity	2010 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	100%	965	100%	849	100%	116	100%
White	64%	594	62%	493	58%	101	87%
Black/African American	13%	215	22%	213	25%	2	2%
Hispanic (any race)	16%	88	9%	86	10%	2	2%
Asian	5%	16	2%	15	2%	1	1%
Native American	1%	6	1%	6	1%	0	0%
Other / Unknown	< 1%	46	5%	36	4%	10	9%

1 This represents the 2010 Census estimated percentage of the U.S. population, the approximate mid-point of the 10-year range. All categories, with the exception of “Hispanic (any race),” are non-Hispanic averages. Percentages represent single-race figures because multiracial percentages are seldom available from available information. Two percent of the U. S. population identifies themselves as multiracial.

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, 2017.

U.S. Census Department, Annual Estimates of the Resident Population by Sex, Age, Race, and Hispanic Origin for the United States and States: April 1, 2010 to July 1, 2015

Staff examined reported deaths associated with EDTs 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.

Nearly half (49%) 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.

Although the trend toward colder months can still be seen with the OEDT-related CO fatalities data, it is not quite as pronounced. Forty percent of the fatalities occurred in the cold months, while 33 percent occurred in the transitional months, and 28 percent in the warm months.

Table 7: Number of Reported Non-Fire Carbon Monoxide Incidents and Fatalities Associated with Engine-Driven Tools by Season, 2005–2016

Season Incident Occurred		All Engine-Driven Tools (EDTs)		Generators		Other Engine-Driven Tools (OEDTs)	
Total	Incidents	743	100%	629	100%	114	100%
	Deaths	965	100%	849	100%	116	100%
Cold months	Incidents	362	49%	317	50%	45	39%
	Deaths	460	48%	414	49%	46	40%
Transitional months	Incidents	216	29%	179	28%	37	32%
	Deaths	296	31%	258	30%	38	33%
Warm months	Incidents	165	22%	133	21%	32	28%
	Deaths	209	22%	177	21%	32	28%

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, 2017.

Incidents involving deaths are further summarized in Table 8 by the location where the death occurred. The majority of non-fire, CO poisoning deaths (826 of 965, or 86%) reported to CPSC staff associated with EDTs occurred at home locations. Seventy-four percent of the deaths occurred at fixed-structures 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. Twenty-two percent (25 of 116) of fatalities occurring in external structures at the home involved OEDTs compared to generators where only six percent (55 of 849) occurred.

Three percent of deaths associated with engine-driven tools 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 EDTs, while the victims were temporarily occupying or otherwise using trailers, horse trailers, RVs, cabins (used as a temporary shelter), tents, campers, etc. 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 CPSC’s jurisdiction; thus, these 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 includes 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 CPSC’s jurisdiction and are not included in this report. The “Other” category includes incidents that occurred in 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 Victim Location, 2005–2016

Victim Location		All Engine-Driven Tools (EDTs)		Generators		Other Engine-Driven Tools (OEDTs)	
Total	Incidents	743	100%	629	100%	114	100%
	Deaths	965	100%	849	100%	116	100%
Home, fixed Structure ¹	Incidents	544	73%	465	74%	79	69%
	Deaths	715	74%	635	75%	80	69%
Home, detached Structure ²	Incidents	78	10%	53	8%	25	22%
	Deaths	80	8%	55	6%	25	22%
Home, non-house ³	Incidents	24	3%	20	3%	4	4%
	Deaths	31	3%	27	3%	4	3%
Temporary shelter	Incidents	54	7%	54	9%	0	0%
	Deaths	83	9%	83	10%	0	0%
Boat/Vehicle	Incidents	24	3%	23	4%	1	1%
	Deaths	30	3%	28	3%	2	2%
Other	Incidents	15	2%	11	2%	4	4%
	Deaths	20	2%	16	2%	4	3%
Outside ⁴	Incidents	1	< 1%	1	< 1%	0	0%
	Deaths	1	< 1%	1	< 1%	0	0%
Not reported	Incidents	3	< 1%	2	< 1%	1	1%
	Deaths	5	1%	4	< 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 attached garages.

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.

4 This incident involved a victim sitting near a generator located outside a camper.

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, 2017.

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). The four categories are “Urban Core,” “Sub-Urban,” “Large Rural,” and “Small Rural/Isolated.” Details on the process of determining population density or rurality can be found at the USDA website at: <http://www.ers.usda.gov/data-products/rural-urban-commuting-area-codes.aspx>. Additional information regarding the cross-referencing of zip codes to RUCA codes can be obtained

from the University of Washington, WWAMI³ Rural Health Research Center website at: <http://depts.washington.edu/uwruca/>.

Fifty-six percent (544 of 965) of CO fatalities associated with the use of EDTs 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-four percent (421 of 965) 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. Eighteen percent (176 of 965) 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 percent of the U.S. population lives.

Table 9: Number of Reported Non-Fire Carbon Monoxide Fatalities Associated with Engine-Driven Tools by Population Density of Place of Death, 2005–2016

Population Density		Estimated Percentage of U.S. Population ¹	All Engine-Driven Tools (EDTs)		Generators		Other Engine-Driven Tools (OEDTs)	
Total	Incident	100%	743	100%	629	100%	114	100%
	Deaths		965	100%	849	100%	116	100%
Urban Core	Incident	71%	416	56%	360	57%	56	49%
	Deaths		544	56%	487	57%	57	49%
Sub-Urban	Incident	10%	94	13%	75	12%	19	17%
	Deaths		122	13%	103	12%	19	16%
Large Rural	Incident	10%	104	14%	81	13%	23	20%
	Deaths		123	13%	99	12%	24	21%
Small Rural /Isolated	Incident	9%	129	17%	113	18%	16	14%
	Deaths		176	18%	160	19%	16	14%

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. The year 2010 is the approximate mid-point year of the 10-year range.

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, 2017.

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

U.S. Census Bureau, 2011.

³ 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.

III. Alarm Usage

Table 10 presents a summary of known CO fatalities characterized by CO alarm usage and alarm status. In 65 percent of the fatal incidents (481 of 743), and 61 percent of reported CO poisoning deaths (589 of 965), the presence of a CO alarm at the location of the incident was unknown or unreported. Of the 262 fatal incidents (376 CO fatalities) associated with EDTs in which it was known whether a CO alarm was present, a CO alarm was present in only 25 incidents (10%) involving 36 CO fatalities. Of these 25 fatal incidents, the alarm was known to be inoperable in nine incidents (17 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 nine fatal incidents with inoperable alarms were associated with generator usage.

For the remaining 16 fatal incidents (19 fatalities) where an alarm was known to be present, the alarm was known to have sounded in only nine incidents (ten deaths):

- 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 three incidents, a CO alarm was heard sounding inside the house when the victim was discovered. In these cases, the victims were found inside an attached garage, apparently working on or using an engine-driven tool (a lawn tractor in one case, and a snow blower in the other), which presumably had been running.
- In one incident, the victim was working on a power washer inside a building equipped with a CO alarm system. The victim was found deceased with the alarm sounding.
- In one incident, the victim was working with a concrete saw inside a townhouse equipped with a CO alarm system. The victim was found deceased with the alarm sounding.
- In another incident, two victims were found in a home in which 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 nine deaths from seven incidents in which a CO alarm was present in the house, but it was unknown whether the alarm sounded or if the alarm was operable.

Table 10: Carbon Monoxide Alarm Usage Associated with Engine-Driven Tools Non-Fire Carbon Monoxide Poisoning Deaths, 2005–2016

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	743	965	-	629	849	-	114	116	-
Alarm Status Known	262	376	100%	232	344	100%	30	32	100%
No Alarm[#]	237	340	90%	213	314	91%	24	26	81%
Alarm Present	25	36	10%	19	30	9%	6	6	19%
Alarmed	9	10	3%	5	6	2%	4	4	13%
Did not alarm, batteries removed, incorrectly inserted, or drained	5	10	3%	5	10	3%	0	0	0%
Did not alarm, plug-in type, no power	4	7	2%	4	7	2%	0	0	0%
Alarm present, Unknown if it alarmed	7	9	2%	5	7	2%	2	2	6%
Alarm Status Unknown	481	589	-	397	505	-	84	84	-

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.

[#]Includes one incident where the victim was located outside near a running generator.

Source: U.S. Consumer Product Safety Commission, Directorate for Epidemiology, 2017.

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 June 14, 2017, CPSC staff is aware of 629 generator-related incidents from 2005 through 2016, which resulted in non-fire CO fatalities. Staff completed, or otherwise resolved, IDIs for 591 of 629 (94%) fatal CO incidents associated with generators that occurred from 2005 through 2016. For the remaining 38 incidents in which an IDI was not performed or was not completed by the cut-off date of June 14, 2017, attempts were made to augment the data from reports of the incident in 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 629 incidents resulting in 849 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-five percent of the incidents (26 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-one percent of the fatal incidents (21 percent of deaths) were associated with the use of generators after a power shutoff by the utility company for nonpayment of a bill, a bill dispute, or other reason. For 21 percent of the fatal incidents (20 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.

Most of the generators that were associated with fatal CO poisoning were gasoline-fueled. In 72 of the 629 incidents, the fuel type could not be ascertained. Of the 557 cases where the fuel type used in the generator was known, 99 percent (552 of 557) were gasoline-fueled. Of the remaining incidents, four involved propane-fueled generators, and the other incident involved a diesel-fueled generator.

Table 11: Number of Reported Non-Fire Carbon Monoxide Fatalities for Incidents Associated with Generators¹ by Reason for Use, 2005–2016

Reason for Use		Total	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Total	Incidents	629	80	63	57	70	45	37	69	43	46	36	48	35
	Deaths	849	103	93	72	95	66	46	96	49	59	46	73	51
Power outage due to weather, or problem with power distribution	Incidents	156	37	11	15	19	10	5	19	15	12	5	4	4
	Deaths	220	53	17	23	26	17	6	27	16	13	5	6	11
Electricity turned off by power company due to bill dispute, nonpayment, or other reason	Incidents	129	11	17	13	13	6	12	17	5	9	7	12	7
	Deaths	179	12	23	16	19	9	16	25	6	11	10	23	9
Provide power to storage shed, trailer, boat, camper, cabin, campsite	Incidents	79	8	13	8	5	8	2	8	5	5	3	5	9
	Deaths	108	11	19	9	7	11	5	13	6	5	4	8	10
New home or homeowner, and power not yet turned on, home under construction or renovation	Incidents	61	4	6	5	7	5	5	5	3	6	5	5	5
	Deaths	88	6	9	5	13	6	5	10	4	11	5	8	6
Provide power to home or mobile home that normally does not have electricity	Incidents	42	6	3	4	4	3	3	4	4	2	5	4	0
	Deaths	57	6	5	5	5	7	3	4	6	2	8	6	0
Working on or preparing a home for predicted storm / Periodic testing	Incidents	7	0	1	0	4	0	0	0	0	0	0	1	1
	Deaths	7	0	1	0	4	0	0	0	0	0	0	1	1
Provide power to a shed or garage that normally does not have electricity	Incidents	7	0	0	0	2	0	1	2	1	1	0	0	0
	Deaths	8	0	0	0	2	0	1	2	1	2	0	0	0
Other (previous fire in house, power shut off by owners, servicing power supply, or other usage)	Incidents	15	1	1	0	3	2	1	1	1	1	1	3	0
	Deaths	17	1	1	0	3	2	1	2	1	2	1	3	0
Unknown why electricity off	Incidents	133	13	11	12	13	11	8	13	9	10	10	14	9
	Deaths	165	14	18	14	16	14	9	13	9	13	13	18	14

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, 2017.

For the 156 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 known to be 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 (49%) of the power outage-related incidents. Hurricanes and tropical storms are also associated with 24 percent of CO fatal incidents over the 12-year period from 2005 to 2016. Fifty-seven percent (31 of 54) of the generator-related CO fatalities that were hurricane- or tropical storm-related (20 of 38 fatal incidents) occurred in 2005.

Table 12: Number of Reported Non-Fire Carbon Monoxide Fatalities for Incidents Associated with Generators¹ by Reason for Power Outage, 2005–2016

Reason for Power Outage		Total	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Total	Incidents	156	37	11	15	19	10	5	19	15	12	5	4	4
	Deaths	220	53	17	23	26	17	6	27	16	13	5	6	11
Ice or snow storm	Incidents	77	15	6	9	7	9	3	10	5	8	1	3	1
	Deaths	102	20	8	13	9	14	4	14	5	8	1	4	2
Hurricane or tropical storm	Incidents	38	20	1	0	6	0	0	3	7	0	0	0	1
	Deaths	54	31	1	0	8	0	0	5	8	0	0	0	1
Wind storm	Incidents	9	0	2	1	1	0	0	1	1	0	1	1	1
	Deaths	19	0	6	1	1	0	0	1	1	0	1	2	6
Thunderstorm or rainstorm	Incidents	10	1	2	1	1	0	2	2	0	0	1	0	0
	Deaths	12	1	2	1	2	0	2	3	0	0	1	0	0
Tornado	Incidents	3	0	0	0	2	0	0	1	0	0	0	0	0
	Deaths	5	0	0	0	3	0	0	2	0	0	0	0	0
Storm, unspecified	Incidents	8	0	0	2	1	0	0	1	2	1	1	0	0
	Deaths	10	0	0	4	1	0	0	1	2	1	1	0	0
Unknown or other reason for outage	Incidents	11	1	0	2	1	1	0	1	0	3	1	0	1
	Deaths	18	1	0	4	2	3	0	1	0	4	1	0	2

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, 2017.

As shown in Table 8 above, 635 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 635 generator-related deaths that occurred in a fixed-structure home, information was available for 527 deaths (83%) regarding the victim’s location in relation to the generator. One hundred and twenty-three of these 527 fatalities (23%) occurred in the same room or space as the generator.

The 635 deaths that occurred in a fixed-structure home were the result of 465 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-nine percent (322 of 465) of the CO fatal incidents at home locations occurred when a generator was known to be placed inside the home, including the living space (167), a basement (108), closet (5), doorway (1), or inside the house, with no further information provided (41). Another 24 percent of the fatal incidents (113 of 465) occurred when the generator was placed in an attached garage, enclosed carport, or attached barn. Nearly half (48%) of the fatal incidents (221 of 465) occurred when the generator was placed in an attached structure (113) or in the basement or crawlspace (108).

Seventeen deaths from 13 incidents were associated with the use of a generator placed outside the home. Usually, this involved placing the generator too near an open window or vent. This category also includes incidents where a generator was running outside the home but inside a building (*e.g.*, outside an apartment but still inside the building). Additional fatalities occurred with generators placed outside in non-fixed structure house incidents. A summary of all fatal scenarios where generator was located outside is given in Appendix C to this report.

Table 13: Non-Fire Carbon Monoxide Poisoning Deaths in the Fixed-Structure Home Location¹ by Location of the Generator,² 2005–2016

Generator Location		Total	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015 ³	2016
Total	Incidents	465	55	40	45	52	35	29	54	36	35	27	34	23
	Deaths	635	70	57	59	72	52	35	76	41	46	35	56	36
Living space (non-basement)	Incidents	167	17	12	15	20	15	14	17	9	9	11	17	11
	Deaths	231	23	17	19	27	21	14	24	13	11	17	30	15
Garage/enclosed carport / attached barn	Incidents	113	17	13	10	13	8	5	14	14	9	2	4	4
	Deaths	148	18	20	17	15	11	6	19	14	13	2	7	6
Basement/crawlspace	Incidents	108	12	9	10	12	6	5	16	5	12	9	7	5
	Deaths	159	15	11	13	21	11	8	25	5	16	11	11	12
Inside house, no further information reported	Incidents	41	2	4	5	4	4	1	4	5	3	3	3	3
	Deaths	46	2	4	5	5	6	2	4	5	3	3	4	3
Closet in home	Incidents	5	1	1	1	0	1	0	0	0	1	0	0	0
	Deaths	12	6	3	1	0	1	0	0	0	1	0	0	0
Outside the home	Incidents	13	4	0	3	0	0	1	1	1	1	1	1	0
	Deaths	17	4	0	3	0	0	1	2	2	2	1	2	0
Doorway to home	Incidents	1	0	1	0	0	0	0	0	0	0	0	0	0
	Deaths	2	0	2	0	0	0	0	0	0	0	0	0	0
Unknown location, but at home	Incidents	17	2	0	1	3	1	3	2	2	0	1	2	0
	Deaths	20	2	0	1	4	2	4	2	2	0	1	2	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.

3 In 2015, there was one incident (one fatality) where the victim was running two generators simultaneously, one in the living space and one in the basement. This incident was included in the “living space” category as the victim was found in the living space.

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, 2017.

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 (218 of the 465 incidents) did not contain information about the ventilation of the generator.

In 159 of the 247 incidents (64%), accounting for 238 deaths, in which information on ventilation of the generator was available, there was no ventilation when the incident occurred. In four of these fatal incidents (six deaths), a window or door was open during some period of use but later closed. There were 88 incidents associated with generators in which it was reported that some type of ventilation was attempted. Of these 88 incidents, 61 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 75 CO deaths. As noted here and in Table 13, 13 incidents (17 deaths) were associated with generators that were placed outside the home near open windows, doors, or vents, where carbon monoxide entered the home. In 14 incidents (25 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. This included one case in which a victim placed a generator outside 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, 2005–2016

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	465	635	100%	100%
Some ventilation attempted	88	117	18%	33%
Open window(s), open door(s), an open garage door, or a combination of these	61	75	12%	21%
Actively trying to vent either by fans or by directing exhaust out a window or door	14	25	4%	7%
Placed outside, but near a window, door or A/C unit ³	13	17	3%	5%
No ventilation	159	238	37%	67%
Unknown ventilation	218	280	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 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, 2017.

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 29 percent (133 of 465) of the fatal incidents and 27 percent of the deaths (172 of 635), CPSC staff could not ascertain the size of the home. Home size information was available for 332 of 465 fatal incidents (463 of the 635 deaths). Information regarding the size of the homes reported in this document comes from one of two sources: (1) CPSC

IDIs, which include information gathered from police, fire department, or public records; and (2) Internet databases of real estate information, which contain public record data. 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.

Sixty-four percent (213 of 332) of the reported fatal incidents (299 of 463 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 87 percent (289 of 332) of the reported incidents and 87 percent of the deaths (405 of 463) 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 1,296 square feet. As a point of reference, according to the U.S. Census Bureau’s, *American Housing Survey for the United States: 2011*, the median housing unit as of 2010 was 1,800 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, because smaller-volume structures are filled more quickly by deadly carbon monoxide, a combination of the two factors, or some yet-unidentified reason, is unclear.

Table 15: Non-Fire CO Fatalities in the Fixed-Structure Home¹ Reported to CPSC Staff and Associated with Generators² Categorized by Size of Home, 2005–2016

Home Size (in sq. feet) ³	Number of Incidents	Number of Deaths	Percentage of Incidents	Percentage of Incidents Where Home Size is Known	Estimated Percentage of U.S. Occupied Housing Units (2010) ⁴
Total	465	635	100%	100%	100%
Under 500	4	5	1%	1%	1%
500–999	87	111	19%	26%	9%
1,000–1,499	122	183	26%	37%	24%
1,500–1,999	76	106	16%	23%	25%
2,000–2,499	21	33	5%	6%	18%
2,500–2,999	12	14	3%	4%	9%
3,000 or Larger	10	11	2%	3%	14%
Unknown	133	172	29%	-	-

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 various Internet real estate databases.

4 The 2011 housing unit figures represent an approximate mid-point year.

Note: Totals may not add to 100 percent due to rounding.

Source: U.S. Consumer Product Safety Commission, Directorate for Epidemiology, 2017.

U.S. Census Bureau, *American Housing Survey for the United States: 2011*.

Conclusions

Between 2005 and 2016, 965 non-fire CO-poisoning deaths from 743 incidents that were associated with EDTs were reported to CPSC staff. The majority of these deaths (849) involved generators, or a generator and another consumer product. OEDTs, 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.

Seventy-five percent of the reported deaths associated with generators occurred at fixed-structure home locations. Sixty-nine 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 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 220 of the 849 fatalities (26 percent). Generators were often used with little or no ventilation. In only about 10 percent of the fatalities was it known that there was a CO alarm installed—and many 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 about 82 percent of the non-fire CO poisoning deaths that were associated with generators reported to CPSC staff, and the majority (76 percent) of the victims were male. 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 OEDTs. Males accounted for 97 percent of the deaths associated with OEDTs. 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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University of Washington, WWAMI Rural Health Research Center. Rural-Urban Commuting Area Codes (RUCAs) <http://depts.washington.edu/uwruca/>

Appendix A: Epidemiology Data Retrieval Specifics

The queries below were submitted through EpiSearch, CPSC staff's epidemiology data access application, accessing data from the Consumer Product Safety Commission Risk Management System (CPSRMS). Query results were reviewed to include only non-fire carbon monoxide poisoning fatality incidents related to EDTs and to exclude duplicates and out-of-scope cases, which were cases that were intentional in nature or that occurred during a work-related activity.

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 EDT, or an EDT used in conjunction with another non-fire-related CO generating source.
- The fatal injury was unintentional in nature.
- The EDT involved was a consumer product.
- The incident was not work related.

Date of Queries: 06/14/2017

Incident Dates: 1/1/05-12/31/16

Product Codes: 113, 606, 800-899, 1062, 1400-1464, 3285-3287

Narrative/Text Contains: "CARB" or "MONO"

Appendix B: Engine Class of Generators Involved in Fatal CO Incidents

Table B-1 provides a summary of generator incidents and fatalities broken down by engine classification and year of incident⁴. Note that this summary includes stationary generators (3 incidents, 5 deaths) and generator-welders (3 incidents, 3 deaths). These incidents are footnoted below the table. In the majority of cases (56%), CPSC staff was unable to obtain sufficient information about the engine class of the involved generator. In the incidents where engine classification could be determined, slightly more than one third (35%) involved Class I powered generators, and slightly less than two thirds (62%) involved single cylinder Class II powered generators. Handheld class generators were known to be involved in four incidents (five fatalities) during this time period; while twin cylinder, Class II powered generators were known to be involved in five incidents and nine fatalities.

Additionally, note that an incident in 2015 involved both a Class I and Class II, single-cylinder generator. This case was included in the “Class II” category in the summary table.

⁴ Staff used engine classifications defined by the U.S. Environmental Protection Agency (EPA) and also the number of cylinders that the engine has. EPA broadly categorizes small SI engines as either non-handheld or handheld and within each of those categories further distinguishes them into different classes, which are based upon engine displacement. Non-handheld engines are divided into class I and class II, with class I engines having displacement above 80 cc up to 225 cc and class II having displacement at or above 225 cc but maximum power of 19 kilowatts (kW). Handheld engines, which are divided into classes III, IV, and V, are all at or below 80 cc.

Table B-1: Engine Class of Generators Involved in Fatal CO Incidents, 2005–2016¹

Year	Handheld		Class I		Class II, Single Cylinder		Class II, Twin Cylinder		Unknown		Total	
	Incidents	Deaths	Incidents	Deaths	Incidents	Deaths	Incidents	Deaths	Incidents	Deaths	Incidents	Deaths
Total	4	5	98	151	172	245	5	9	350	439	629	849
2005	1	1	10	13	23	33			46 [#]	56 [#]	80 [#]	103 [#]
2006			13	18	21	34			29	41	63	93
2007			9	13	16	22	1 [#]	1 [#]	31	36	57 [#]	72 [#]
2008			12	17	22	29	1	1	35	48	70	95
2009			5	8	12	19			28	39	45	66
2010	1	1	6	8	13	15			17	22	37	46
2011			13	22	15 ⁺	24 ⁺	1	5	40 ⁺	45 ⁺	69 ⁺	96 ⁺
2012			7	10	6	7			30	32	43	49
2013			9	13	17	22			20	24	46	59
2014	1	1	1	4	5	8	1 [#]	1 [#]	28	32	36 [#]	46 [#]
2015			6	13	13 [*]	17 [*]	1	1	28	42	48	73
2016	1	2	7	12	9	15			18	22	35	51

* One incident (one fatality) in 2015 involved both a Class I and Class II generator. This case was included in the “Class II” category.

These counts include an incident with one fatality that involved a generator/welder.

+ In 2011, three incidents involved stationary generators: one incident classified as a Class II, Single Cylinder (two deaths), and two incidents of unknown classification (one involving two deaths and the other involving a single death).

1 – In 2004, there were 5 “Class I” incidents (5 deaths), 14 “Class II, Single Cylinder” incidents (21 deaths), and 16 “Unknown” incidents (21 deaths).

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, 2017.

When the IDI did not report the generator’s engine displacement or it was not obtainable from other information in the IDI, staff classified generators with a reported wattage of 3.5 kW and larger as being powered by a class II engine and those less than 3.5 kW as powered by either a handheld or a class I engine. To distinguish the handheld powered generators from the class I powered generators when there was no information to ascertain the engine displacement, generators with wattage 2 kW and larger, up to 3.5 kW, were considered to have a class I engine. There was only one generator with wattage below 2kW in which the engine displacement could not be ascertained. That was a 1,000 watt generator, which staff classified as a handheld generator because staff’s online review of generators nominally, in this size, showed them being powered by handheld engines. To distinguish the single-cylinder class II engines from the twin-cylinder class II engines, staff found from looking at the EPA’s exhaust emission certification database at: www3.epa.gov/otaq/certdata.htm#smallsi that twin-cylinder class II engines largely have a maximum engine power of nominally 12 or 13 kW and higher. Staff then found, from looking at manufacturers’ generator specifications available online, that generators with engines having power equal to or greater 12 or 13 kW, typically have a rated power of 9kW and higher. Therefore, generators with rated power of 3.5 kW up to 9 kW were considered powered by a single-cylinder class II engine and those 9 kW and greater were considered powered by a twin-cylinder class II engine.

Appendix C: Fatal CO Exposure Incidents Where Generator Was Located Outside the Victim Location

Table C-1 provides a summary of portable generator incidents and fatalities where the generator was placed outside the victim’s location. The table presents the data broken down by the specific type of incident location. This table demonstrates that even when a generator is placed outside the victim location, there can still be potentially fatal scenarios. In fact, 7 percent of all generator incidents (45 of 629) and fatalities (60 of 849) occurred when the victim placed the generator outside of their occupied area.

Note that the incidents and deaths presented in this table do not directly correspond to those shown for “Outside the Home” incidents as shown in Table 13 because the latter table only presents incidents that occurred in fixed-structure homes. This table includes all locations, including vehicles, apartments in business locations, cabins and trailers.

The two categories “Outside Apartment, Inside Building” and “Outside Trailer, Inside Building” are included here, even though the generator was placed inside a building. It is surmised that the victims believed that they had adequately mitigated the dangers of CO exposure by placing the generator outside their living space. Additionally, there was one incident involving one fatality where the victim was located outside near the generator. It is unclear why the individual was sitting so close to the generator – perhaps in an effort to keep warm as the incident occurred at a campsite outside a camper trailer. But, even if these three categories are eliminated from the summary, the generator placed “outdoors” scenario still represents 6 percent of all generator-related CO fatalities (52 of 849) and incidents (38 of 629).

Table C-1: Fatal CO Generator Incidents Where the Generator Was Located Outside the Occupied Space, 2005–2016¹

Location	Incidents	Deaths
Total – Occupied Area	45	60
House/Mobile Home	10	12
Apartment	2	3
Cabin	1	1
Vehicle: RV/Camper Shell	11	20
Vehicle: Automobile/Truck	3	3
Camper Trailer/Horse Trailer	10	12
Boat	2	2
Outside Apartment, Inside Building	3	4
Outside Trailer, Inside Building	2	2
Outside (sitting near generator)	1	1

Note: 1 – In 2004, there was one incident (two fatalities) in a house where the generator was placed outside. Source: U.S. Consumer Product Safety Commission, Directorate for Epidemiology, 2017.

Appendix D: 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 because it hinders delivery of oxygen to the body. COHb data are helpful in estimating the concentration of CO in the product exhaust and the lethality of the product, which can affect 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 EDTs.

In healthy adults, a COHb level of 40 percent–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 531 of the 965 fatalities (55% of the CO fatalities). Table D-1 shows the frequency of reports by COHb level categories. Percentages in the table are the category proportions of reported COHb levels. Eighty-one percent (431 of the 531) of fatalities had reported COHb levels of 50 percent or greater.

Table D-1: Carboxyhemoglobin Levels Associated with Engine-Driven Tools Non-Fire Carbon Monoxide Poisoning Deaths, 2005–2016¹

COHb Level	All Engine-Driven Tools (EDTs)		Generators		Other Engine-Driven Tools (OEDTs)	
Total	965	-	849	-	116	-
Reported Levels	531	100%	467	100%	64	100%
Less than 30%	28	5%	26	6%	2	3%
30–39.9%	26	5%	23	5%	3	5%
40–49.9%	46	9%	39	8%	7	11%
50–59.9%	103	19%	95	20%	8	13%
60–69.9%	149	28%	132	28%	17	27%
70–79.9%	140	26%	119	25%	21	33%
80–89.9%	34	6%	28	6%	6	9%
90–99.9%	5	1%	5	1%	0	0%
Not reported	434	-	382	-	52	-

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, 2017.

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.

Appendix E: Historical Data

Figure 1 illustrates the trend in the number of non-fire CO fatalities associated with the use of generators and other EDTs from 1999 to 2016. 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 the low 40s and below 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. Since the 2008 annual report, the most recent year's counts have increased by an average of about 31 percent from the previous report. Between the second and third year, the average increase, report to report, is about an additional 8 percent.

The number of CO fatalities associated with the use of non-generators EDTs has been relatively steady over the period 1999 through 2016.

Figure 1: Number of Reported Non-Fire Carbon Monoxide Fatalities Associated with Engine-Driven Tools, 1999–2016

