Fatal and Nonfatal Incidents Associated with Non-Fire Carbon Monoxide from Engine-Driven Generators and Other Engine-Driven Tools, 2008–2018

Matthew V. Hnatov
U.S. Consumer Product Safety Commission
Directorate for Epidemiology
Division of Hazard Analysis
4330 East West Highway
Bethesda, MD 20814
July 2019

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

Table of Contents

Executive Summary

This report summarizes non-fire, carbon monoxide (CO) incidents associated with engine-driven generators and other engine-driven tools (EDTs) that occurred between 2008 and 2018, and were reported to U.S. Consumer Product Safety Commission (CPSC) staff as of June 18, 2019. Due to incident reporting delays, statistics for the most recent years (2017 and 2018) should be considered incomplete. Because data collection is ongoing, 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 EDTs (OEDTs, which include power lawn mowers, garden tractors, portable pumps, power sprayers and washers, snow blowers, and concrete saws) that were reported to CPSC staff. The information on these fatalities is anecdotal and does not represent a complete set of all incidents that may have occurred during the relevant period. However, the information represents a minimum count for the number of CO-poisoning deaths associated with these products.

Additionally, included in this report are summaries of fatal, non-fire CO incidents, in which an EDT and one or more other fuel-burning consumer products[1] also may have been involved, and the EDT was believed to be, at least, a contributing factor to the fatal levels of CO. This report also provides a more detailed look at fatal, non-fire CO-poisoning incidents associated with EDTs, 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:

- 834 fatalities from 645 incidents during 2008-2018;
  - 699 fatalities (84%) from 520 incidents associated with generators *only*;
  - 89 fatalities (11%) from 87 incidents involved OEDTs *only*; and
  - 46 fatalities (6%) from 38 incidents involved *multiple* fuel-burning consumer products, in which one product was either a generator or an Other Engine-Driven Tools (OEDT) and the other product was a non-EDT.
    - In 96 percent of fatalities involving multiple consumer products, the second product involved was either heating equipment (portable liquid propane- or kerosene- fueled) or a cooking product;
- 52 fatalities from 36 separate incidents in 2018;
  - 47 fatalities involved one or (in two cases) two portable generators only;
  - 4 fatalities involved OEDTs *only*;
  - 1 fatality involved multiple products, namely a kerosene heater and a portable generator.

[1] Combustion consumer products produce heat or energy by burning a fuel source. All fuel-burning consumer products may produce gases that contain CO because CO is a by-product of incomplete combustion.

- Compared to the 2018 report, this report presents
  - 19 additional fatalities in 2017;
  - 8 additional fatalities in 2016;
  - 2 additional fatalities in 2015; and
  - 1 fewer fatality in 2014, because one fatality was added and two fatalities were reclassified as out of scope, based on additional information obtained by staff.

Socio-Demographic Characteristics of Victims and EDT-Use Patterns (2008-2018):

- Age: 84 percent of portable generator-related decedents and 99 percent of OEDT-related decedents were 25 years old or older.
- Gender: More than 75 percent of portable generator-related decedents and 99 percent of the OEDT-related decedents were males.
- Race/Ethnicity: 23 percent of portable generator-related decedents were non-Hispanic Black or African Americans, which is nearly double their share of the U.S. population. Non-Hispanic White Americans constituted 84 percent of OEDT-related decedents, which is much higher than their share in the U.S. population.
- Seasonal effects: 45 percent of fatalities from EDTs happen during the four colder months of the year (November through February); 33 percent during the transition months; and 22 percent in the warmer months.
- Structure type: 77 percent all EDT-related fatalities occurred in fixed-structure homes.
- Urban versus rural: 54 percent all EDT-related fatalities occurred in urban areas, and 19 percent occurred in small, rural, and isolated areas, more than double the proportion of the U.S. population who live in rural and isolated areas.

CO Alarm Usage (2008-2018):

- A CO alarm: Only 36 (13%) of the EDT-related fatalities were known to have alarms present.
  - For 17 of the deaths, the alarm was inoperable, due to no batteries, batteries inserted incorrectly, probable drained batteries, or no electric current.
  - For 11 of the deaths, the alarm sounded, but the signal was misunderstood, the alarm was subsequently disarmed, or the alarm sounded inside the house, while the fatality occurred inside an attached garage.
  - For eight deaths, we do not know if the alarm sounded during the event.

Hazard Patterns Associated with Generators (2008-2018):

- The two most common reasons for using generators are power outages and power shut-offs.
  - Power outages: 112 incidents with 152 fatalities. Mostly for weather-related issues, such as ice/snow storms and hurricanes/tropical storms.
  - Power shut-offs: 107 incidents involving 154 fatalities.
- The two most common locations with generator-related fatalities were fixed-structure homes and temporary shelters.
  - Fixed-structure homes: 569 non-fire CO fatalities (416 incidents). The incidents involved a generator or a generator in use with another potential CO-generating consumer product, mostly placed inside the living area of the home.

        - In more than two-thirds of these fatalities (where information was available), no apparent ventilation of the generator exhaust was attempted.
        - A majority of the incidents (where information was available) occurred in houses less than 1,500 square feet in size.
    - Temporary shelters: The second most common location was in temporary shelters like campers, RVs, cabins, horse trailers, in which the consumers were, most often, attempting to provide power to a structure or vehicle that does not normally have electrical power.
- Generator located outside victim location: In 5 percent of the fatalities, the associated generator was outdoors, situated too close to windows, air conditioners, or other locations, which allowed CO to infiltrate an enclosed space; or the generator was placed outside of the victims' location, but within an enclosed space, like outside an apartment in the building's hallway, or outside a travel trailer, inside a garage, in which it was parked.

Engine Class of Generators Involved in Fatal CO Incidents (2008-2018):

- Of the 556 fatal generator incidents between 2008 and 2018 (including the generator plus OEDT category), the generator engine class could only be determined in 244 cases. Ninety-seven percent of the 244 incidents involved a portable generator with a Class I engine (90 incidents) or Class II, Single-Cylinder engine (146 incidents).

Carboxyhemoglobin Levels in CO Fatality Victims (2008-2018):

- Of the CO fatality victims associated with EDTs, 83 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 2017 and 2018 are italicized in table headings, indicating that incident and death counts are likely to change as additional information is received. Incident and death counts may change for other years, as well, 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

CPSC staff searched databases to prepare the statistics recorded in this report through the Consumer Product Safety Commission
Risk Management System (CPSRMS). 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, we reviewed each record to determine whether the incident was in scope for this report and to correct any discrepancies in 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 18, 2019. We included 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.

CPSC records contain information on 834 non-fire CO fatalities associated with EDTs during the years 2008 through 2018. Last year's report, dated June 2018, contained summary information and analyses for the 13-year period 2005−2017. In addition to dropping years 2005 through 2007 from the reporting period, this updated report added information on 81 CO fatalities associated with engine-driven tools, and the report removed one fatality (see explanation below).

Changes to previous report:

- 2014 – One incident, accounting for one death, was added, and two incidents were removed because further information indicated that the incidents were out of scope.
- 2015 – Two incidents added, accounting for two deaths added.
- 2016 – Eight incidents added, accounting for eight deaths added.
- 2017 – Eighteen incidents added, accounting for 19 deaths.
- 2018 – Thirty-six new incidents added, accounting for 52 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, there are five appendices:

- Appendix A presents the database search criteria;
- Appendix B presents the generator-size class distribution involved in the fatal CO incidents;
- Appendix C presents a summary of fatal CO incidents that occurred with the generator located in outdoor locations;
- Appendix D 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; and
- Appendix E graphically presents the year-by-year summary of CO fatalities broken out separately by generators and OEDTs for the years 1999 through 2018.

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

Table 1 presents the reported fatal incidents and the number of deaths in 2018, along with a revised summary of CO incidents and fatalities associated with engine-driven tools from 2008 through 2018. The table records the number of incidents and deaths by the broad categories of "Generators," "OEDT," and "Multiple Products." Within each broad category, the frequency of reports is summarized by product type. Staff is aware of 645 incidents involving EDTs, with a total of 834 deaths, due to non-fire CO exposure that occurred between 2008 and 2018. For 2018 alone, as of June 18, 2019, 36 fatal, non-fire CO exposure incidents involving EDTs were reported to have occurred between January 1, 2018 and December 31, 2018. Fifty-two deaths occurred in these 36 fatality CO incidents.

Multiple product incidents are fatal CO poisonings that involved several fuel-burning consumer products of different types that generate CO, with at least one product an EDT, or investigating authorities could not determine from which of the multiple consumer products in use the source of the CO came. By this definition, incidents involving multiple products of the same type, (*e.g.*, 2 lawn mowers) were not classified as "Multiple Products." Incidents in which multiple CO-producing products were involved, but one of the sources of CO is not under the CPSC's jurisdiction, such as automobiles, boats, or recreational vehicles, which we determined were out of scope and are not included in this report. Thus, this report may underestimate the incidents of CO fatalities. For the rest of the report after Table 1, "Multiple Products" incidents will be included in the summary for the involved engine-driven tool type, either "Generators" or OEDTs. CPSC staff is aware of 46 fatalities associated with multiple consumer products occurring in the period 2008 through 2018.

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. Two of the five fatal, non-fire CO incidents associated with the use of welding equipment as a generator and that occurred between 2008 and 2018, involved using the welder to provide power during a power outage. The remaining three fatal, non-fire CO incidents (four fatalities) involved the use of welding equipment, but not did not specifically identify the welder as a generator.

All but two of the 46 non-fire CO fatalities in the "Multiple Products" category for 2008–2018 involved a heating- or cooking-related consumer product other than an EDT. One of the two exceptions involved a gasoline-fueled, walk-behind mower, and a gasoline-fueled trimmer, both running in a closed garage. The other exception involved a generator and a vehicle of unspecified type being used in a storage shed.[3] In addition, during 2008-2018, there was a fatal incident in which two generators and an LP heater were in use; this incident is included as a generator- and

[3] This incident is based solely on information given in a death certificate. It was assumed that the vehicle was not a motor vehicle due to the location being specified as a storage shed. However, an In-Depth Investigation into this incident has been requested which should clarify the actual details of the event. Next year's report will reflect any changes necessary based on the expanded information.

heater-associated fatality in Table 1. In addition, among five single-fatality incidents that may have involved more than one generator (either known by officials to be in use or identified by officials as possibly in use), one incident may have included the use of three generators.

Table 1: Number of Reported Fatal Non-Fire CO Exposure Incidents and Deaths Associated with Engine-Driven Tools, 2008–*2018*

Product	2017		2018		Total: 2008–*2018*	
	Number of Incidents	Number of Deaths	Number of Incidents	Number of Deaths	Number of Incidents	Number of Deaths
Total Engine-Driven Tools	73	89	36	52	645	834
Generators	**66**	**82**	***31***	***47***	**520**	**699**
Generator, portable	65	81	*31*	*47*	514	691
Generator, fixed location	0	0	*0*	*0*	4	6
Welder (used as a generator)[1]	1	1	*0*	*0*	2	2
Other Engine-Driven Tools (OEDT)	**7**	**7**	***4***	***4***	**87**	**89**
Lawn mowers	4	4	*3*	*3*	43	43
Riding lawn mower/Garden tractor	3	3	*2*	*2*	35	35
Push lawn mower	0	0	*0*	*0*	2	2
Powered lawn mower, unspecified type	1	1	*1*	*1*	6	6
Snow blower	0	0	*0*	*0*	10	10
Power washer/sprayer	1	1	*0*	*0*	9	9
All-terrain vehicle	1	1	*1*	*1*	8	9
Welder (used as welder or other reason)[1]	0	0	*0*	*0*	3	4
Water pump	0	0	*0*	*0*	3	3
Concrete saw	0	0	*0*	*0*	2	2
Wood Splitter	0	0	*0*	*0*	2	2
Paint sprayer	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	0	0	*0*	*0*	1	1
Antique Tractor	1	1	*0*	*0*	1	1
Multiple Products[2]	**0**	**0**	***1***	***1***	**38**	**46**
Generator + Other Consumer Product	0	0	*1*	*1*	36	44
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, 2019.

Five hundred and twenty of the 645 incidents (81%) reported to CPSC staff during the 2008−2018 period were associated with a generator, and the incidents accounted for 699 of the 834 CO deaths (84%). Additionally, 44 other CO fatalities from 36 incidents were associated with the use of a generator and another combustion consumer product—most commonly an LP- or kerosene-fueled heater. In addition, because the majority of incidents were associated with generators, characteristics of these incidents are reported separately in Section IV. About half of the OEDT CO incidents (45 of 89) involved a garden tractor or other powered lawn mower (including both of the "Multiple Products" incidents). Deaths associated with powered lawn mowers were often associated with an individual repairing or otherwise working on the product in an enclosed space. Additionally, there was one fatal incident in which a consumer was apparently repairing an antique tractor in his garage. Due to the relatively small number of non-generator, engine-driven tool CO fatalities, throughout the remainder of this report, these incidents will simply be reported as "OEDT."

CPSC staff examined the number of deaths associated with each fatal incident (Table 2). Of the 645 fatal incidents, 80 percent involved a single fatality. Seventy-eight percent (431 of 556) 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 father and his seven children). In 2016, another incident resulted in six deaths. This incident involved an LP-fueled generator. Of the 89 fatal incidents in the OEDTs category, only two incidents resulted in more than one fatality.

Table 2: Number of Reported Fatal Non-Fire CO Exposure Incidents and Deaths Associated with Engine-Driven Tools by Number of Deaths per Incident, 2008–*2018*

Number of Deaths Reported in Incident[1]	All Engine-Driven Tools (EDTs)		Generator		Other Engine-Driven Tools (OEDTs)	
All Incidents	**645**	**100%**	**556**	**100%**	**89**	**100%**
1	518	80%	431	78%	87	98%
2	101	16%	99	18%	2	2%
3	12	2%	12	2%	0	0%
4	11	2%	11	2%	0	0%
5	1	< 1%	1	< 1%	0	0%
6	1	< 1%	1	< 1%	0	0%
7	0	0%	0	0%	0	0%
8	1	< 1%	1	< 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, 2019.

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 18, 2019. 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. Since 2008, prior year counts have increased by an average of 31 percent in the following year's report and jumped an additional average of 7 percent 2 years later. Over the last 3 years, the rate has been even higher, at about a 35 percent increase in the latest year, when compared to the prior year's report.

The average number of non-fire CO fatalities associated with both generators and OEDTs for years 2014 through 2016, 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 collection is nearly 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 CO Exposure Incidents and Deaths Associated with Engine-Driven Tools by Year, 2008–*2018*

Year	All Engine-Driven Tools (EDTs)		Generators		Other Engine-Driven Tools (OEDTs)	
	Incidents	Deaths	Incidents	Deaths	Incidents	Deaths
Total	***645***	***834***	***556***	***743***	***89***	***91***
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	45	56	38	49	7	7
2015	59	84	52	77	7	7
2016	68	86	58	76	10	10
2017	*73*	*89*	*66*	*82*	*7*	*7*
2018	*36*	*52*	*32*	*48*	*4*	*4*
Average: 2014–2016	**57**	**75**	**49**	**67**	**8**	**8**

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, 2019.

II. Socio-Demographic Characteristics of Victims and EDT-Use Patterns 2008-2018

This section presents socio-demographic information about the victims of reported fatal CO incidents associated with EDTs. Tables 4, 5, and 6 summarize socio-demographic characteristics of the victims. Table 4 presents the distribution of ages of the victims.

According to the 2013 Census estimates (an approximate mid-point of this data summary), 67 percent of the U.S. population is over the age of 25 years. In comparison, 86 percent (714 of 829 where age was known) of reported non-fire, CO poisoning decedents associated with all EDTs, 85 percent (624 of 738 with known age) of decedents associated with generators, and all but one of the decedents (90 of 91) associated with OEDTs, were 25 years or older. In fact, 81 percent of the non-fire CO fatalities associated with OEDTs (74 of 91) involved victims age 45 or older.

It appears from the data summary that all EDT-related CO fatalities have been occurring to older consumers at a higher rate, relative to their proportion in the general U.S. population, than younger consumers. Specifically, 55 percent of the CO fatalities (where the age was known) were over the age of 44, while only 41 percent of the U.S. population was above 44 years of age during this period. By contrast, only 13 percent of EDT-related victims (of known age) were below the age of 25, while 33 percent of the U.S. population was below 25 years of age during this period.

Table 4: Number of Reported Non-Fire CO Fatalities Associated with Engine-Driven Tools by Age of Victim, 2008–*2018*

Age	2013 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%**	**834**	**100%**	**743**	**100%**	**91**	**100%**
Under 5	6%	9	1%	9	1%	0	0%
5–14	13%	35	4%	35	5%	0	0%
15–24	14%	71	9%	70	9%	1	1%
25–44	26%	259	31%	243	33%	16	18%
45–64	26%	315	38%	279	38%	36	40%
65 and over	14%	140	17%	102	14%	38	42%
Adult, age unknown	- -	5	1%	5	1%	0	0%

[1]This percentage represents the 2013 Census-estimated percentage of the U.S. population, an approximate mid-point of the 11-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.

Sources: U.S. Consumer Product Safety Commission, Directorate for Epidemiology, 2019.

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, 2013.

Table 5 presents the distribution of the gender of the victims. Male victims accounted for 79 percent of the deaths associated with all EDTs. Male victims comprised 76 percent of the deaths associated with generators and 99 percent of OEDT fatalities.

Table 5: Number of Reported Non-Fire CO Fatalities Associated with Engine-Driven Tools by Gender of Victim, 2008–*2018*

Gender	2013 Estimated U.S. Resident Population	All Engine-Driven Tools (EDTs)		Generators		All Other Engine-Driven Tools (OEDTs)	
		Deaths	Percentage	Deaths	Percentage	Deaths	Percentage
Total	**100%**	**834**	**100%**	**743**	**100%**	**91**	**100%**
Male	49%	656	79%	566	76%	90	99%
Female	51%	176	21%	175	24%	1	1%
Unknown	- -	2	< 1%	2	< 1%	0	0%

Notes:
[1] This percentage represents the 2013 Census-estimated percentage of the U.S. population, an approximate mid-point of the 11-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.
Sources: U.S. Consumer Product Safety Commission, Directorate for Epidemiology, 2019.
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, 2013.

Table 6 summarizes the race/ethnicity of the reported CO fatalities associated with EDTs. The percentage of generator-related CO fatalities identified as “Black/African American” (23% 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 OEDT-related CO fatalities identified as non-Hispanic “White” (84% 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 CO Fatalities Associated with Engine-Driven Tools by Race/Ethnicity of Victim, 2008–*2018*

Race / Ethnicity	2013 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%**	**834**	**100%**	**743**	**100%**	**91**	**100%**
White	64%	517	62%	441	59%	76	84%
Black/African American	13%	174	21%	172	23%	2	2%
Hispanic (any race)	17%	76	9%	74	10%	2	2%
Asian	5%	10	1%	9	1%	1	1%
Native American[2]	1%	7	1%	7	1%	0	0%
Other / Unknown	- -	50	6%	40	5%	10	11%

1 This represents the 2013 Census estimated percentage of the U.S. population, an approximate mid-point of the 11-year range. All categories, with the exception of "Hispanic (any race)," are non-Hispanic averages. Percentages represent single-race figures because multiracial percentages are not consistently reported in currently available information. Less than two percent of the U. S. population identifies themselves as multiracial.

2 Includes American Indian, Alaska Native, Native Hawaiian and Other Pacific Islander.

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, 2019.

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, 2013.

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.

Through the 11 years covered by this report, non-fire CO deaths associated with EDTs have tended to occur more often in the four colder months of the year (November through February) than in others. Forty-six of the incidents (45% of fatalities) of the non-fire CO deaths associated with EDTs occurred in these months. Many of the fatalities can be directly associated with the use of generators during power outages because of weather conditions, such as ice or snow storms. Thirty-three percent of the EDT-related CO deaths occurred in the transitional months. 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 because of hurricanes and tropical storms, many occurring in September, and to a lesser extent, in October. Additional details on this issue are presented in Section IV of this report.

Table 7: Number of Reported Non-Fire CO Incidents and Fatalities Associated with Engine-Driven Tools by Season, 2008–*2018*

Season Incident Occurred		All Engine-Driven Tools (EDTs)		Generators		Other Engine-Driven Tools (OEDTs)	
Total	**Incidents**	**645**	**100%**	**556**	**100%**	**89**	**100%**
	Deaths	**834**	**100%**	**743**	**100%**	**91**	**100%**
Cold months	Incidents	299	46%	262	47%	37	42%
	Deaths	373	45%	335	45%	38	42%
Transitional months	Incidents	206	32%	177	32%	29	33%
	Deaths	277	33%	247	33%	30	33%
Warm months	Incidents	140	22%	117	21%	23	26%
	Deaths	184	22%	161	22%	23	25%

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, 2019.

Incidents involving deaths are described further in Table 8 by the location where the death occurred. The majority of non-fire, CO poisoning deaths associated with EDTs (716 of 834, or 86%) were reported to have occurred at fixed – home residential locations, which include fixed homes, detached structures like detached garages and sheds, and residential locations in non-traditional structures, like camper trailers and RVs used as a primary residence. Seventy-seven 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 7 percent occurred in external or detached structures at home locations, such as detached garages or sheds. A larger portion of these external structure fatalities were related to OEDTs, such as lawnmowers running in sheds or detached garages. For example, 15 percent of OEDT-related fatalities occurred in external structures at home locations, while only 6 percent of generator-deaths occurred there.

Two percent of deaths associated with engine-driven tools occurred in nontraditional homes, such as travel trailers, houseboats, or storage sheds being 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, or campers. Incidents that involved built-in generators at temporary shelters, or generators built specifically for use in an RV, are not within the CPSC's jurisdiction, and as such, have been excluded from the analyses. However, one fatality that involved a portable generator retrofitted into an RV generator compartment was included because it involved what was originally a portable generator.

The "Boat/Vehicle" category only includes incidents in which an EDT was not an integral part of the boat/vehicle (such as a van), but was brought onto the boat/vehicle. 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 therefore, are not included in this report. Two fatalities resulting from

an incident on a boat, where the consumers connected a portable generator inside the engine compartment of the boat, were included because the generator was a portable generator that was retrofitted for use on the boat.

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 CO Incidents and Fatalities Associated with Engine-Driven Tools by Victim Location, 2008–*2018*

Victim Location		All Engine-Driven Tools (EDTs)		Generators		Other Engine-Driven Tools (OEDTs)	
Total	**Incidents**	**645**	100%	**556**	**100%**	**89**	**100%**
	Deaths	**834**	100%	**743**	**100%**	**91**	**100%**
Home, fixed Structure[1]	Incidents	485	75%	416	75%	69	78%
	Deaths	639	77%	569	77%	70	77%
Home, detached Structure[2]	Incidents	57	9%	43	8%	14	16%
	Deaths	58	7%	44	6%	14	15%
Home, non-house[3]	Incidents	16	2%	16	3%	0	0%
	Deaths	19	2%	19	3%	0	0%
Temporary shelter	Incidents	37	6%	37	7%	0	0%
	Deaths	55	7%	55	7%	0	0%
Boat/Vehicle	Incidents	27	4%	26	5%	1	1%
	Deaths	31	4%	29	4%	2	2%
Other	Incidents	20	3%	15	3%	5	6%
	Deaths	27	3%	22	3%	5	5%
Outdoors	Incidents	2	< 1%	2	< 1%	0	0%
	Deaths	2	< 1%	2	< 1%	0	0%
Not reported	Incidents	1	< 1%	1	< 1%	0	0%
	Deaths	3	< 1%	3	< 1%	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 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.
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, 2019.

Table 9 presents the number of non-fire, CO poisoning deaths reported to CPSC staff that were 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, WWAMI[4] Rural Health Research Center website at: http://depts.washington.edu/uwruca/. This study is updated approximately once every ten years, the last update occurring in 2010.

Fifty-four percent (447 of 834) 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-six percent (386 of 834) 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. Nineteen percent (157 of 834) of the CO fatalities known by 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 CO Fatalities Associated with Engine-Driven Tools by Population Density of Place of Death, 2008–*2018*

Population Density		Estimated Percentage of U.S. Population[1]	All Engine-Driven Tools (EDTs)		Generators		Other Engine-Driven Tools (OEDTs)	
Total	**Incident**	**100%**	**645**	**100%**	**556**	**100%**	**89**	**100%**
	Deaths		**834**	**100%**	**743**	**100%**	**91**	**100%**
Urban Core	Incident	71%	349	54%	308	55%	41	46%
	Deaths		448	54%	406	55%	42	46%
Sub-Urban	Incident	10%	83	13%	63	11%	20	22%
	Deaths		105	13%	85	11%	20	22%
Large Rural	Incident	10%	98	15%	81	15%	17	19%
	Deaths		124	15%	106	14%	18	20%
Small Rural /Isolated	Incident	9%	115	18%	104	19%	11	12%
	Deaths		157	19%	146	20%	11	12%

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. USDA updates the RUCA tables once every 10 years. The tables for the year 2010 are the most up to date.

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, 2019.
United States Department of Agriculture, Economic Research Service, 2016.
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 of Wyoming, Alaska, Montana, and Idaho.

III. Alarm Usage 2008-2018

Table 10 presents a summary of CO fatalities characterized by CO alarm usage and alarm status. In 72 percent of the fatal incidents (462 of 645), and 68 percent of reported CO poisoning deaths (564 of 834), the presence of a CO alarm at the location of the incident was unknown or unreported. Of the 181 fatal incidents (268 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 (14%) involving 36 CO fatalities. Of these 25 fatal incidents, the alarm was known to be inoperable in 10 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 10 fatal incidents with inoperable alarms were associated with generator usage.

For the remaining 15 fatal incidents (19 fatalities) in which an alarm was known to be present, the alarm sounded in only nine incidents (11 deaths):

- 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 two incidents, the alarm sounded, and the victim removed the batteries, thus, disabling it.
    - In one of these incidents, the victim was transported to the hospital but was pronounced dead.
    - In the second incident, a man died, but his daughter survived the incident.
- In two 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 wood splitter 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 one incident, two victims were found in a home in which a CO alarm was sounding. It is unknown if the alarm triggered after the victims became incapacitated by CO poisoning, or if the victims simply misunderstood or ignored the signal.
- In another incident, two victims were found in a camper trailer at a remote site with a CO alarm sounding. Again, it is unknown whether 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 the alarm sounded or whether the alarm was operable.

Table 10: Carbon Monoxide Alarm Usage Associated with Engine-Driven Tools Non-Fire CO Poisoning Deaths, 2008–*2018*

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	**645**	**834**	**-**	**556**	**743**	**-**	**89**	**91**	**-**
Alarm Status Known	**181**	**268**	**100%**	**160**	**245**	**100%**	**21**	**23**	**100%**
No Alarm[#]	**156**	**232**	**87%**	**141**	**215**	**88%**	**15**	**17**	**74%**
Alarm Present	**25**	**36**	**13%**	**19**	**30**	**12%**	**6**	**6**	**26%**
Alarmed	9	11	4%	5	7	3%	4	4	17%
Did not alarm, batteries removed, incorrectly inserted, or drained	7	13	5%	7	13	5%	0	0	0%
Did not alarm, plug-in type, no power	3	4	1%	3	4	2%	0	0	0%
Alarm present, Unknown if it alarmed	6	8	3%	4	6	2%	2	2	9%
Not applicable, victim outdoors	**2**	**2**	**-**	**2**	**2**	**-**	**0**	**0**	**-**
Alarm Status Unknown	**462**	**564**	**-**	**394**	**496**	**-**	**68**	**68**	**-**

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, 2019.

IV. Hazard Patterns Associated with Generators 2008-2018

This section presents information about the usage patterns associated with fatal CO poisonings specific to generators, as well as information about the homes in which fatal generator incidents occurred. As of June 18, 2019, CPSC staff is aware of 556 generator-related incidents from 2008 through 2018, which resulted in non-fire CO fatalities. Staff completed, or otherwise resolved, in-depth investigations (IDIs) for 519 of 556 (93%) fatal CO incidents associated with generators that occurred from 2008 through 2018. For the remaining 37 incidents in which staff did not perform an IDI, or did not complete an IDI by the cut-off date of June 18, 2019, we attempted 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 in which multiple, fuel-burning consumer products were involved, including a generator.

A review of records for the 556 incidents resulting in 743 generator-related, non-fire CO deaths reported to CPSC staff suggests two primary reasons for using a generator. One reason for using a generator was to provide electricity to a location after a temporary situation (*e.g.*, a power outage); the other reason 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 percent of the incidents (20 percent of the reported deaths) involving generator-related, non-fire CO fatalities were associated with temporary power outage stemming from a weather problem or a problem with power distribution. Nineteen percent of the fatal incidents (21 percent of deaths) were associated with a power shutoff by the utility company for nonpayment. However, for 23 percent of the fatal incidents (22 percent of deaths), we could not determine why the generator was in use, or why there was no electricity at the location of the incident.

Most of the generators associated with fatal CO poisoning were gasoline-fueled. In 46 of the 556 incidents, staff could not ascertain the fuel type. Of the 510 cases remaining cases, 99 percent (505 of 510) were gasoline-fueled. Four additional incidents involved propane-fueled generators (three of which were stationary generators), and one involved a diesel-fueled generator.

Table 11: Number of Reported Non-Fire CO Fatalities for Incidents Associated with Generators[1] by Reason for Use, 2008–*2018*

Reason for Use		Total	2008	2009	2010	2011	2012	2013	2014	2015	2016	*2017*	*2018*
Total	**Incidents**	**556**	**70**	**45**	**37**	**69**	**43**	**46**	**38**	**52**	**58**	***66***	***32***
	Deaths	**743**	**95**	**66**	**46**	**96**	**49**	**59**	**49**	**77**	**76**	***82***	***48***
Power outage due to weather, or problem with power distribution	Incidents	112	19	10	5	19	15	12	5	4	4	*16*	*3*
	Deaths	152	26	17	6	27	16	13	5	6	11	*21*	*4*
Electricity turned off by power company due to bill dispute, nonpayment, or other reason	Incidents	107	13	6	12	17	5	9	8	11	11	*11*	*4*
	Deaths	154	19	9	16	25	6	11	11	22	13	*16*	*6*
Provide power to storage shed, trailer, boat, camper, cabin, campsite	Incidents	73	5	8	2	8	5	5	5	7	11	*11*	*6*
	Deaths	97	7	11	5	13	6	5	7	10	13	*12*	*8*
New home or homeowner, and power not yet turned on, home under construction or renovation	Incidents	59	7	5	5	5	3	6	5	5	8	*5*	*5*
	Deaths	83	13	6	5	10	4	11	5	8	9	*5*	*7*
Provide power to home or mobile home that normally does not have electricity	Incidents	43	4	3	3	4	4	2	5	4	1	*10*	*3*
	Deaths	60	5	7	3	4	6	2	8	6	1	*14*	*4*
Working on or preparing a home for predicted storm / Periodic testing	Incidents	6	4	0	0	0	0	0	0	1	1	*0*	*0*
	Deaths	6	4	0	0	0	0	0	0	1	1	*0*	*0*
Provide power to a shed or garage that normally does not have electricity	Incidents	9	2	0	1	2	1	1	0	0	0	*0*	*2*
	Deaths	11	2	0	1	2	1	2	0	0	0	*0*	*3*
Other (previous fire in house, power shut off by owners, servicing power supply, or other usage)	Incidents	17	3	2	1	1	1	1	1	4	1	*1*	*1*
	Deaths	20	3	2	1	2	1	2	1	4	1	*1*	*2*
Unknown why electricity off	Incidents	130	13	11	8	13	9	10	9	16	21	*12*	*8*
	Deaths	160	16	14	9	13	9	13	12	20	27	*13*	*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, 2019.

For the 112 fatal incidents associated with a power outage due to weather or a problem with power distribution, Table 12 provides a breakdown by year and a cause of the power outage. Ninety-one percent of the fatal incidents associated with power outages were known to be due to specific weather conditions. Of the 103 incidents (comprising 139 fatalities) when the reason for the outage was known, ice or snow storms are associated with the largest percentage of weather-related CO fatal incidents, accounting for nearly half (46%) of the power outage-related incidents. Hurricanes and tropical storms are also associated with 30 percent of CO fatal incidents over the 11-year period from 2008 to 2018. Of the 41 known hurricane- or tropical storm-related fatalities between 2008 and 2018, 41 percent (17 deaths) occurred in 2017 alone.

Table 12: Number of Reported Non-Fire CO Fatalities for Incidents Associated with Generators[1] by Reason for Power Outage, 2008–*2018*

Reason for Power Outage		Total	2008	2009	2010	2011	2012	2013	2014	2015	2016	*2017*	*2018*
Total	**Incidents**	**112**	**19**	**10**	**5**	**19**	**15**	**12**	**5**	**4**	**4**	***16***	***3***
	Deaths	**152**	**26**	**17**	**6**	**27**	**16**	**13**	**5**	**6**	**11**	***21***	***4***
Ice or snow storm	Incidents	47	7	9	3	10	5	8	1	3	1	*0*	*0*
	Deaths	61	9	14	4	14	5	8	1	4	2	*0*	*0*
Hurricane or tropical storm	Incidents	31	6	0	0	3	7	0	0	0	1	*13*	*1*
	Deaths	41	8	0	0	5	8	0	0	0	1	*17*	*2*
Wind storm	Incidents	7	1	0	0	1	1	0	1	1	1	*1*	*0*
	Deaths	14	1	0	0	1	1	0	1	2	6	*2*	*0*
Thunderstorm, rainstorm, or flooding	Incidents	8	1	0	2	2	0	0	1	0	1	*1*	*0*
	Deaths	11	2	0	2	3	0	0	1	0	2	*1*	*0*
Tornado	Incidents	3	2	0	0	1	0	0	0	0	0	*0*	*0*
	Deaths	5	3	0	0	2	0	0	0	0	0	*0*	*0*
Storm, unspecified	Incidents	7	1	0	0	1	2	1	1	0	0	*0*	*1*
	Deaths	7	1	0	0	1	2	1	1	0	0	*0*	*1*
Unknown or other reason for outage	Incidents	9	1	1	0	1	0	3	1	0	0	*1*	*1*
	Deaths	13	2	3	0	1	0	4	1	0	0	*1*	*1*

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, 2019.

As shown in Table 8, 569 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 569 generator-related deaths that occurred in a fixed-structure home, information was available for 457 deaths (80%) regarding the victim’s location in relation to the generator. One hundred fifteen of these 457 fatalities (25%) occurred in the same room or space as the generator.

The 569 deaths that occurred in a fixed-structure home resulted from 416 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 in which the generator was placed outside a home, but near an open window, door, or vent of the home. Seventy-four percent (420 of 569) of the CO fatalities at fixed-home locations occurred when a generator was known to be placed inside the home, including the living space (235), a basement/crawlspace (137), closet (5), or inside the house, with no further information provided (43). Another 18 percent of the fatalities (103 of 569) occurred when the generator was placed in an attached garage, enclosed carport, or attached barn. Forty-two percent of the fatalities (240 of 569) occurred when the generator was placed in an attached structure (103), or in the basement or crawlspace (137).

Sixteen deaths from 10 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 in which a generator was running outside the home but inside a building (*e.g.*, outside an apartment but still inside the building). Additional fatalities occurred during incidents in which generators were placed outside in non-fixed structure houses. A summary of all fatal scenarios in which a generator was located outside is provided in Appendix C to this report.

Table 13: Non-Fire CO Poisoning Deaths in the Fixed-Structure Home Location[1] by Location of the Generator,[2] 2008–*2018*

Generator Location		Total	2008	2009	2010	2011	2012	2013	2014	2015[3]	*2016*	*2017*	*2018*
Total	**Incidents**	**416**	**52**	**35**	**29**	**54**	**36**	**35**	**28**	**34**	***43***	***48***	***22***
	Deaths	**569**	**72**	**52**	**35**	**76**	**41**	**46**	**36**	**56**	***58***	***63***	***34***
Living space (non-basement)	Incidents	170	20	15	14	17	9	9	12	15	*24*	*24*	*11*
	Deaths	235	27	21	14	24	13	11	18	28	*30*	*31*	*18*
Basement / crawlspace	Incidents	91	12	6	5	16	5	12	9	9	*6*	*8*	*3*
	Deaths	137	21	11	8	25	5	16	11	13	*13*	*10*	*4*
Garage/enclosed carport / attached barn	Incidents	80	13	8	5	14	14	9	2	4	*5*	*6*	*0*
	Deaths	103	15	11	6	19	14	13	2	7	*7*	*9*	*0*
Inside house, no further information reported	Incidents	38	4	4	1	4	5	3	3	3	*6*	*5*	*0*
	Deaths	43	5	6	2	4	5	3	3	4	*6*	*5*	*0*
Closet in home / utility room	Incidents	4	0	1	0	0	0	1	0	0	*0*	*0*	*2*
	Deaths	5	0	1	0	0	0	1	0	0	*0*	*0*	*3*
Outside the home	Incidents	10	0	0	1	1	1	1	1	1	*2*	*2*	*0*
	Deaths	16	0	0	1	2	2	2	1	2	*2*	*4*	*0*
Unknown location, but at home	Incidents	23	3	1	3	2	2	0	1	2	*0*	*3*	*6*
	Deaths	30	4	2	4	2	2	0	1	2	*0*	*4*	*9*

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, 2019.

Table 14 sets forth non-fire CO fatalities that occurred in a fixed-structure home, characterized by ventilation status. Many of the incidents with generator-associated fatalities in the home (199 of the 416 incidents) did not contain information about the ventilation of the generator. Of the other 217 incidents, 149 (69%), accounting for 224 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 68 incidents associated with generators in which it was reported that some type of ventilation was attempted. Of these 68 incidents, 46 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 58 CO deaths. As also noted here, and in Table 13, 10 incidents (16 deaths) were associated with generators that were placed outside the home, near open windows, doors, or vents, where carbon monoxide entered the home. In 12 incidents (19 deaths), consumers actively but unsuccessfully attempted to vent generator exhaust outside through a window or door, or by using a fan.

Table 14: Non-Fire CO Fatalities in the Fixed-Structure Home[1] Reported to CPSC Staff and Associated with Generators[2] Categorized by Status of Ventilation, 2008–*2018*

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	**416**	**569**	**100%**	**100%**
Some ventilation attempted	**68**	**93**	**16%**	**29%**
Open window(s), open door(s), an open garage door, or a combination of these	46	58	10%	18%
Actively trying to vent either by fans or by directing exhaust out a window or door	12	19	3%	6%
Placed outside of home, but near a window, door, A/C unit, or other outdoor location[3]	10	16	3%	5%
No ventilation	**149**	**224**	**39%**	**71%**
Unknown ventilation	**199**	**252**	**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.

Source: U.S. Consumer Product Safety Commission, Directorate for Epidemiology, 2019.

Table 15 presents a summary of the CO incidents and fatalities characterized by the size of the home in which the fatalities occurred. Home size information was available for 303 of 416 fatal incidents (419 of the 569 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 agreed on the size of the home because both databases are based on public records from the county, state, or municipality.

Sixty-three percent (190 of 303) of the reported fatal incidents (269 of 419 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 86 percent (262 of 303) of the reported incidents

and 89 percent of the deaths (371 of 419) occurred in homes 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 approximately 1,320 square feet. As a point of reference, according to the U.S. Census Bureau's, *American Housing Survey for the United States: 2015*, the median housing unit as of 2013 was 1,500 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 Home[1] Reported to CPSC Staff and Associated with Generators[2] Categorized by Size of Home, 2008–*2018*

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 (2013)[4]
Total	**416**	**569**	**100%**	**100%**	**100%**
Under 500	2	3	< 1%	1%	3%
500–999	82	107	20%	27%	20%
1,000–1,499	106	159	25%	35%	25%
1,500–1,999	72	102	17%	24%	20%
2,000–2,499	20	25	5%	7%	14%
2,500–2,999	11	12	3%	4%	7%
3,000 or Larger	10	11	2%	3%	11%
Unknown	113	150	27%	-	-

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 2013 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, 2019.
U.S. Census Bureau, American Housing Survey for the United States: 2015.

Conclusions

Between 2008 and 2018, 834 non-fire CO-poisoning deaths from 645 incidents that were associated with EDTs were reported to CPSC staff. The majority of these deaths (743) 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. 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 (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 99 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. Most reported deaths occurred while an individual was at home.

In only about 13 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.

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, and utility company shut-off, due to a bill dispute, non-payment, or another reason, were the most common reasons for generator usage that resulted in a non-fire CO fatality.

Seventy-seven percent of the reported deaths associated with generators occurred at fixed-structure home locations. Seventy-four 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 18 percent occurred when a generator was used inside an attached garage or shed. Generators were often used with little or no ventilation.

Conclusions about why consumers used generators indoors or determinations about whether users were aware of the potential non-fire CO-poisoning hazard could not be drawn with the available information.

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.

References

Hnatov, Matthew V. *Incidents, Deaths, and In-Depth Investigations Associated with Non-Fire Carbon Monoxide from Engine-Driven Generators and Other Engine-Driven Tools, 2005-2016*. U.S. Consumer Product Safety Commission. June 2018. https://www.cpsc.gov/s3fs-public/Generators%20and%20OEDT%20Fatalities%202018%20FINAL.pdf?EHbNEzxP3czGisZg9_BY2b7wPgMJltZu

Hnatov, Matthew V. *Non-Fire Carbon Monoxide Deaths Associated with the Use of Consumer Products: 2014 Annual Estimates*. U.S. Consumer Product Safety Commission. September 2017. https://www.cpsc.gov/s3fs-public/Non-Fire-Carbon-Monoxide-Deaths-Associated-with-the-Use-of-Consumer-Products-2014-Annual-Estimates.pdf?VzenVwwvL5p7j_Mt0WrQvZkchDBFCM48

U.S. Census Bureau, Population Division. 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, 2013 https://www.census.gov/data/tables/time-series/demo/popest/2010s-national-detail.html

U.S. Census Bureau. American Housing Survey for the United States: 2013. https://www.census.gov/programs-surveys/ahs/data/interactive/ahstablecreator.html#?s_areas=a00000&s_year=n2013&s_tableName=Table1&s_byGroup1=a1&s_byGroup2=a1&s_filterGroup1=t1&s_filterGroup2=g1&s_show=S

U.S. Department of Agriculture. Rural-Urban Commuting Area Codes, October 12, 2016. https://www.ers.usda.gov/data-products/rural-urban-commuting-area-codes.aspx

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

CPSC staff queried epidemiology 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: 06/28/2019

Incident Dates: 1/1/08-12/31/18
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 incident.[5] This summary includes stationary generators (4 incidents, 6 deaths) and generator-welders (2 incidents, 2 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, 37 percent involved Class I powered generators, and 57 percent involved single cylinder Class II powered generators. Handheld class generators were known to be involved in three incidents (four fatalities) during this period; while twin cylinder, Class II powered generators were known to be involved in five incidents and 10 fatalities.

Additionally, 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. In three other incidents, each involving one fatality, there were multiple generators present although it is unknown if more than one were in use during the fatal incident. In all three cases, the size of the generators is unknown.

[5] 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, 2008–*2018*

	Handheld		Class I		Class II, Single Cylinder		Class II, Twin Cylinder		Unknown		Total	
Year	**Incidents**	**Deaths**	**Incidents**	**Deaths**	**Incidents**	**Deaths**	**Incidents**	**Deaths**	**Incidents**	**Deaths**	**Incidents**	**Deaths**
Total	***3***	***4***	***90***	***140***	***146***	***201***	***5***	***10***	***311***	***387***	***556***	***743***
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	4	8	5	8	1#	1#	27	31	38#	49#
2015			6	13	14*	18*	1	1	31+	45+	52	77
2016	1	2	11	17	13	19			33	38	58	76
2017			*11*	*15*	*16#*	*19#*	*1*	*2*	*38*	*46*	*66*	*82*
2018			*6*	*9*	*13*	*21*			*13*	*18*	*32*	*48*

* 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). In 2017, there was an incident involving a stationary generator of unknown engine classification.
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, 2019.

When an 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, 5 percent of all generator incidents (30 of 645) and fatalities (43 of 834) 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. There were also two incidents involving one fatality each where the victim was located outside near the generator. In one case, it was 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. In another incident, a generator was in use in a parking lot, but it was unclear exactly where the decedent was – outside near the generator or inside a vehicle near the generator – this case was included in the "Outside (near generator)" category.

Table C-1: Fatal CO Generator Incidents Where the Generator Was Located Outside of the Occupied Space, 2008–*2018*

Location of victim(s)	Incidents	Deaths
Total – Occupied Area	**30**	**43**
House/Mobile Home	8	12
Apartment	1	2
Cabin	1	1
Vehicle: RV/Camper Shell	6	12
Vehicle: Automobile/Truck	3	3
Camper Trailer/Horse Trailer	5	6
Boat	1	1
Outside Apartment, Inside Building	1	2
Outside Trailer, Inside Building	2	2
Outside (near generator)	2	2

Source: U.S. Consumer Product Safety Commission, Directorate for Epidemiology, 2019.

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 to 50 percent in the blood approximately correlates with symptoms of confusion, unconsciousness, coma, and possible death; a level of 50 to 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 448 of the 834 fatalities (54% 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-three percent (370 of the 448) of fatalities had reported COHb levels of 50 percent or greater.

Table D-1: Carboxyhemoglobin Levels Associated with Engine-Driven Tools Non-Fire CO Poisoning Deaths, 2008–*2018*[1]

COHb Level	All Engine-Driven Tools (EDTs)		Generators		Other Engine-Driven Tools (OEDTs)	
Total	**834**	**-**	**743**	**-**	**91**	**-**
Reported Levels	**448**	**100%**	**399**	**100%**	**49**	**100%**
Less than 30%	25	6%	23	6%	2	4%
30–39.9%	18	4%	16	4%	2	4%
40–49.9%	35	8%	32	8%	3	6%
50–59.9%	81	18%	74	19%	7	14%
60–69.9%	138	31%	124	31%	14	29%
70–79.9%	122	27%	103	26%	19	39%
80–89.9%	26	6%	24	6%	2	4%
90–99.9%	3	1%	3	1%	0	0%
Not reported	386	-	344	-	42	-

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, 2019.

[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 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 2018. 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, when additional information became available. Between the second and third year, the average increase, report to report, is about seven percent.

The number of CO fatalities associated with the use of OEDTs has been relatively steady over the period 1999 through 2018.

Figure 1: Number of Reported Non-Fire CO Fatalities Associated with Engine-Driven Tools, 1999–*2018*