



Fatal Incidents Associated with Non-Fire Carbon Monoxide Poisoning from Engine- Driven Generators and Other Engine-Driven Tools, 2009–2019

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Executive Summary

This report summarizes non-fire, carbon monoxide (CO) incidents associated with all engine-driven tools (EDTs), such as generators and other engine-driven tools, which occurred between 2009 and 2019, and that were reported to U.S. Consumer Product Safety Commission (CPSC) staff as of May 12, 2020. Due to incident reporting delays, statistics for the most recent years (2018 and 2019) 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. 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:

- 820 fatalities from 639 incidents during 2009-2019;
 - 686 fatalities (84%) from 515 incidents associated with generators *only*;
 - 93 fatalities (11%) from 91 incidents involved OEDTs *only*; and
 - 41 fatalities (5%) from 33 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 all incidents involving multiple consumer products, the second product involved was either heating equipment (portable liquid propane- or kerosene-fueled), or a cooking product;
- 60 fatalities from 46 separate incidents in 2019;
 - 52 fatalities involved one, or in one case, two portable generators *only*;
 - 5 fatalities involved OEDTs *only*;
 - 3 fatalities involved multiple products, all three involved a portable generator and another product used for heat.

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 2019 report, this report presents
 - 27 additional fatalities in 2018;
 - 2 additional fatalities in 2017; and
 - 1 fewer fatality in 2016.

Socio-Demographic Characteristics of Victims and EDT-Use Patterns (2009-2019):

- Age: 86 percent of portable generator-related decedents and 99 percent of OEDT-related decedents were 25 years old or older.
- Gender: More than 76 percent of portable generator-related decedents and 99 percent of the OEDT-related decedents were males.
- Race/Ethnicity: 22 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 83 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); 34 percent during the transition months; and 21 percent in the warmer months.
- Structure type: 75 percent of all EDT-related fatalities occurred in fixed-structure homes.
- Urban versus rural: 55 percent of 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 (2009-2019):

- A CO alarm: Only 39 (16%) of the EDT-related fatalities were known to have alarms present.
 - For 20 of the deaths, the alarm was inoperable, due to no batteries, batteries inserted incorrectly, possibly drained batteries, no electric current, or did not sound for some unknown reason.
 - 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 8 deaths, we do not know if the alarm sounded during the event.

Hazard Patterns Associated with Generators (2009-2019):

- The two most common reasons for using generators are power outages and power shut-offs.
 - Power outages: 100 incidents with 134 fatalities. Mostly for weather-related issues, such as ice/snow storms and hurricanes/tropical storms.
 - Power shut-offs: 102 incidents involving 146 fatalities.
- The two most common locations with generator-related fatalities were fixed-structure homes and temporary shelters.
 - Fixed-structure homes: 544 non-fire CO fatalities (401 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 70 percent 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 8 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. In two cases, the victim was outside, too close to the running generator and did not survive.

Engine Class of Generators Involved in Fatal CO Incidents (2009-2019):

- Of the 547 fatal generator incidents between 2009 and 2019 (including the generator plus non-EDT category), the generator engine class could only be determined in 240 cases. Ninety-six percent of the 240 incidents involved a portable generator with a Class I engine (88 incidents) or Class II, Single-Cylinder engine (143 incidents).

Carboxyhemoglobin Levels in CO Fatality Victims (2009-2019):

- Of the CO fatality victims associated with EDTs, 84 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 2018 and 2019 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 the Consumer Product Safety Commission Risk Management System (CPSRMS) databases to prepare the statistics recorded in this report. 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 set of 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 May 12, 2020. 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 incidents.

CPSC records contain information on 820 non-fire CO fatalities associated with EDTs during the years 2009 through 2019. Last year's report, dated June 2019, contained summary information and analyses for the 11-year period 2008–2018. In addition to dropping year 2008 from the reporting period, this updated report added information on 88 CO fatalities associated with engine-driven tools, and the report removed one fatality (see explanation below).

Changes to previous report:

- 2016 – One incident removed, accounting for 1 death due to new information indicating an out-of-scope pickup truck was also involved.
- 2017 – Two incidents added, accounting for 2 deaths.
- 2018 – Twenty-four new incidents added, accounting for 27 deaths.
- 2019 – Forty-six new incidents add, accounting for 60 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 2019.

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 2019, along with a revised summary of CO incidents and fatalities associated with engine-driven tools from 2009 through 2019. 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 639 incidents involving EDTs, with a total of 820 deaths, due to non-fire CO exposure that occurred between 2009 and 2019. For 2019 alone, as of May 12, 2020, 46 fatal, non-fire CO exposure incidents involving EDTs were reported to have occurred between January 1, 2019 and December 31, 2019. Sixty deaths occurred in these 46 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 where at least 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. 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 41 fatalities associated with multiple consumer products occurring in the period 2009 through 2019.

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 2009 and 2019, involved use of 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 did not specifically identify the welder as a generator.

All 41 non-fire CO fatalities in the “Multiple Products” category for 2009–2019 involved a heating- or cooking-related consumer product other than an EDT. In addition, during 2009–2019, there was a fatal incident in which two generators and an LP heater were in use; this incident is included as a generator- and heater-associated fatality in Table 1. In addition, among eight fatal incidents (nine deaths) 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 possible use of three generators.

**Table 1: Number of Reported Fatal Non-Fire CO Exposure Incidents and Deaths
Associated with Engine-Driven Tools, 2009–2019**

Product	2018		2019		Total: 2009–2019	
	Number of Incidents	Number of Deaths	Number of Incidents	Number of Deaths	Number of Incidents	Number of Deaths
Total Engine-Driven Tools	60	79	46	60	639	820
Generators	50	69	39	52	515	686
Generator, portable	50	69	39	52	509	678
Generator, fixed location	0	0	0	0	4	6
Welder (used as a generator) ¹	0	0	0	0	2	2
Other Engine-Driven Tools (OEDT)	8	8	5	5	91	93
Lawn mowers	4	4	1	1	43	43
Riding lawn mower/Garden tractor	2	2	0	0	34	34
Powered push lawn mower	0	0	0	0	1	1
Powered lawn mower, unspecified type	2	2	1	1	8	8
Snow blower	1	1	1	1	12	12
Power washer/sprayer	1	1	1	1	11	11
All-terrain vehicle	1	1	0	0	6	7
Welder (used as welder or other reason) ¹	0	0	0	0	3	4
Water pump / Sump pump	0	0	1	1	4	4
Concrete saw	0	0	0	0	1	1
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	1	1	0	0	2	2
Antique Tractor	0	0	0	0	1	1
Unspecified Gas Power Equipment	0	0	1	1	1	1
Multiple Products²	2	2	2	3	33	41
Generator + Other Consumer Product	2	2	2	3	32	40
OEDT + Other Consumer Product ³	0	0	0	0	1	1

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

² “Multiple Products” includes incidents involving generators or OEDTs with other combustion fuel-burning consumer products. “Other Consumer Products” includes one or more of the following: portable LP-fueled heaters, portable kerosene-fueled heaters, camp stoves, lanterns, outdoor cookers, furnaces, and wood stoves.

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

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

Source: U.S. Consumer Product Safety Commission, Directorate for Epidemiology, 2020.

Five hundred and fifteen of the 639 incidents (81%) reported to CPSC staff during the 2009–2019 period were associated with a generator alone, and the incidents accounted for 686 of the 820 CO deaths (84%). Additionally, 40 other CO fatalities from 32 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. Slightly fewer than half of the OEDT CO incidents (47%, 43 of 91) involved a garden tractor or other powered lawn mower (including the single “Multiple Products” incident involving and OEDT). 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-related.”

CPSC staff examined the number of deaths associated with each fatal incident (Table 2). Of the 639 fatal incidents, 79 percent involved a single fatality. Seventy-six percent (415 of 547) 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 92 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, 2009–2019

Number of Deaths Reported in Incident¹						
All Incidents	639	100%	547	100%	92	100%
1	504	79%	414	76%	90	98%
2	110	17%	108	20%	2	2%
3	11	2%	11	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, 2020.

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 May 12, 2020. 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 2009, prior year counts have increased by an average of 37 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 43 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 2015 through 2017, 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, 2009–2019

Year	All Engine-Driven Tools (EDTs)		Generators		Other Engine-Driven Tools (OEDTs)	
	Incidents	Deaths	Incidents	Deaths	Incidents	Deaths
Total	639	820	547	726	92	94
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	67	85	57	75	10	10
2017	75	91	67	83	8	8
<i>2018</i>	<i>60</i>	<i>79</i>	<i>52</i>	<i>71</i>	<i>8</i>	<i>8</i>
<i>2019</i>	<i>46</i>	<i>60</i>	<i>41</i>	<i>55</i>	<i>5</i>	<i>5</i>
Average: 2015–2017	67	87	59	78	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, 2020.

II. Socio-Demographic Characteristics of Victims and EDT-Use Patterns 2009-2019

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 U.S. Census's 2016 5-Year Estimated U.S. Resident Population figures (the approximate mid-point range of this data summary), 67 percent of the U.S. population is over the age of 25 years. In comparison, 87 percent (715 of 820) of reported non-fire, CO poisoning decedents associated with all EDTs, 86 percent (622 of 726) of decedents associated with generators, and all but one of the decedents (93 of 94) associated with OEDTs, were 25 years or older. In fact, 82 percent of the non-fire CO fatalities associated with OEDTs (77 of 94) involved victims age 45 or older.

It appears from the data summary that all EDT-related CO fatalities have involved older consumers at a higher rate than younger consumers, relative to their respective proportion in the general U.S. population. Specifically, 57 percent of the CO fatalities were to victims 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 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, 2009–2019

Age	2016 5-Year 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%	820	100%	726	100%	94	100%
Under 5	6%	9	1%	9	1%	0	0%
5–14	13%	35	4%	35	5%	0	0%
15–24	14%	61	7%	60	8%	1	1%
25–44	26%	247	30%	231	32%	16	17%
45–64	26%	321	39%	283	39%	38	40%
65 and over	14%	147	18%	108	15%	39	41%

¹This percentage represents the 2012-2016 Census-estimated percentage of the U.S. population, an approximate mid-point range of the 11-year range.

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

Sources: U.S. Consumer Product Safety Commission, Directorate for Epidemiology, 2020.

5-Year Estimates of the Resident Population by Sex, Age, Race, and Hispanic Origin for the United States and States:
January 1, 2012 to December 31, 2016.

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, 2009–2019

Gender	2016 5-Year 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%	820	100%	726	100%	94	100%
Male	49%	646	79%	553	76%	93	99%
Female	51%	174	21%	173	24%	1	1%

Notes:

¹This percentage represents the 2012-2016 Census-estimated percentage of the U.S. population, an approximate mid-point range of the 11-year range.

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

Sources: U.S. Consumer Product Safety Commission, Directorate for Epidemiology, 2020.

5-Year Estimates of the Resident Population by Sex, Age, Race, and Hispanic Origin for the United States and States: January 1, 2012 to December 31, 2016.

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” (22% 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 12%). The percentage of the OEDT-related CO fatalities identified as non-Hispanic “White” (83% of deaths) was much higher than the proportion classified as non-Hispanic “White” by of the U.S. Census Bureau (an estimated 62% of the U.S. population).

Table 6: Number of Reported Non-Fire CO Fatalities Associated with Engine-Driven Tools by Race/Ethnicity of Victim, 2009–2019

Race / Ethnicity	2016 5-Year 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%	820	100%	726	100%	94	100%
White ²	62%	517	63%	439	60%	78	83%
Black/African American ²	12%	162	20%	159	22%	3	3%
Hispanic (any race)	17%	76	9%	74	10%	2	2%
Asian ²	5%	10	1%	9	1%	1	1%
Native American ^{2,3}	1%	7	1%	7	1%	0	0%
Other/Multi/Unknown ⁴	2%	48	6%	38	5%	10	11%

1 This percentage represents the 2012-2016 Census-estimated percentage of the U.S. population, an approximate mid-point range of the 11-year range.

2 These Race/Ethnicity designations are for single race only.

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

4 Includes Other races, multiple Races, and those where the race of the victims are unknown.

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

Sources: U.S. Consumer Product Safety Commission, Directorate for Epidemiology, 2020.

5-Year Estimates of the Resident Population by Sex, Age, Race, and Hispanic Origin for the United States and States: January 1, 2012 to December 31, 2016.

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-five percent of the incidents (44% 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-five 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, 2009–2019

Season Incident Occurred		All Engine-Driven Tools (EDTs)		Generators		Other Engine-Driven Tools (OEDTs)	
Total	Incidents	639	100%	547	100%	92	100%
	Deaths	820	100%	726	100%	94	100%
Cold months	Incidents	290	45%	252	46%	38	41%
	Deaths	360	44%	321	44%	39	41%
Transitional months	Incidents	215	34%	184	34%	31	34%
	Deaths	284	35%	252	35%	32	34%
Warm months	Incidents	134	21%	111	20%	23	25%
	Deaths	176	21%	153	21%	23	24%

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

Source: U.S. Consumer Product Safety Commission, Directorate for Epidemiology, 2020.

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 (690 of 820, or 84%) 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-five 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, 16 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, 2009–2019

Victim Location		All Engine-Driven Tools (EDTs)		Generators		Other Engine-Driven Tools (OEDTs)	
Total	Incidents	639	100%	547	100%	92	100%
	Deaths	820	100%	726	100%	94	100%
Home, fixed Structure ¹	Incidents	472	74%	401	73%	71	77%
	Deaths	616	75%	544	75%	72	77%
Home, detached Structure ²	Incidents	58	9%	43	8%	15	16%
	Deaths	59	7%	44	6%	15	16%
Home, non-house ³	Incidents	13	2%	13	2%	0	0%
	Deaths	15	2%	15	2%	0	0%
Temporary shelter	Incidents	41	6%	41	7%	0	0%
	Deaths	62	8%	62	9%	0	0%
Boat/Vehicle	Incidents	33	5%	32	6%	1	1%
	Deaths	41	5%	39	5%	2	2%
Other	Incidents	19	3%	14	3%	5	5%
	Deaths	24	3%	19	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	1	< 1%	1	< 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.

Source: U.S. Consumer Product Safety Commission, Directorate for Epidemiology, 2020.

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, WWAMI³ Rural Health Research Center website at: <http://depts.washington.edu/uwruca/>. This study is updated approximately once every 10 years, the last update occurring in 2010.

Fifty-five percent (447 of 820) 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-five percent (373 of 820) 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 (155 of 820) 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.

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.

Table 9: Number of Reported Non-Fire CO Fatalities Associated with Engine-Driven Tools by Population Density of Place of Death, 2009–2019

Population Density		Estimated Percentage of U.S. Population ¹	All Engine-Driven Tools (EDTs)		Generators		Other Engine-Driven Tools (OEDTs)	
Total	Incident	100%	639	100%	547	100%	92	100%
	Deaths		820	100%	726	100%	94	100%
Urban Core	Incident	71%	350	55%	307	56%	43	47%
	Deaths		447	55%	403	56%	44	47%
Sub-Urban	Incident	10%	80	13%	60	11%	20	22%
	Deaths		100	12%	80	11%	20	21%
Large Rural	Incident	10%	94	15%	77	14%	17	18%
	Deaths		118	14%	100	14%	18	19%
Small Rural /Isolated	Incident	9%	115	18%	103	19%	12	13%
	Deaths		155	19%	143	20%	12	13%

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

Source: U.S. Consumer Product Safety Commission, Directorate for Epidemiology, 2020.

United States Department of Agriculture, Economic Research Service, 2019.

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

U.S. Census Bureau, 2011.

III. Alarm Usage 2009-2019

Table 10 presents a summary of CO fatalities characterized by CO alarm usage and alarm status. In 74 percent of the fatal incidents (471 of 639), and 70 percent of reported CO poisoning deaths (573 of 820), the presence of a CO alarm at the location of the incident was unknown or unreported. Of the 166 fatal incidents (245 CO fatalities) associated with EDTs, in which it was known whether a CO alarm was present, a CO alarm was present in only 27 incidents (16%) involving 39 CO fatalities. Of these 27 fatal incidents, the alarm was known to be inoperable in 12 incidents (20 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. Additionally, there was one incident with one fatality, where the consumer bought an alarm, but had not set it up yet. All 12 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.

For the remaining six (out of 15) incidents with eight deaths in which a CO alarm was present in the house, 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, 2009–2019**

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	639	820	-	547	726	-	92	94	-
Alarm Status Known	166	245	100%	147	224	100%	19	21	100%
No Alarm[#]	139	206	84%	126	191	85%	13	15	71%
Alarm Present	27	39	16%	21	33	15%	6	6	29%
Alarmed	9	11	4%	5	7	3%	4	4	19%
Did not alarm, batteries removed, incorrectly inserted, or drained	9	16	7%	9	16	7%	0	0	0%
Did not alarm, plug-in type, no power	2	3	1%	2	3	1%	0	0	0%
Alarm present, Unknown if it Alarmed	6	8	3%	4	6	3%	2	2	10%
Did not alarm, Unknown reason	1	1	<1%	1	1	<1%	0	0	0%
Not applicable, victim outdoors	2	2	-	2	2	-	0	0	-
Alarm Status Unknown	471	573	-	398	500	-	73	73	-

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

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

Source: U.S. Consumer Product Safety Commission, Directorate for Epidemiology, 2020.

IV. Hazard Patterns Associated with Generators 2009-2019

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 May 12, 2020, CPSC staff is aware of 547 generator-related incidents from 2009 through 2019, which resulted in non-fire CO fatalities. Thirty-two of these incidents may have also involved a second fuel-burning device that may have contributed to the CO poisonings. Staff completed, or otherwise resolved, in-depth investigations (IDIs) for 509 of 547 (93%) fatal CO incidents associated with generators that occurred from 2009 through 2019. For the remaining 38 incidents in which staff did not perform an IDI, or did not complete an IDI by the cut-off date of May 12, 2020, attempts were made to augment the data from reports of the incidents 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 547 incidents resulting in 726 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. Eighteen percent of the incidents (18 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 (20 percent of deaths) were associated with a power shutoff by the utility company for nonpayment. However, for 24 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 generators. In 74 of the 547 incidents, staff could not ascertain the fuel type. Of the 473 cases remaining cases, 99 percent (468 of 473) were gasoline-fueled generators. 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 Generators¹ by Reason for Use, 2009–2019

Reason for Use		Total	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Total	Incidents	547	45	37	69	43	46	38	52	57	67	52	41
	Deaths	726	66	46	96	49	59	49	77	75	83	71	55
Power outage due to weather, or problem with power distribution	Incidents	100	10	5	19	15	12	5	4	4	16	4	6
	Deaths	134	17	6	27	16	13	5	6	11	21	5	7
Electricity turned off by power company due to bill dispute, nonpayment, or other reason	Incidents	102	6	12	17	5	9	8	11	11	11	6	6
	Deaths	146	9	16	25	6	11	11	22	13	16	8	9
Provide power to storage shed, trailer, boat, camper, cabin, campsite	Incidents	85	8	2	8	5	5	5	7	10	11	16	8
	Deaths	113	11	5	13	6	5	7	10	12	12	21	11
New home or homeowner, and power not yet turned on, home under construction or renovation	Incidents	58	5	5	5	3	6	5	5	8	5	6	5
	Deaths	80	6	5	10	4	11	5	8	9	5	8	9
Provide power to home or mobile home that normally does not have electricity	Incidents	46	3	3	4	4	2	5	4	1	10	5	5
	Deaths	63	7	3	4	6	2	8	6	1	14	6	6
Working on or preparing a home for predicted storm/ Periodic testing	Incidents	2	0	0	0	0	0	0	1	1	0	0	0
	Deaths	2	0	0	0	0	0	0	1	1	0	0	0
Provide power to a shed or garage that normally does not have electricity	Incidents	9	0	1	2	1	1	0	0	0	0	3	1
	Deaths	11	0	1	2	1	2	0	0	0	0	4	1
Other (previous fire in house, power shut off by owners, servicing power supply, or other usage)	Incidents	14	2	1	1	1	1	1	4	1	1	1	0
	Deaths	17	2	1	2	1	2	1	4	1	1	2	0
Unknown why electricity off	Incidents	131	11	8	13	9	10	9	16	21	13	11	10
	Deaths	160	14	9	13	9	13	12	20	27	14	17	12

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, 2020.

For the 100 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 percent of the fatal incidents associated with power outages were known to be due to specific weather conditions. Of the 90 incidents (comprising 121 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 (44%) 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 2009 to 2019. Of the 35 known hurricane- or tropical storm-related fatalities between 2009 and 2019, nearly half (49%, 17 deaths) occurred in 2017 alone.

Table 12: Number of Reported Non-Fire CO Fatalities for Incidents Associated with Generators¹ by Reason for Power Outage, 2009–2019

Reason for Power Outage		Total	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Total	Incidents	100	10	5	19	15	12	5	4	4	16	4	6
	Deaths	134	17	6	27	16	13	5	6	11	21	5	7
Ice or snow storm	Incidents	40	9	3	10	5	8	1	3	1	0	0	0
	Deaths	52	14	4	14	5	8	1	4	2	0	0	0
Hurricane or tropical storm	Incidents	27	0	0	3	7	0	0	0	1	13	2	1
	Deaths	35	0	0	5	8	0	0	0	1	17	3	1
Wind storm	Incidents	6	0	0	1	1	0	1	1	1	1	0	0
	Deaths	13	0	0	1	1	0	1	2	6	2	0	0
Thunderstorm, rainstorm, or flooding ²	Incidents	8	0	2	2	0	0	1	0	1	1	0	1
	Deaths	10	0	2	3	0	0	1	0	2	1	0	1
Tornado	Incidents	1	0	0	1	0	0	0	0	0	0	0	0
	Deaths	2	0	0	2	0	0	0	0	0	0	0	0
Storm, unspecified	Incidents	8	0	0	1	2	1	1	0	0	0	1	2
	Deaths	9	0	0	1	2	1	1	0	0	0	1	3
Unknown or other reason for outage	Incidents	10	1	0	1	0	3	1	0	0	1	1	2
	Deaths	13	3	0	1	0	4	1	0	0	1	1	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.

2 This category includes a 2019 incident with flooding during an ice storm. The incident was included here as the victim was attempting running a gas-powered sump pump to clear water from his house.

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, 2020.

As shown in Table 8, 544 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 544 generator-related deaths that occurred in a fixed-structure home, information was available for 443 deaths (81%) regarding the victim’s location in relation to the generator. One hundred and eleven of these 443 fatalities (25%) occurred in the same room or space as the generator.

The 544 deaths that occurred in a fixed-structure home resulted from 401 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; nor does it include transitory locations where consumers are not expected to spend a lot of time, such as laundry rooms, utility rooms, or bathrooms. 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-five percent (408 of 544) of the CO fatalities at fixed-home locations occurred when a generator was known to be placed inside the home, including the living space (216), a basement/crawlspace (122), in a transitory place (Closet/laundry room/utility room) (23), or inside the house, with no additional information provided (47). Another 18 percent of the fatalities (98 of 544) occurred when the generator was placed in an attached garage, enclosed carport, or attached barn. Forty percent of the fatalities (220 of 544) occurred when the generator was placed in an attached structure (98), or in the basement or crawlspace (122).

Eighteen deaths from 12 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 Location¹
by Location of the Generator,² 2009–2019**

Generator Location		Total	2009	2010	2011	2012	2013	2014	2015 ³	2016	2017	2018	2019
Total	Incidents	401	35	29	54	36	35	28	34	43	49	30	28
	Deaths	544	52	35	76	41	46	36	56	58	64	42	38
Living space (non-basement)	Incidents	157	14	13	15	8	9	12	13	23	22	16	12
	Deaths	216	20	13	20	11	11	18	23	29	29	23	19
Basement / crawlspace	Incidents	84	6	5	16	5	12	9	9	6	8	5	3
	Deaths	122	11	8	25	5	16	11	13	13	10	6	4
Garage/enclosed carport / attached barn	Incidents	76	8	5	14	14	9	2	4	5	7	0	8
	Deaths	98	11	6	19	14	13	2	7	7	10	0	9
Inside house, no further information reported	Incidents	41	4	1	4	5	3	3	3	6	5	3	4
	Deaths	47	6	2	4	5	3	3	4	6	5	5	4
Transit Area (Closet / laundry room / utility room)	Incidents	15	2	1	2	1	1	0	2	1	2	3	0
	Deaths	23	2	1	4	2	1	0	5	1	2	5	0
Outside the home	Incidents	12	0	1	1	1	1	1	1	2	2	2	0
	Deaths	18	0	1	2	2	2	1	2	2	4	2	0
Unknown location, but at home	Incidents	16	1	3	2	2	0	1	2	0	3	1	1
	Deaths	20	2	4	2	2	0	1	2	0	4	1	2

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 because the victim was found in the living space. Notes: 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, 2020.

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 (198 of the 401 incidents) did not contain information about the ventilation of the generator. Of the other 203 incidents, 138 accounting for 210 deaths, indicated there was no ventilation when the incident occurred. In two of these fatal incidents (three deaths), a window or door was open during some period of use, but later closed. There were 65 incidents associated with generators in which it was

reported that some type of ventilation was attempted. Of these 65 incidents, 43 (56 deaths) were associated with incidents in which it was reported that there was an open or partially open window, door, garage door, or a combination of these. As also noted here, and in Table 13, 12 incidents (18 deaths) were associated with generators that were placed outside the home, near open windows, doors, or vents, where carbon monoxide entered the home. In 10 incidents (14 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 Home¹ Reported to CPSC Staff and Associated with Generators² Categorized by Status of Ventilation, 2009–2019

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	401	544	100%	100%
Some ventilation attempted	65	88	16%	30%
Open window(s), open door(s), an open garage door, or a combination of these	43	56	10%	19%
Actively trying to vent either by fans or by directing exhaust out a window or door	10	14	3%	5%
Placed outside of home, but near a window, door, A/C unit, or other outdoor location ³	12	18	3%	6%
No ventilation	138	210	39%	70%
Unknown ventilation	198	246	45%	-

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, 2020.

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 290 of 401 fatal incidents (402 of the 544 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 (184 of 290) of the reported fatal incidents (258 of 402 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 88 percent (254 of 290) of the reported incidents and 89 percent of the deaths (359 of 402) occurred in homes that were less than 2,000 square feet.

Table 15 includes incident location details for fatalities that occurred in apartments and mobile homes as well as fixed structure homes. Fatal incidents that occurred in a detached structure are not included in these figures. 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 Home¹ Reported to CPSC Staff and Associated with Generators² Categorized by Size of Home, 2009–2019

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	401	544	100%	100%	100%
Under 500	3	4	1%	1%	3%
500–999	78	102	19%	27%	20%
1,000–1,499	103	152	26%	36%	25%
1,500–1,999	70	101	17%	24%	20%
2,000–2,499	17	22	4%	6%	14%
2,500–2,999	10	10	2%	3%	7%
3,000 or Larger	9	11	2%	3%	11%
Unknown	111	142	28%	-	-

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 IDs 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, 2020.

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

Conclusions

Between 2009 and 2019, 820 non-fire CO-poisoning deaths from 639 incidents that were associated with EDTs were reported to CPSC staff. The majority of these deaths (726) 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 86 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 16 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-five percent of the reported deaths associated with generators occurred at fixed-structure home locations. Seventy-five 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, transit area or basement of the home. Another 19 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.

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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: 05/12/2020

Incident Dates: 1/1/09-12/31/19

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.⁴ 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 60 percent involved single cylinder Class II powered generators. Handheld class generators were known to be involved in four incidents (five fatalities) during this period; while twin cylinder, Class II powered generators were known to be involved in four incidents and nine 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 two other cases, each involving a single fatality, it was reported that two generators were both in use. In neither case was there information available on the generator classification. Additionally, in four other cases, one involving two fatalities, multiple generators were at the scene but it was unclear whether more than one was in operation at the time of the fatalities. In one case, two Class I powered generators were present and, in another, two Class II powered generators were present. Additionally, in one case three generators present of unknown classification were present, although it is not known how many were in use at the time of the fatal accident.

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, 2009–2019

	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	4	5	88	138	143	195	4	9	307	378	547	726
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			32	37	57	75
2017			11	15	17 [#]	20 [#]	1	2	38	46	67	83
2018	1	1	9	14	15	23			27	33	52	71
2019			7	10	17	21			17	24	41	55

* 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, 2020.

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: <https://www.epa.gov/compliance-and-fuel-economy-data/annual-certification-data-vehicles-engines-and-equipment#small-nrsi> 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 (32 of 639) and fatalities (45 of 820) 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, 2009–2019

Location of victim(s)	Incidents	Deaths
Total – Occupied Area	32	45
House/Mobile Home	10	14
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, 2020.

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.⁵ COHb levels were available for 443 of the 820 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-four percent (370 of the 443) 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, 2009–2019¹**

COHb Level	All Engine-Driven Tools (EDTs)		Generators		Other Engine-Driven Tools (OEDTs)	
Total	820	-	726	-	94	-
Reported Levels	443	100%	395	100%	48	100%
Less than 30%	21	5%	20	5%	1	2%
30–39.9%	17	4%	14	4%	3	6%
40–49.9%	35	8%	33	9%	2	4%
50–59.9%	74	17%	67	17%	7	15%
60–69.9%	144	32%	128	32%	16	33%
70–79.9%	120	27%	103	26%	17	35%
80–89.9%	28	6%	26	7%	2	4%
90–99.9%	4	1%	4	1%	0	0%
Not reported	377	-	331	-	46	-

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

Source: U.S. Consumer Product Safety Commission, Directorate for Epidemiology, 2020.

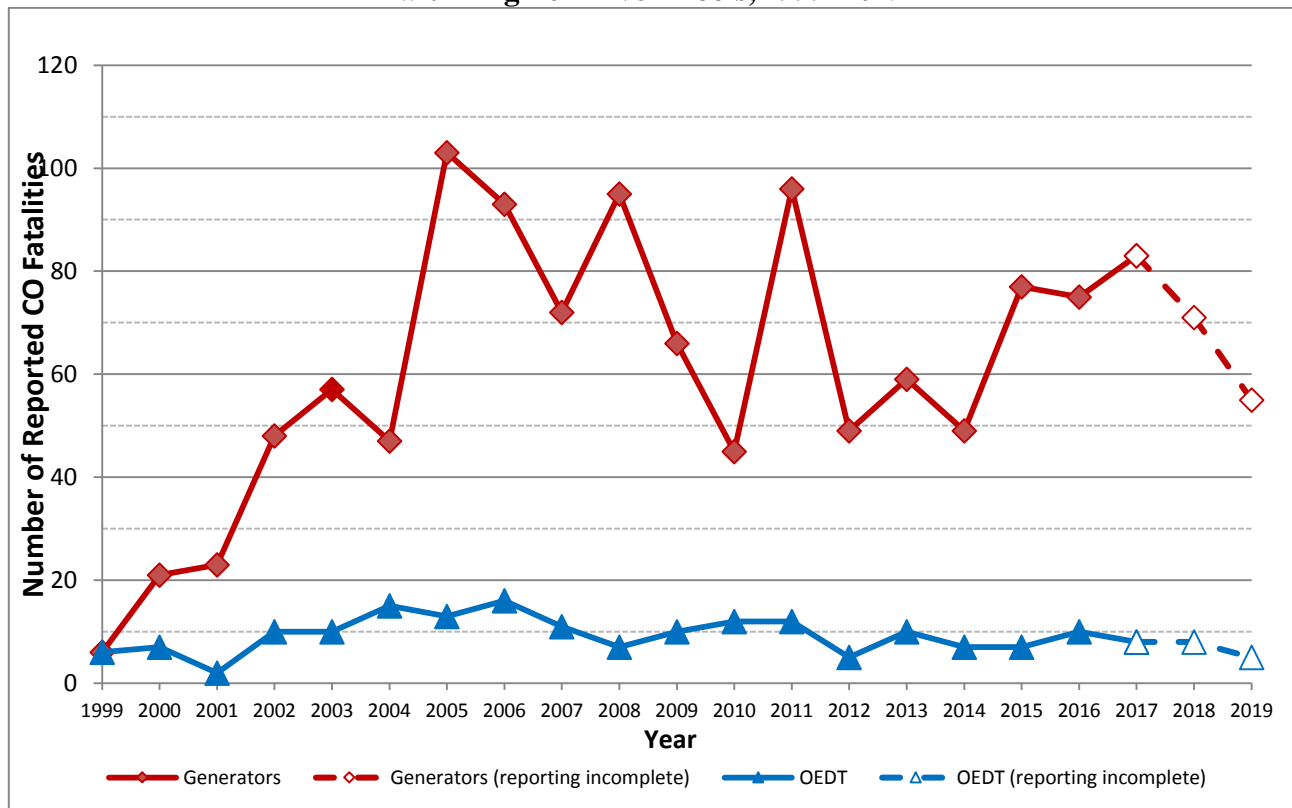
⁵ Inkster S.E. *Health hazard assessment of CO poisoning associated with emissions from a portable, 5.5 Kilowatt, gasoline-powered generator*. Washington, D.C.: U.S. Consumer Product Safety Commission. 2004.

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 2019. 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 2009 annual report, the most recent year's counts have increased by an average of about 37 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 2019.

Figure 1: Number of Reported Non-Fire CO Fatalities Associated with Engine-Driven Tools, 1999–2019



Note: Data presented in this graph are based on anecdotal data; no statistical inference about the trend is possible.

Source: U.S. Consumer Product Safety Commission, Directorate for Epidemiology, 2020.