



Fatal Incidents Associated with Non-Fire Carbon Monoxide Poisoning from Engine- Driven Generators and Other Engine-Driven Tools, 2010–2020

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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 (OEDTs) that occurred between 2010 and 2020, and were reported to U.S. Consumer Product Safety Commission (CPSC) staff as of May 17, 2021. Due to incident reporting delays, statistics for the most recent years (2019 and 2020) 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 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:

- 846 fatalities from 666 incidents during 2010-2020;
 - 711 fatalities (84%) from 542 incidents associated with generators *only*;
 - 92 fatalities (11%) from 90 incidents involved OEDTs *only*; and
 - 43 fatalities (5%) from 34 incidents involved *multiple* fuel-burning consumer products, in which one product was either a generator or an OEDT and the other product was a non-EDT.
 - In all incidents involving multiple consumer products, the second product involved was heating equipment (portable liquid propane- or kerosene-fueled), or a cooking product;
- 56 fatalities from 37 separate incidents in 2020;
 - 51 fatalities involved portable generators *only*, including 1 incident with a welder being used as a generator (4 fatalities)
 - 2 fatalities involved OEDTs *only*;

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.

- 3 fatalities involved multiple products, all 3 involved a portable generator and another product used for heat.
- Compared to the 2019 report, this report presents
 - 38 additional fatalities in 2019; and
 - 8 additional fatalities in 2018.

Socio-Demographic Characteristics of Victims and EDT-Use Patterns (2010-2020):

- Age: 87 percent of portable generator-related decedents and 99 percent of OEDT-related decedents were 25 years old or older.
- Gender: More than 77 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 much higher than their share in the U.S. population. Non-Hispanic White Americans constituted 85 percent of OEDT-related decedents, which is also much higher than their share in the U.S. population.
- Seasonal effects: 44 percent of fatalities from EDTs happen during the four colder months of the year (November through February); 34 percent during the transition months (March, April, September and October); and 22 percent in the warmer months.
- Structure type: 73 percent of all EDT-related fatalities occurred in fixed-structure homes.
- Urban versus rural: 54 percent of all EDT-related fatalities occurred in urban areas, and 19 percent occurred in small, rural, and isolated areas, a much greater proportion of the U.S. population than the population of individuals who live in rural and isolated areas.

CO Alarm Usage (2010-2020):

- A CO alarm: Only 36 (15%) 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 the alarm did not sound for some unknown reason.
 - For 12 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 4 deaths, we do not know if the alarm sounded during the event.

Hazard Patterns Associated with Generators (2010-2020):

- The three most common reasons for using generators among reported incidents are power outages, power shut-offs, and attempts to provide power to temporary locations, such as cabins, campers, and trailers.
 - Power outages: 99 incidents with 134 fatalities. Mostly for weather-related issues, such as ice/snow storms and hurricanes/tropical storms.
 - Power shut-offs: 103 incidents involving 146 fatalities.
 - Power to temporary locations: 96 incidents with 126 fatalities.
- The most common locations with generator-related fatalities were residential locations, accounting for 83 percent of the generator-related CO fatalities.

- Fixed-structure homes: 553 non-fire CO fatalities (410 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 68 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.
- Generator located outside victim location: In 5 percent of the fatalities (see Appendix C), 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 (2010-2020):

- Of the 575 fatal generator incidents between 2010 and 2020 (including the generator plus non-EDT category), the generator engine class could only be determined in 246 cases. Ninety-six percent of the 246 incidents involved a portable generator with a Class I engine (95 incidents) or Class II, Single-Cylinder engine (141 incidents). (See Appendix B for engine class definition.)

Carboxyhemoglobin Levels in CO Fatality Victims (2010-2020):

- Of the CO fatalities 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 2019 and 2020 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 it 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, staff 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 17, 2021. Staff 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 846 non-fire CO fatalities associated with EDTs during the years 2010 through 2020. Last year's report, dated August 2020, contained summary information and analyses for the 11-year period 2009–2019. In addition to dropping year 2009 from the reporting period, this updated report added information on 102 CO fatalities associated with engine-driven tools, and the report removed 1 fatality (see explanation below).

Changes to previous report:

- 2018 – 8 new incidents added, accounting for 8 deaths.
- 2019 – 37 new incidents added, accounting for 38 deaths.
- 2020 – 37 new incidents added, accounting for 56 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 reported 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 2020.

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 through 2020, along with a revised summary of CO incidents and fatalities associated with engine-driven tools from 2010 through 2020. 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 666 incidents involving EDTs, with a total of 846 deaths due to non-fire CO exposure that occurred between 2010 and 2020. For 2020 alone, as of May 17, 2021, 37 fatal, non-fire CO exposure incidents involving EDTs were reported to have occurred between January 1, 2020 and December 31, 2020. Fifty-six deaths occurred in these 37 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 which of the multiple consumer products in use was the source of the CO. 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 they 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 43 fatalities associated with multiple consumer products occurring in the period 2010 through 2020.

In Table 1, the product type, “welder,” appears in both the “Generator” and OEDT categories. Some welding equipment is designed to be used as a welder or as an electric generator. Three of the six fatal, non-fire CO incidents were associated with the use of welding equipment as a generator to provide power to a location. In 2020, one such incident killed four individuals. 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 43 non-fire CO fatalities in the “Multiple Products” category for 2010–2020 involved a heating- or cooking-related consumer product other than an EDT. In addition, during 2010–2020, 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, 2010–2020**

Product	2018		2019		2020		Total: 2010–2020	
	Number of Incidents	Number of Deaths	Number of Incidents	Number of Deaths	Number of Incidents	Number of Deaths	Number of Incidents	Number of Deaths
Total Engine-Driven Tools	68	87	83	98	37	56	666	846
Generators	55	74	71	85	33	51	542	711
Generator, portable	55	74	71	85	32	47	535	699
Generator, fixed location	0	0	0	0	0	0	4	6
Welder (used as a generator) ¹	0	0	0	0	1	4	3	6
Other Engine-Driven Tools (OEDT)	11	11	9	9	2	2	90	92
Lawn mowers	6	6	3	3	1	1	44	44
Riding lawn mower/Garden tractor	3	3	0	0	1	1	32	32
Powered push lawn mower	0	0	0	0	0	0	1	1
Powered lawn mower, unspecified type	3	3	3	3	0	0	11	11
Snow blower	1	1	1	1	1	1	10	10
Power washer/sprayer	1	1	2	2	0	0	11	11
All-terrain vehicle	1	1	1	1	0	0	7	8
Welder (used as welder or other reason) ¹	0	0	0	0	0	0	3	4
Water pump / Sump pump	0	0	1	1	0	0	4	4
Concrete saw	0	0	0	0	0	0	1	1
Wood Splitter	0	0	0	0	0	0	2	2
Paint sprayer	0	0	0	0	0	0	1	1
Edger	0	0	0	0	0	0	1	1
Stump Grinder	0	0	0	0	0	0	1	1
Leaf Blower	1	1	0	0	0	0	2	2
Antique Tractor	0	0	0	0	0	0	1	1
Unspecified Gas Power Equipment	1	1	1	1	0	0	2	2
Multiple Products²	2	2	3	4	2	3	34	43
Generator + Other Consumer Product	2	2	3	4	2	3	33	42
OEDT + Other Consumer Product ³	0	0	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 involved 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, 2021.

Five hundred and forty-two of the 666 incidents (81%) reported to CPSC staff during the 2010–2020 period were associated with a generator alone, and the incidents accounted for 711 of the 846 CO deaths (84%). Additionally, 43 other CO fatalities from 34 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 (48%, 45 of 93) involved a garden tractor or other powered lawn mower (including the single “Multiple Products” incident involving an 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 666 fatal incidents, 80 percent involved a single fatality. Seventy-seven percent (444 of 575) 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 91 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, 2010–2020

Number of Deaths Reported per Incident ¹	All Engine-Driven Tools (EDTs) Incidents		Generator Incidents		Other Engine-Driven Tools (OEDTs) Incidents	
	<i>666</i>	<i>100%</i>	<i>575</i>	<i>100%</i>	<i>91</i>	<i>100%</i>
1	533	80%	444	77%	89	98%
2	109	16%	107	19%	2	2%
3	9	1%	9	2%	0	0%
4	11	2%	11	2%	0	0%
5	2	< 1%	2	< 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, 2021.

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 17, 2021. 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 2010, prior year counts have increased by an average of 40 percent in the following year’s report and by an additional average of 7 percent 2 years later. Over the last 3 years, the rate has been even higher, at about a 52 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 2016 through 2018, is also presented in Table 3. Although slight changes are still possible in the future, these 3 years represent the most recent years for which CPSC staff believes reporting is substantially 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, 2010–2020

Year	All Engine-Driven Tools (EDTs)		Generators		Other Engine-Driven Tools (OEDTs)	
	Incidents	Deaths	Incidents	Deaths	Incidents	Deaths
Total	666	846	575	753	91	93
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
2018	68	87	57	76	11	11
<i>2019</i>	<i>83</i>	<i>98</i>	<i>74</i>	<i>89</i>	<i>9</i>	<i>9</i>
<i>2020</i>	<i>37</i>	<i>56</i>	<i>35</i>	<i>54</i>	<i>2</i>	<i>2</i>
Average: 2016–2018	70	88	60	78	10	10

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, 2021.

II. Socio-Demographic Characteristics of Victims and EDT-Use Patterns 2010-2020

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 2017 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 24 years. In comparison, 88 percent (744 of 846) of reported non-fire, CO poisoning decedents associated with all EDTs, 87 percent (652 of 753) of decedents associated with generators, and all but one of the decedents (92 of 93) associated with OEDTs, were 25 years or older. In fact, 84 percent of the non-fire CO fatalities associated with OEDTs (78 of 93) 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, 59 percent of the CO fatalities were to victims over the age of 44, while only 42 percent of the U.S. population was above 44 years of age during this period. By contrast, only 12 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, 2010–2020

Age	2017 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%	846	100%	753	100%	93	100%
Under 5	6%	7	1%	7	1%	0	0%
5–14	13%	34	4%	34	5%	0	0%
15–24	14%	61	7%	57	8%	1	1%
25–44	26%	242	29%	228	30%	14	15%
45–64	27%	339	40%	305	41%	34	37%
65 and over	15%	163	19%	119	16%	44	47%

¹This percentage represents the 2013-2017 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, 2021.

5-Year Estimates of the Resident Population by Sex, Age, Race, and Hispanic Origin for the United States and States: January 1, 2013 to December 31, 2017.

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 77 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, 2010–2020

Gender	2017 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%	846	100%	753	100%	93	100%
Male	49%	670	79%	578	77%	92	99%
Female	51%	176	21%	175	23%	1	1%

Notes:

¹This percentage represents the 2013-2017 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, 2021.

5-Year Estimates of the Resident Population by Sex, Age, Race, and Hispanic Origin for the United States and States: January 1, 2013 to December 31, 2017.

Table 6 summarizes the race/ethnicity of the reported CO fatalities associated with EDTs. The percentage of generator-related CO fatalities identified as non-Hispanic “Black/African American” (22% of deaths) was a much higher proportion classified than those classified by the U.S. Census Bureau as non-Hispanic “Black/African Americans” in the U.S. population (an estimated 12%). The percentage of the OEDT-related CO fatalities identified as non-Hispanic “White” (85% 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). It should be noted that race/ethnicity determinations are based on available information. Many of the race/ethnicity determinations are based on death certificate data. However, some states do not provide this information on the death certificate and, barring other available information, these individuals were designated as “Unknown”. Additionally, some individuals were identified as “mixed” or “multiple” as a race/ethnicity designation. And finally, some individuals were simply designated as “Other”. Individuals falling into these three designations were combined into the “Other/Multi/Unknown” category.

Table 6: Number of Reported Non-Fire CO Fatalities Associated with Engine-Driven Tools by Race/Ethnicity of Victim, 2010–2020

Race / Ethnicity	2017 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%	846	100%	753	100%	93	100%
White ²	62%	517	61%	438	58%	79	85%
Black/African American ²	12%	171	20%	168	22%	3	3%
Hispanic (any race)	18%	85	10%	83	11%	2	2%
Asian ²	5%	11	1%	11	1%	0	0%
Native American ^{2,3}	1%	10	1%	10	1%	0	0%
Other/Multi/Unknown ⁴	3%	52	6%	43	6%	9	10%

1 This percentage represents the 2013-2017 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, 2021.

5-Year Estimates of the Resident Population by Sex, Age, Race, and Hispanic Origin for the United States and States: January 1, 2013 to December 31, 2017.

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-four 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, 2010–2020

Season Incident Occurred		All Engine-Driven Tools (EDTs)		Generators		Other Engine-Driven Tools (OEDTs)	
Total	Incidents	666	100%	575	100%	91	100%
	Deaths	846	100%	753	100%	93	100%
Cold months	Incidents	303	45%	263	46%	40	44%
	Deaths	370	44%	329	44%	41	44%
Transitional months	Incidents	221	33%	193	34%	28	31%
	Deaths	288	34%	259	34%	29	31%
Warm months	Incidents	142	21%	119	21%	23	25%
	Deaths	188	22%	165	22%	23	25%

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

Source: U.S. Consumer Product Safety Commission, Directorate for Epidemiology, 2021.

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 (703 of 846, or 83%) were reported to have occurred at residential locations, which include fixed-structure homes, apartments, detached structures located at a residence, like detached garages and sheds, and residential locations in non-traditional structures, like camper trailers and RVs used as a primary residence. Seventy-three percent of the deaths occurred at fixed-structures used as a residence, which includes houses, mobile homes, apartments, townhouses, and structures attached to the house, such as an attached garage. Another 8 percent occurred in external or detached structures at home locations, such as detached garages or sheds. A larger portion of these external structure fatalities were related to OEDTs, such as lawnmowers running in sheds or detached garages. For example, 20 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, they 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 locations such as 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, 2010–2020

Victim Location		All Engine-Driven Tools (EDTs)		Generators		Other Engine-Driven Tools (OEDTs)	
Total	Incidents	666	100%	575	100%	91	100%
	Deaths	846	100%	753	100%	93	100%
Home, fixed Structure ¹	Incidents	475	71%	410	71%	65	71%
	Deaths	619	73%	553	73%	66	71%
Home, detached Structure ²	Incidents	65	10%	46	8%	19	21%
	Deaths	66	8%	47	6%	19	20%
Home, non-house ³	Incidents	16	2%	16	3%	0	0%
	Deaths	18	2%	18	2%	0	0%
Temporary shelter	Incidents	40	6%	40	7%	0	0%
	Deaths	59	7%	59	8%	0	0%
Boat/Vehicle	Incidents	39	6%	38	7%	1	1%
	Deaths	47	6%	45	6%	2	2%
Other	Incidents	27	4%	21	4%	6	7%
	Deaths	33	4%	27	4%	6	6%
Outdoors	Incidents	2	< 1%	2	< 1%	0	0%
	Deaths	2	< 1%	2	< 1%	0	0%
Not reported	Incidents	2	< 1%	2	< 1%	0	0%
	Deaths	2	< 1%	2	< 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, 2021.

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; but revisions were made on July 3, 2019, to correct a programming error affecting the 2010 secondary RUCA codes.

Fifty-four percent (459 of 846) 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 (383 of 846) 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 (163 of 846) 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, 2010–2020

Population Density		Estimated Percentage of U.S. Population ¹	All Engine-Driven Tools (EDTs)		Generators		Other Engine-Driven Tools (OEDTs)	
Total	Incidents	100%	666	100%	575	100%	91	100%
	Deaths		846	100%	753	100%	93	100%
Urban Core	Incidents	71%	357	56%	321	56%	36	40%
	Deaths		459	54%	422	56%	37	40%
Sub-Urban	Incidents	10%	81	15%	58	10%	23	25%
	Deaths		96	15%	73	10%	23	25%
Large Rural	Incidents	10%	100	13%	80	14%	19	21%
	Deaths		124	12%	103	14%	20	22%
Small Rural /Isolated	Incidents	9%	126	16%	113	20%	13	14%
	Deaths		163	19%	150	20%	13	14%
Unknown	Incidents	-	2	< 1%	3	1%	0	-
	Deaths		4	< 1%	5	1%	0	-

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. These tables were modified in 2019 to correct a programming error.

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

Source: U.S. Consumer Product Safety Commission, Directorate for Epidemiology, 2021.

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 2010-2020

Table 10 presents a summary of CO fatalities characterized by CO alarm usage and alarm status. In 75 percent of the fatal incidents (501 of 666), and 72 percent of reported CO poisoning deaths (605 of 846), the presence of a CO alarm at the location of the incident was unknown or unreported. Of the 163 fatal incidents (237 CO fatalities) associated with EDTs, in which it was known whether a CO alarm was present, a CO alarm was present in only 26 incidents (16%) involving 36 CO fatalities. Of these 26 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 14 fatal incidents (16 fatalities) in which an alarm was known to be present, the alarm sounded in only 10 incidents (12 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.
- In one incident, a victim was found in a motor home with the alarm sounding. It is unclear if the alarm sounded in time to save the victim or he ignored the warning.

For the remaining four (out of 14) incidents with four 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, 2010–2020**

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	666	846	-	575	753	-	91	93	-
Alarm Status Known	163	237	100%	147	219	100%	16	18	100%
No Alarm	137	201	85%	127	189	86%	10	12	67%
Alarm Present	26	36	15%	20	30	14%	6	6	33%
Alarmed	10	12	5%	6	8	4%	4	4	22%
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	4	4	1%	2	2	1%	2	2	11%
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	501	605	-	426	532	-	75	75	-

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

Source: U.S. Consumer Product Safety Commission, Directorate for Epidemiology, 2021.

IV. Hazard Patterns Associated with Generators 2010-2020

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 17, 2021, CPSC staff is aware of 575 generator-related incidents from 2010 through 2020, which resulted in non-fire CO fatalities. Thirty-four 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 542 of 575 (94%) fatal CO incidents associated with generators that occurred from 2010 through 2020. For the remaining 34 incidents in which staff did not perform an IDI, or did not complete an IDI by the cut-off date of May 17, 2021, attempts were made to augment the data from reports of the incidents from other sources, such as death certificates. 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 575 incidents resulting in 753 generator-related, non-fire CO deaths reported to CPSC staff suggests three 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). A second reason was to provide power after a shutoff to the residence by the utility company, due to bill dispute or nonpayment. A third primary reason is to provide power to a temporary location, such as a camper or a cabin. Table 11 provides a breakdown, by year, listing the reasons why a generator was in use at the time of the incident. Seventeen percent of the incidents (18 percent of the reported deaths) involving generator-related, non-fire CO fatalities were associated with a temporary power outage stemming from a weather problem, or a problem with power distribution. Eighteen percent of the fatal incidents (19 percent of deaths) were associated with a power shutoff by the utility company for nonpayment. Additionally, 17 percent of incidents (17 percent of deaths) were associated with attempting to provide power to temporary locations, like storage sheds, trailers, boats, campers, cabins, and campsites. However, for 25 percent of the fatal incidents (23 percent of deaths), staff 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 90 of the 575 incidents, staff could not ascertain the fuel type. Of the 485 cases remaining cases, 99 percent (479 of 485) were gasoline-fueled generators. Five additional incidents involved propane-fueled generators (three of which were stationary generators and another was a welder/generator), 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, 2010–2020

Reason for Use		Total	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Total	Incidents	575	37	69	43	46	38	52	57	67	57	74	35
	Deaths	753	46	96	49	59	49	77	75	83	76	89	54
Power outage due to weather, or problem with power distribution	Incidents	99	5	19	15	12	5	4	4	16	5	7	7
	Deaths	134	6	27	16	13	5	6	11	21	6	8	15
Electricity turned off by power company due to bill dispute, nonpayment, or other reason	Incidents	103	12	17	5	9	8	11	11	11	6	9	4
	Deaths	146	16	25	6	11	11	22	13	16	8	12	6
Provide power to temporary locations (storage shed, trailer, boat, camper, cabin, campsite, etc.)	Incidents	96	2	8	5	5	5	7	10	11	18	18	7
	Deaths	126	5	13	6	5	7	10	12	12	23	21	12
New home or homeowner, and power not yet turned on, home under construction or renovation	Incidents	59	5	5	3	6	5	5	8	5	6	9	2
	Deaths	80	5	10	4	11	5	8	9	5	8	13	2
Provide power to home or mobile home that normally does not have electricity	Incidents	51	3	4	4	2	5	4	1	10	5	8	5
	Deaths	65	3	4	6	2	8	6	1	14	6	9	6
Working on or preparing a home for predicted storm/ Periodic testing	Incidents	2	0	0	0	0	0	1	1	0	0	0	0
	Deaths	2	0	0	0	0	0	1	1	0	0	0	0
Provide power to a shed or garage that normally does not have electricity	Incidents	9	1	2	1	1	0	0	0	0	3	1	0
	Deaths	11	1	2	1	2	0	0	0	0	4	1	0
Other (previous fire in house, power shut off by owners, servicing power supply, or other usage)	Incidents	12	1	1	1	1	1	4	1	1	1	0	0
	Deaths	15	1	2	1	2	1	4	1	1	2	0	0
Unknown why electricity off	Incidents	145	8	13	9	10	9	16	21	13	13	22	10
	Deaths	175	9	13	9	13	12	20	27	14	19	25	13

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, 2021.

For the 99 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 89 incidents (comprising 123 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 (34%) but only 31 percent of the deaths. Hurricanes and tropical storms were associated with 31 percent of CO fatal incidents over the 11-year period from 2010 to 2020. Of the 47 known hurricane- or tropical storm-related fatalities between 2010 and 2020, the majority of deaths (62%, 29 deaths) occurred in the 2 years 2017 and 2020, combined.

Table 12: Number of Reported Non-Fire CO Fatalities for Incidents Associated with Generators¹ by Reason for Power Outage, 2010–2020

Reason for Power Outage		Total	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Total	Incidents	99	5	19	15	12	5	4	4	16	5	7	7
	Deaths	134	6	27	16	13	5	6	11	21	6	8	15
Ice or snow storm ²	Incidents	34	3	10	5	8	1	3	1	0	0	<i>1</i>	2
	Deaths	41	4	14	5	8	1	4	2	0	0	<i>1</i>	2
Hurricane or tropical storm	Incidents	31	0	3	7	0	0	0	1	13	2	<i>1</i>	4
	Deaths	47	0	5	8	0	0	0	1	17	3	<i>1</i>	12
Wind storm	Incidents	6	0	1	1	0	1	1	1	1	0	<i>0</i>	<i>0</i>
	Deaths	13	0	1	1	0	1	2	6	2	0	<i>0</i>	<i>0</i>
Thunderstorm, rainstorm, or flooding	Incidents	7	2	2	0	0	1	0	1	1	0	<i>0</i>	<i>0</i>
	Deaths	9	2	3	0	0	1	0	2	1	0	<i>0</i>	<i>0</i>
Tornado	Incidents	1	0	1	0	0	0	0	0	0	0	<i>0</i>	<i>0</i>
	Deaths	2	0	2	0	0	0	0	0	0	0	<i>0</i>	<i>0</i>
Storm, unspecified	Incidents	10	0	1	2	1	1	0	0	0	2	3	<i>0</i>
	Deaths	11	0	1	2	1	1	0	0	0	2	4	<i>0</i>
Unknown or other reason for outage	Incidents	10	0	1	0	3	1	0	0	1	1	2	<i>1</i>
	Deaths	11	0	1	0	4	1	0	0	1	1	2	<i>1</i>

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 because the victim was attempting to run 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, 2021.

As shown in Table 8, 553 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 553 generator-related deaths that occurred in a fixed-structure home, information was available for 444 deaths (80%) regarding the victim’s location in relation to the generator. One hundred and eight of these 444 fatalities (24%) occurred in the same room or space as the generator.

The 553 deaths that occurred in a fixed-structure home resulted from 410 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, 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-one percent (392 of 553) of the CO fatalities at fixed-home locations occurred when a generator was known to be placed inside the home, including the living space (203), a basement/crawlspace (119), in a transitory place (Closet/laundry room/utility room/hallway) (23), or inside the house, with no additional information provided (47). Another 19 percent of the fatalities (103 of 553) occurred when the generator was placed in an attached garage, enclosed carport, or attached barn.

Twenty-one deaths from 14 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 2010–2020**

Generator Location		Total	2010	2011	2012	2013	2014	2015 ³	2016	2017	2018	2019	2020
Total	Incidents	410	29	54	36	35	28	34	43	49	32	46	24
	Deaths	553	35	76	41	46	36	56	58	64	44	56	41
Living space (non-basement)	Incidents	146	13	15	8	8	12	13	21	20	15	17	6
	Deaths	203	13	20	11	10	18	23	27	27	21	24	11
Basement/crawlspace	Incidents	85	5	16	5	12	9	9	6	8	5	8	2
	Deaths	119	8	25	5	16	11	13	13	10	6	9	3
Garage/enclosed carport/attached barn	Incidents	76	5	14	14	9	2	4	5	7	1	10	5
	Deaths	103	6	19	14	13	2	7	7	10	1	11	13
Inside house, no further information reported	Incidents	43	1	4	5	3	3	3	6	5	3	6	7
	Deaths	47	2	4	5	3	3	4	6	5	5	6	7
Transit Area (closet/laundry room/utility room/hallway)	Incidents	14	1	2	1	1	0	2	1	2	4	0	0
	Deaths	23	1	4	2	1	0	5	1	2	7	0	0
Outside the home	Incidents	14	1	1	1	0	1	1	2	2	2	0	3
	Deaths	21	1	2	2	0	1	2	2	4	2	0	5
Unknown location, but at home	Incidents	21	3	2	2	0	1	2	0	3	2	5	1
	Deaths	25	4	2	2	0	1	2	0	4	2	6	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, 2021.

Table 14 sets forth non-fire CO fatalities that occurred in a fixed-structure home, characterized by ventilation status. Almost half of the incidents with generator-associated fatalities in the home (200 of the 410 incidents, 49%) did not contain information about the ventilation of the generator. Of the other 210 incidents, 135 accounting for 206 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 75 incidents associated with generators in which it

was reported that some type of ventilation was attempted. Of these 75 incidents, 48 (61 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, 14 incidents (21 deaths) were associated with generators that were placed outside the home, near open windows, doors, or vents, where carbon monoxide entered the home. In 13 incidents (17 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, 2010–2020

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	410	553	100%	-
Some ventilation attempted	75	99	18%	32%
Open window(s), open door(s), an open garage door, or a combination of these	48	61	11%	20%
Actively trying to vent either by fans or by directing exhaust out a window or door	13	17	3%	6%
Placed outside of home, but near a window, door, A/C unit, or other outdoor location ³	14	21	4%	7%
No ventilation	135	206	37%	68%
Unknown ventilation	200	248	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, 2021.

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 298 of 410 fatal incidents (408 of the 553 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 were consistent about the size of the home, because both databases are based on public records from the county, state, or municipality.

Sixty-three percent (188 of 298) of the reported fatal incidents (258 of 408 CO fatalities) associated with generators that occurred in the home, where the size of the structure was known, occurred in homes that were less than 1,500 square feet; and 87 percent (258 of 298) of the reported incidents

and 88 percent of the deaths (358 of 408) 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 1,300 square feet. As a point of reference, according to the U.S. Census Bureau's, *American Housing Survey for the United States: 2021*, the median housing unit as of 2019 was 1,473 square feet. Comparing the percentages of fatal incidents by home size to the U.S. Census figures, it appears that the fatal CO incidents are skewed toward smaller homes. Whether this is due to economic reasons, or because smaller-volume structures are filled more quickly by deadly carbon monoxide, or 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, 2010–2020

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 (2019) ⁴
Total	410	553	100%	100%	100%
Under 500	3	4	1%	1%	3%
500–999	75	93	18%	25%	21%
1,000–1,499	110	161	27%	37%	26%
1,500–1,999	70	100	17%	23%	20%
2,000–2,499	19	23	5%	6%	13%
2,500–2,999	10	10	2%	3%	7%
3,000 or Larger	11	17	3%	4%	10%
Unknown	112	145	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 2019 housing unit figures are the most current year available.

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

Source: U.S. Consumer Product Safety Commission, Directorate for Epidemiology, 2021.
U.S. Census Bureau, American Housing Survey for the United States: 2021.

Conclusions

Between 2010 and 2020, 846 non-fire CO-poisoning deaths from 666 incidents that were associated with EDTs were reported to CPSC staff. The majority of these deaths 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. Only a small percentage of victims were below the age of 25 years that were associated with generators reported to CPSC staff, and the majority of the victims were male. Victims age 25 years and older accounted for nearly all of the non-fire CO poisoning deaths reported to CPSC staff that were associated with OEDTs. Males also accounted for nearly all 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.

CO alarms were seldom found installed in the fatal incidents contained in CPSC records—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.

The majority of the reported deaths associated with generators occurred at fixed-structure home locations. Also, in the majority 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 common scenario 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: 05/17/2021

Incident Dates: 1/1/10-12/31/20

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 (3 incidents, 6 deaths). These incidents are footnoted below the table. In the majority of cases (57%), 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, 39 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 four incidents (five fatalities) during this period; while twin cylinder, Class II powered generators were known to be involved in five incidents and 13 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, 2010–2020

Year	Handheld		Class I		Class II, Single Cylinder		Class II, Twin Cylinder		Unknown		Total	
	Incidents	Deaths	Incidents	Deaths	Incidents	Deaths	Incidents	Deaths	Incidents	Deaths	Incidents	Deaths
Total	4	5	95	147	141	187	5	13	329	399	575	753
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			10	15	16	20			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	10	16	16	23			30	36	57	76
2019			14	19	19	21			41	49	74	89
2020			3	4	8	14	1 [@]	4 [@]	23	32	35	54

* 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.

@ In 2020, there was an incident involving a Class II, Twin Cylinder generator/welder used as a generator in a home which killed four individuals.

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, 2021.

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 666) and fatalities (46 of 846) 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 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. In the other incident identified as “Outside (near generator)”, the victim was found sitting in a chair outside of a camper next to a running generator. Note that there was another case not included here where there was insufficient information to identify if the incident occurred in a temporary structure (camper, tent, etc.) or if the generator was located outside. The minimal description available simply notes that the incident occurred on or off a Bureau of Land Management road.

Table C-1: Fatal CO Generator Incidents Where the Generator Was Located Outside of the Occupied Space, 2010–2020

Location of victim(s)	Incidents	Deaths
Total – Occupied Area	33	47
House/Mobile Home	11	16
Apartment	1	2
Cabin	1	1
Vehicle: RV/Camper Shell	5	11
Vehicle: Automobile/Truck	2	2
Camper Trailer/Horse Trailer	7	8
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, 2021.

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 454 of the 847 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 454) 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, 2010–2020¹**

COHb Level	All Engine-Driven Tools (EDTs)		Generators		Other Engine-Driven Tools (OEDTs)	
Total	846	-	753	-	93	-
Reported Levels	454	100%	407	100%	47	100%
Less than 30%	21	5%	20	5%	1	2%
30–39.9%	17	4%	14	3%	3	6%
40–49.9%	37	8%	35	9%	2	4%
50–59.9%	67	15%	61	15%	6	13%
60–69.9%	150	33%	135	33%	15	32%
70–79.9%	124	27%	106	26%	18	38%
80–89.9%	33	7%	31	8%	2	4%
90–99.9%	5	1%	5	1%	0	0%
Not reported	392	-	346	-	46	-

¹ Percentages shown are the percentage of reported COHb levels per category.
Source: U.S. Consumer Product Safety Commission, Directorate for Epidemiology, 2021.

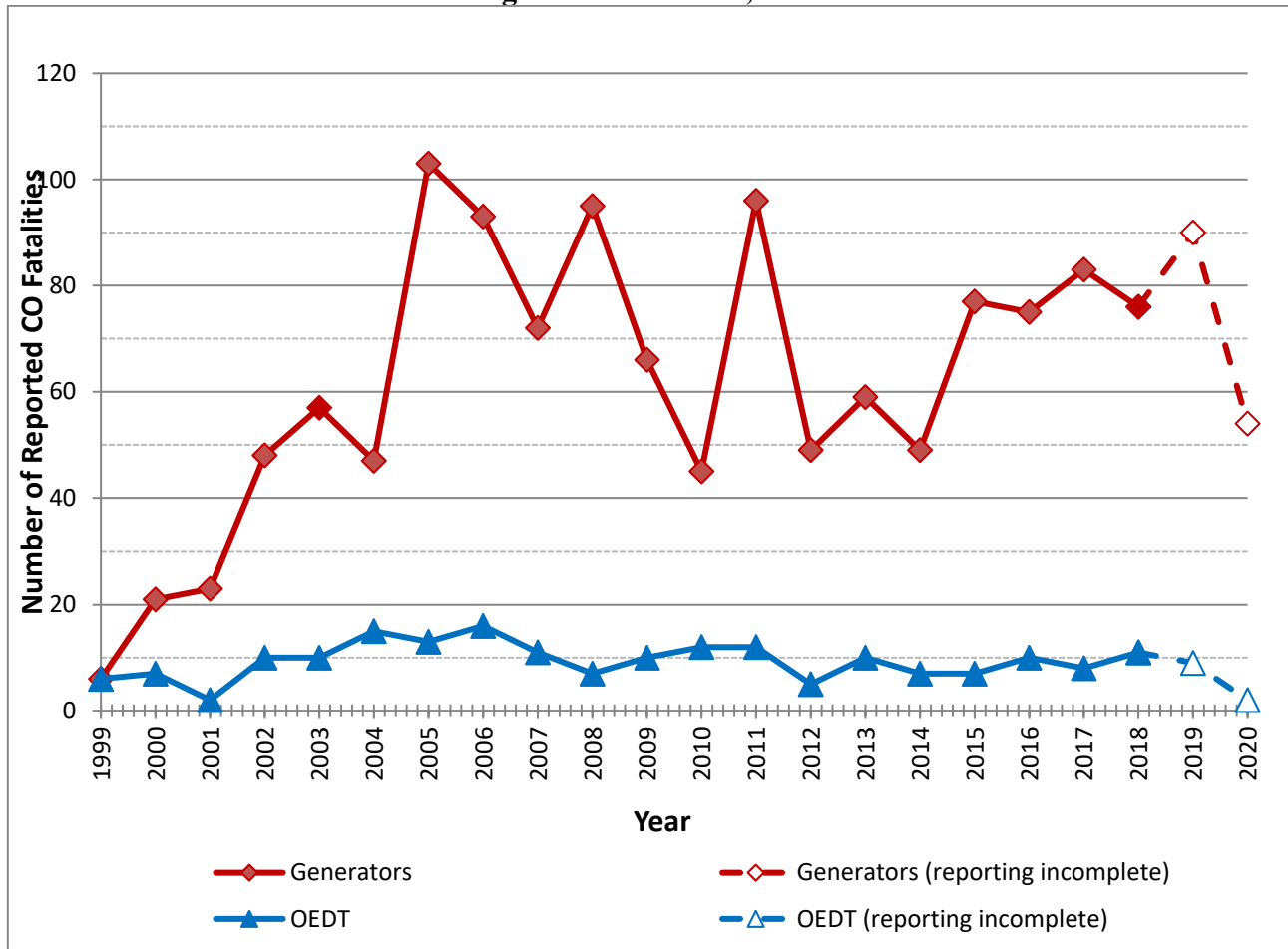
⁵ Inkster S.E. *Health hazard assessment of CO poisoning associated with emissions from a portable, 5.5 Kilowatt, gasoline-powered generator*. Washington, D.C.: U.S. Consumer Product Safety Commission. 2004.

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 2020. 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 2010 annual report, the most recent year's counts have increased by an average of about 40 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 2020.

Figure 1: Number of Reported Non-Fire CO Fatalities Associated with Engine-Driven Tools, 1999–2020



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, 2021.