



United States

Consumer Product Safety Commission

Non-Fire Carbon Monoxide Deaths Associated with the Use of Consumer Products 2021 Annual Estimates

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*This report was prepared by the CPSC staff.
It has not been reviewed or approved by,
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the Commission.*

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Executive Summary

This report provides information about the estimated number of unintentional, non-fire deaths attributed to carbon monoxide (CO) poisoning that were associated with the use of consumer products in 2021, along with companion statistics since 2011. Because the U.S. Consumer Product Safety Commission (CPSC) has not received reports of deaths from every state for 2018, 2019, 2020, and 2021, the estimates for those years may change in subsequent reports.

Some of the key findings¹ in this report are:

For 2021:

- CPSC has records from 169 reported incidents resulting in an estimated 204 unintentional, non-fire CO poisoning deaths associated with the use of consumer products under the CPSC's jurisdiction.²
- Seventeen percent of the 169 reported incidents involved multiple deaths, including one incident where four people died, five incidents where three people died, and 22 incidents where two people died.
- Engine-Driven Tools (EDTs) were associated with the largest percentage of non-fire CO poisoning deaths, more than any other category. This category includes generators, the single product under CPSC's jurisdiction that is associated with the most CO deaths. About half (110 or 54%) of the *estimated* 204 non-fire CO poisoning deaths associated with consumer products involved an EDT.³ One-hundred two (102) of the 110 estimated EDT-associated deaths involved generators.
- Heating Systems were associated with the second largest percentage of non-fire CO poisoning deaths. An estimated 63 deaths (31%) were associated with some type of heating appliance.
- Eighty-six percent of the estimated 204 CO deaths in 2021 resulted from CO exposure in a home location. Incidents coded as home locations include deaths from CO exposure in an external structure at a residence (e.g., detached garage), a non-fixed location domicile used as a home (e.g., camper trailers), a structure not designed for habitation but used as a home (e.g., shed), as well as tents or temporary shelters.
- In 2021, males constituted an estimated 79 percent of CO poisoning victims. Among reported single-fatality incidents, males constituted 82 percent of victims; among reported multiple-fatality incidents, males constituted 62 percent of victims.

¹ Note that the estimates for individual categories may not sum to that of the broader category due to rounding effects.

² A post-weighting adjustment applies for 2021, as total known reported fatalities exceeded the initial estimate (see Appendix A for further details).

³ It so happens that among the data supporting 2021 estimates, no EDTs or generators were found involved in multiple product incidents. Consequently, this finding would be the same for 2021 regardless of the inclusion of multiple-product incidents.

For 2019-2021:

- The estimated annual average from 2019 to 2021 was 227 unintentional, non-fire CO poisoning deaths.
- Most CO deaths occurred in the colder months of the year, with more than half (56%) of the deaths occurring during the four cold months of November, December, January, and February.
- Adults 45 years and older constituted on average about 71 percent of all non-fire, consumer product-related CO deaths, which was disproportionately higher for this age group than their 42 percent representation in the U.S. population. Conversely, children younger than 15 years of age (18 percent of the U.S. population) accounted for a disproportionately lower annual average of about 4 percent of the yearly CO poisoning.
- Although the estimates of deaths associated with various race/ethnicity may differ somewhat from the U.S. population, none of the differences are statistically significant in this three-year period.

For 2011-2021:

- Staff found evidence of a statistically significant upward trend in non-fire CO deaths for the 11-year period from 2011 to 2021. The estimated number of consumer product-related CO deaths rose to an all-time high in 2019. Although there were fewer estimated deaths in 2020 than in 2019, the 2020 death estimate otherwise exceeds all earlier years in the period.
- Since 2011, portable generators alone have been associated with an estimated 858 non-fire CO poisoning deaths, accounting for 42 percent of all non-fire CO deaths related to consumer products under CPSC's jurisdiction.

Introduction

Carbon monoxide (CO) is a colorless, odorless, and poisonous gas that results from the incomplete combustion of fuels, such as natural or liquefied petroleum (LP) gas, gasoline, oil, wood, coal, and other fuels. The health effects related to CO depend upon its concentration in blood, which, in turn, depends upon its concentration in air, an individual's duration of exposure, and an individual's general health. Carbon monoxide combines with the body's hemoglobin (Hb) with an affinity about 250 times that of oxygen, forming carboxyhemoglobin (COHb) and interfering with oxygen uptake, delivery, and use by the cells. Generally, no perceptible health effects or symptoms in healthy individuals occur at COHb levels below 10 percent. Symptoms associated with blood levels at or above 10 percent COHb include headache, fatigue, nausea, and cognitive impairment. Loss of consciousness, coma, and death can occur at COHb levels greater than 20 percent; but for healthy adults, CO deaths typically require levels above 50 percent COHb.⁴ During exposure to rapidly rising, high CO levels (as can result with exposure to exhaust from gasoline-powered, engine-driven tools), sudden extreme hypoxia can result in rapid incapacitation and loss of consciousness, which prevent exposed individuals from leaving the hazardous environment.

Some symptoms of CO poisoning may mimic common illnesses, such as influenza or colds. Thus, the possibility of initial misdiagnosis by physicians and victims exists (Long and Saltzman, 1995). Frequently, patients are unaware of exposures, and health care providers may not always consider CO poisoning as a cause of such nonspecific symptoms. COHb formation is reversible, as are some clinical symptoms of CO poisoning. However, some delayed neurological effects that develop after severe poisonings, especially those involving prolonged unconsciousness, may not be reversible. Prompt medical attention is important to reduce the risk of permanent damage.

Any fuel-burning appliance can be a potential source of fatal or hazardous CO levels. Fuels, such as natural and LP gas, kerosene, oil, coal, and wood, can produce large amounts of CO when insufficient oxygen is available for combustion. Consumer products that burn kerosene, oil, coal, or wood (such as wood stoves, oil boilers, and kerosene heaters) often produce irritating smoke that can sometimes alert the victim to a potentially hazardous situation. However, EDTs powered by gasoline engines may not emit an irritating exhaust smoke, even though they produce large amounts of CO, even in locations where sufficient oxygen is available for combustion. Other fuels, such as charcoal briquettes and pressed wood-chip logs produce relatively smokeless fires, even at times of inefficient combustion. In these cases, victims receive no obvious sensory warning that can alert victims to a potentially hazardous situation.

⁴ 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.

Another hazard scenario is present when gas appliances are not vented properly or are malfunctioning. Natural and LP gas burn more efficiently and cleanly, compared to other forms of fuel. However, in circumstances of poor maintenance, inadequate ventilation, or faulty exhaust pathways, natural and LP gas appliances may emit potentially lethal amounts of CO without any irritating fumes to alert potential victims to the danger.

National Estimates of Non-Fire CO Poisoning Deaths Associated with Consumer Products

The national estimates presented in this report are based on death certificate records obtained from all 50 states, the District of Columbia, New York City, and some U.S. territories, directly augmented by information collected in CPSC's In-Depth Investigations (IDIs), and, to a lesser extent, news articles and medical examiners' reports contained in the CPSC Injury or Potential Injury Incident (IPII) database. Death certificate data from some states can lag for months, or even years, and may not be available in time for use in this report.

The estimates of consumer product-related CO poisoning deaths presented in this report are based on reporting up to September 20, 2024. The National Center for Health Statistics (NCHS) has records of every death certificate filed in the United States and its territories. Before 2017, there was evidence that CPSC records contained a large portion of the records reported to NCHS. For the years 2008 through 2015, CPSC records contain approximately 82 percent of all the fatal CO poisoning deaths that occurred in the United States as reported to NCHS. However, in 2016, and to a slightly lesser extent in 2017, there appears to have been an anomaly with the method used by Texas in assigning ICD-10 codes used in this analysis, in particular, the Y17 code (see Appendix A for details on the methodology used to determine estimates). The estimates presented here are based on the number of deaths for which CPSC has records, scaled to the NCHS totals, to adjust for missing records. Appendix A of this report describes the detailed process used to generate the national estimates presented in this report.

It also should be noted that, due to extended reporting delays from a small number of U.S. states, a potentially significant portion of death certificates are missing from the 2018, 2019, 2020, and 2021 data. Measured in terms of the number of months/states with at least one death certificate (of any ICD10-code type) reported to CPSC, as of September 25, 2024, completeness is measured at 98% for 2018, 95% for 2019, 92% for 2020, and 89% for 2021. More recent years excluded from this report include 2022 at 80% complete, 2023 at 61% and 2024 at 41%. As of the time of this writing Washington State has not reported a single death certificate to CPSC regarding any of the years 2018, 2019, 2020, or 2021, whereas the District of Columbia and 3 other states (Arizona, New Mexico, and South Dakota) have not yet reported a single death from the year 2021 to CPSC. There may also be anomalies in reporting from various states even among those observed to report at least some death certificates to CPSC. For example, although overall death certificate reporting is not considered incomplete from Wisconsin and Texas in this time period, there were anomalies even prior to this time period suggestive of incomplete capture of relevant death certificates (e.g. X47 and Y17) which may have continued into these more recent years. Adjustments were made for prior completed years

using historical patterns to account for anomalies in the years 2016 and 2017 for the state of Texas, when there was no comparable anomaly for the state of Wisconsin. For the years 2018, 2019, 2020, and 2021 there are not yet sufficient data to support *special* adjustments for any states, while the estimates are not considered fully complete for these most recent 4 years. Some of the estimates for the year 2018 are slightly reduced primarily due to a slight change in the weighing factor consequent to several additional out-of-scope X47 death certificates reported since last year, despite 2018 continuing to be classified as only partially complete. However, with the benefit of additional investigations and reports for 2020 and years prior, some of the estimates are updated relative to the previous findings in last year's report. See additional discussion on this topic in Appendix A.

During 2021, an estimated 204 non-fire CO poisoning deaths were associated with the use of a consumer product under the jurisdiction of the CPSC. This compares with an annual average over the prior 10 years (2011-2020) of 183 estimated deaths of the same type. This report does not include CO poisoning deaths involving products outside CPSC's jurisdiction, incidents where the CO gas resulted from a fire, or solely from a motor vehicle, or directly work related; and the report also does not include deaths that were suicides or otherwise intentional in nature. The estimates and findings for the 11 total years covered in this report include four incidents (one each in 2013, 2015, 2016, and 2020) where the exhaust from a motor vehicle engine may have contributed to the victim's CO poisoning death, in addition to a consumer product. In another included 2016 incident, a farm tractor may have contributed to a CO fatality, along with an unspecified lawn mower that was running in a residential storage shed. Because utility vehicles and ATVs are classified as consumer products (not motor vehicles), CO from their exhaust is considered relevant, regardless.

Although multiple factors may contribute to a CO poisoning fatality, the source of CO is virtually always a fuel-burning product. CPSC staff produces the CO estimates associated with consumer products to identify and monitor product groups involved in these fatal CO scenarios. Within the individual product-specific CPSC projects, additional analysis assesses whether improvements are warranted in the areas of product design, ventilation safeguards, or user information and education.

The annual CO estimates for the years 2011 through 2021 are presented in two formats: by product category (Table 1), and by product within fuel type (Table 2). The data are presented as an average of the most recent 3-year period (2019 through 2021), followed by yearly estimates for each of the 11 years covered by this report. As noted, collection of death certificates from some states is incomplete for 2018, 2019, 2020, and 2021. Accordingly, although reporting for those years is complete from most states through 2021, estimates may change if additional data become available from non-reporting states. Therefore, data for 2018, 2019, 2020, and 2021 are reported using italic font in the tables, to signify reporting is incomplete.

Because the numbers presented in this document represent national estimates of unintentional, non-fire deaths attributed to CO poisoning associated with the use of consumer products, the generator and other EDT death estimates would not be expected to match the observed fatality counts presented in this report or in the CPSC report, "Fatal and Nonfatal Incidents Associated with Non-Fire Carbon Monoxide from Engine-Driven Generators and Other Engine-Driven

Tools, 2012–2022,” published in July 2023. Specifically, this is due to this report estimating the number of actual incidents, which accounts for incidents not reported to CPSC but likely to have occurred based on the observed proportions of in-scope fatalities for the portion of death certificates obtained by CPSC.

By Product Category

Table 1 shows the estimated average annual number of CO poisoning deaths associated with various consumer products for 2019 to 2021 as well as the annual estimated CO deaths for the individual years from 2011 through 2021. The annual average for 2019 through 2021 is estimated to be 227 (with a standard error of approximately 14.6). Appendix B contains a graph, and the data point values for the annual estimates of CO poisoning deaths associated with a consumer product under CPSC’s jurisdiction for 1980 through 2021.

The estimate for Heating Systems, which historically account for a large percentage of the deaths, is further broken down into heating system subcategories within various fuel types. Fatality estimates for the Engine-Driven Tools category were distributed between generators and other engine-driven tools. The consumer product-related estimate and estimate-by-product distribution were derived using the methodology described in Appendix A.

In 2021, products in the Heating Systems category were associated with an estimated 63 deaths (31% of the total 204 CO poisoning deaths from consumer products). Of the 63, the majority (62% or 39 deaths) were known to have involved gas heating systems or devices. Natural gas heating was associated with an estimated 6 deaths (9% of all heating system-related deaths). LP gas heating was associated with an estimated 25 deaths (40% of heating system-related deaths); and unspecified gas heating was associated with an estimated 8 deaths (13% of heating system-related deaths).

Staff notes that several other fuel-burning devices, not specifically designed for heating purposes, were known to be, or suspected of having been, used for heating an enclosed space where a victim died of CO poisoning. In 2021, such devices included charcoal/charcoal grills (an estimated 8 deaths) and gas ranges (10 deaths).

Of the estimated 6 deaths in 2021 associated with natural gas (NG) heating systems, the majority (75% or 4 deaths) involved installed NG wall furnaces. About 78 percent of the estimated 25 deaths in 2021 that were associated with LP gas heating systems were unvented portable propane heaters. The unvented, portable propane heaters were fueled by a propane tank and were not a component of an installed heating system. The portable LP heaters are intended as camping heaters or heaters for other temporary spaces and use disposable, refillable, or exchangeable propane tanks.

There were also an estimated four deaths associated with coal-burning heating devices in 2021—all of which were coal furnaces.

Additionally, in 2021:

- An estimated 8 CO deaths (4% of the 204 total estimated deaths) were associated with charcoal or charcoal grills. As noted, most of these were either known to have been used, or

were suspected of being used, for heating purposes, often in temporary spaces like inside a vehicle.

- An estimated 6 deaths were associated with multiple appliances (3% of the total estimated deaths). The multiple-products category includes all incidents where multiple fuel-burning products were used simultaneously, such that a single source of the CO could not be determined.

In recent years, the Engine-Driven Tools category, which includes generators, lawn mowers, leaf blowers, tillers, power washers, and snow blowers, among other EDTs, has been associated with more CO deaths than any other category. About half of the estimated average number of CO deaths in the three most recent years (2019 through 2021) were associated with engine-driven tools (112 of 227, not including multiple-product incidents). Over the 11 years covered in this report, the total number of estimated CO deaths associated with engine-driven tools (977) exceeds the estimates for heating systems (592). Estimated generator-related CO deaths alone exceed those for heating systems over these 11 years (858 generator-related deaths versus 592 heating system-related deaths). When a single CO-producing product is involved, generator-related deaths compose most EDT-related CO deaths, accounting for 88 percent of all EDT-related deaths over the entire 11 years covered by this report.

The availability of detailed information regarding the condition of products associated with CO deaths varies widely. Information collected often describes conditions indicative of compromised vent systems, flue passageways, and chimneys for furnaces, boilers, and other heating systems. Vent systems include the portion of piping that either connects the flue outlet of the appliance and exhausts air to the outside through a ceiling or sidewall or connects to a chimney. According to the information available, some products had vents that became detached or were installed/maintained improperly. Vents were also sometimes blocked by soot caused by inefficient combustion, which, in turn, may have been caused by several factors, such as leaky or clogged burners, an over-firing condition, or inadequate combustion air.

Other reported furnace-related conditions included compromised heat exchangers or filter doors/covers that were removed or not sealed. Some products were old and apparently not well maintained. Other incidents mentioned a backdraft condition, large amounts of debris in the chimney, and the use of a product that was later prohibited by the utility company and designated not to be turned on until repaired.

Table 1: Estimated Non-Fire Carbon Monoxide Poisoning Deaths by Associated Fuel-Burning Consumer Product, 2011–2021

Consumer Product	2019–2021*		Annual Estimates										
	Average Estimate	Average Percent	2011	2012	2013	2014	2015	2016	2017	2018*	2019*	2020*	2021*
Total	227	100%	163	137	146	164	172	178	188	209	254	223	204
Heating Systems	66	29%	49	46	43	64	37	50	41	63	73	63	63
Furnaces (incl. Boilers)	23	10%	22	27	21	24	20	34	17	27	22	23	24
Coal	3	1%	1	*	*	*	*	*	2	1	1	3	4
Liquid Petroleum (LP) Gas	5	2%	*	4	1	11	3	3	*	2	5	3	6
Natural Gas	8	3%	5	15	5	6	6	15	6	18	13	9	1
Oil	<1	<1%	2	*	5	1	3	2	1	1	*	*	1
Unspecified Gas	4	2%	10	4	10	6	8	11	4	*	1	5	7
Unspecified Fuel	3	1%	2	5	*	*	1	2	4	4	1	4	4
Portable Heaters	29	13%	13	11	12	18	11	11	19	24	25	33	28
Kerosene	5	2%	2	1	*	2	1	4	2	*	1	5	8
Liquid Petroleum (LP) Gas	23	10%	11	10	12	14	10	6	16	24	23	28	20
Natural Gas	*	*	*	*	*	1	*	*	*	*	*	*	*
Unspecified Gas	*	*	*	*	*	*	*	1	*	*	*	*	*
Unspecified Fuel	*	*	*	*	*	*	*	*	1	*	*	*	*
Wall/Floor Furnaces	3	1%	2	*	*	5	1	1	2	1	5	1	4
Liquid Petroleum (LP) Gas	<1	<1%	*	*	*	*	*	1	*	*	1	*	*
Natural Gas	3	1%	1	*	*	2	1	*	*	1	4	1	4
Unspecified Gas	*	*	*	*	*	2	*	*	1	*	*	*	*
Unspecified Fuel	*	*	1	*	*	*	*	*	1	*	*	*	*
Room/Space Heaters	5	2%	5	5	9	8	1	1	1	6	10	1	3
Coal	<1	<1%	2	*	1	1	*	*	*	1	1	*	*
Kerosene	<1	<1%	*	*	*	*	*	*	*	*	*	*	1
Liquid Petroleum (LP) Gas	2	<1%	1	4	3	7	*	*	*	*	6	*	*
Natural Gas	*	*	*	*	2	*	*	*	*	*	*	*	*
Wood	<1	<1%	1	*	2	*	*	*	1	4	1	*	*
Unspecified Gas	<1	<1%	1	*	*	*	*	1	*	1	*	*	1
Unspecified Fuel	1	<1%	*	1	*	*	1	*	*	*	1	1	*
Unspecified Heater/System	6	3%	8	2	1	9	3	3	1	5	10	4	4
Oil	<1	<1%	*	*	*	*	*	*	*	*	*	*	1
Liquid Petroleum (LP) Gas	3	1%	3	1	*	8	1	*	*	2	6	4	*
Natural Gas	*	*	1	*	*	*	*	*	*	*	*	*	*
Unspecified Gas	<1	<1%	1	1	*	*	*	*	*	*	1	*	*
Unspecified Fuel	2	<1%	2	*	1	1	1	3	1	2	3	*	3
Charcoal/Charcoal Grills	12	5%	10	6	11	7	11	7	10	10	14	15	8

Table 1: Estimated Non-Fire Carbon Monoxide Poisoning Deaths by Associated Fuel-Burning Consumer Product, 2011–2021 (continued)

Consumer Product	2019–2021 ⁺		Annual Estimates										
	Average Estimate	Average Percent	2011	2012	2013	2014	2015	2016	2017	2018 ⁺	2019 ⁺	2020 ⁺	2021 ⁺
Engine-Driven Tools	112	49%	73	64	68	62	92	80	104	99	119	106	110
Generators – Gasoline	76	33%	64	57	55	53	84	61	88	71	77	70	80
Generators – LP	3	1%	*	*	*	*	*	7	1	1	*	5	3
Generators – Unspecified Fuel	21	9%	*	*	1	1	*	*	6	11	23	20	20
Other Engine-Driven Tools	12	5%	10	6	13	8	8	12	10	16	18	10	8
Ranges or Ovens	5	2%	8	4	10	*	5	7	12	9	3	3	10
Liquid Petroleum (LP) Gas	1	<1%	1	1	1	*	3	*	1	1	*	*	3
Natural Gas	4	2%	3	*	2	*	3	6	*	2	3	3	7
Unspecified Gas	*	*	3	2	2	*	*	*	11	5	*	*	*
Unspecified Fuel	*	*	*	*	5	*	*	1	*	*	*	*	*
Water Heaters	8	4%	8	5	2	5	9	6	4	5	18	3	4
Liquid Petroleum (LP) Gas	4	2%	1	*	1	1	*	*	*	2	10	*	3
Natural Gas	2	<1%	4	*	*	*	*	1	4	1	6	*	*
Oil	*	*	*	*	*	*	*	*	*	*	*	*	*
Unspecified Gas	1	<1%	1	2	*	2	8	4	*	1	1	3	*
Unspecified Fuel	<1	<1%	1	2	1	1	1	*	*	*	*	*	1
Pool Heaters	1	<1%	1	*	3	2	*	2	4	*	*	4	*
Liquid Petroleum (LP) Gas	*	*	*	*	*	*	*	*	*	*	*	*	*
Natural Gas	<1	<1%	*	*	3	1	*	*	4	*	*	1	*
Unspecified Gas	1	<1%	1	*	*	*	*	2	*	*	*	3	*
Unspecified Fuel	*	*	*	*	*	1	*	*	*	*	*	*	*
Lanterns	*	*	2	2	*	5	5	1	*	*	*	*	*
Liquid Petroleum (LP) Gas	*	*	1	2	*	4	5	1	*	*	*	*	*
Kerosene	*	*	*	*	*	1	*	*	*	*	*	*	*
Unspecified Fuel	*	*	1	*	*	*	*	*	*	*	*	*	*
Grills, Camp Stoves	6	2%	2	*	1	6	4	3	6	4	4	12	1
Liquid Petroleum (LP) Gas	3	1%	2	*	*	2	4	3	6	1	1	9	*
Coal	*	*	*	*	*	*	*	*	*	1	*	*	*
Wood	2	1%	*	*	*	1	*	*	*	*	3	3	1
Unspecified Fuel	*	*	*	*	1	2	*	*	*	1	*	*	*

Note: Use of a natural gas water heater not as the product was intended with Liquid Petroleum (LP) gas (instead of natural gas) is associated with an estimated 4 deaths in 2019. Those deaths are classified based on *product type* under “Water Heaters – *natural gas*”, even though LP gas was used.

Table 1: Estimated Non-Fire Carbon Monoxide Poisoning Deaths by Associated Fuel-Burning Consumer Product, 2011–2021 (continued)

<i>Consumer Product</i>	<i>2019–2021*</i>		<i>Annual Estimates</i>										
	<i>Average Estimate</i>	<i>Average Percent</i>	<i>2011</i>	<i>2012</i>	<i>2013</i>	<i>2014</i>	<i>2015</i>	<i>2016</i>	<i>2017</i>	<i>2018*</i>	<i>2019*</i>	<i>2020*</i>	<i>2021*</i>
Other Products	4	2%	3	2	2	7	1	2	1	7	8	4	1
Chimney/Fireplace – Coal	*	*	*	*	*	*	*	*	*	*	*	*	*
Chimney/Fireplace – Unspecified Fuel	1	<1%	*	1	1	*	*	*	*	*	3	1	*
Fire Pit – Wood	*	*	*	*	*	*	*	1	*	*	*	*	*
Other Products – LP Gas	<1	<1%	2	*	1	4	1	*	1	4	*	*	1
Other Products – Natural Gas	*	*	*	*	*	*	*	*	*	*	*	*	*
Other Products – Unspecified Fuel	*	*	*	*	*	1	*	*	*	*	*	*	*
Unidentified Product	2	<1%	1	1	*	1	*	*	*	1	5	*	*
Unidentified Product – LP Gas	1	<1%	*	*	*	1	*	1	*	2	*	3	*
Multiple Products	12	5%	8	5	5	7	9	19	6	12	16	14	6

+ Data collection for 2018, 2019, 2020, and 2021 is only partially complete. The corresponding estimates for these 4 most recent years are shown in italics to emphasize the possibility of change in the future if more reports of deaths are received.

* No reports received by CPSC staff.

Source: U.S. Consumer Product Safety Commission/EPHA.

CPSC Death Certificate File, CPSC Injury or Potential Injury Incident File, CPSC In-Depth Investigation File,
National Center for Health Statistics Mortality File, 2011–2021.

Note: Reported annual estimates and estimated averages and percentages may not add to subtotals or totals due to rounding.

By Fuel Type

Table 2 organizes the estimates, by product, within fuel type. The three major fuel types include: *Solid-Fueled Products* (charcoal, coal, and wood); *Liquid-Fueled Products* (gasoline, kerosene, and oil); and *Gas-Fueled Products* (natural gas and liquid petroleum—including propane and butane—gas). Of these fuel types, *Solid-Fueled Products* were associated with an estimated 14 (7%) CO deaths in 2021; *Liquid-Fueled Products* were associated with an estimated 101 (49%) deaths; and *Gas-Fueled Products* were associated with 60 of the 204 (29%). There were also 28 fatalities (14%) where the fuel type of the device could not be identified.

In 2021, of the estimated 14 deaths in the *Solid-Fueled Products* category, eight were associated with charcoal or charcoal grills.

Most of the estimated 101 liquid-fueled, appliance-related deaths in 2021 were associated with engine-driven tools (e.g., generators, lawn mowers/garden tractors). An estimated 80 deaths were associated with gasoline-fueled generators alone. An estimated 8 deaths were associated with other engine-driven tools alone. Only an estimated 13 of the 101 liquid-associated deaths had no generator or engine-driven tool involvement, all related to heaters or heating systems. Ten involved kerosene heaters (eight of which were portable heaters).

In the *Gas-Fueled Products* category in 2021, an estimated 39 of the 60 gas-fueled appliance deaths (65%) were associated with heating systems or heaters, including furnaces, portable heaters, and room or space heaters. Additionally, all four of the *Multiple Gas-Fueled Products* fatalities were associated with a heating-related product and another product.⁵

⁵ “Heating-related” products includes water heaters or consumer products combined to serve as a gas-powered, home-made heating system in addition to the previously mentioned heating systems.

Table 2: Estimated Non-Fire Carbon Monoxide Poisoning Deaths Associated with Consumer Products Organized by Fuel Type, 2011–2021

	2019–2021 ⁺		Annual Estimates											
Consumer Product	Average Estimate	Average Percent	2011	2012	2013	2014	2015	2016	2017	2018 ⁺	2019 ⁺	2020 ⁺	2021 ⁺	
Total	227	100%	163	137	146	164	172	178	188	209	254	223	204	
Solid-Fueled Products	18	8%	14	6	14	9	11	8	13	17	21	20	14	
Charcoal-Fueled	12	5%	10	6	11	7	11	7	10	10	14	15	8	
Charcoal/Charcoal Grills	12	5%	10	6	11	7	11	7	10	10	14	15	8	
Coal-Fueled	3	1%	3	*	1	1	*	*	2	4	3	3	4	
Furnace (incl. Boilers)	3	1%	1	*	*	*	*	*	2	1	1	3	4	
Room/Space Heater	<1	<1%	2	*	1	1	*	*	*	1	1	*	*	
Coal Grill/Coal	*	*	*	*	*	*	*	*	*	1	*	*	*	
Wood-Fueled	3	1%	1	*	2	1	*	1	1	4	4	3	1	
Fire Pit	*	*	*	*	*	*	*	1	*	*	*	*	*	
Grill/Stove	2	1%	*	*	*	1	*	*	*	*	3	3	1	
Room/Space Heater	<1	<1%	1	*	2	*	*	*	1	4	1	*	*	
Liquid-Fueled Products	96	42%	79	65	73	67	96	83	102	88	100	87	101	
Gasoline-Fueled	87	38%	73	64	67	61	92	73	98	86	94	80	88	
Generator	75	33%	64	57	55	53	84	61	88	71	77	70	80	
Other Engine-Driven Tools	12	5%	10	6	13	8	8	12	10	14	17	10	8	
Kerosene-Fueled	5	2%	2	1	*	4	1	4	2	*	1	5	10	
Portable Heater	5	2%	2	1	*	2	1	4	2	*	1	5	8	
Space Heater	<1	<1%	*	*	*	*	*	*	*	*	*	*	1	
Lantern	*	*	*	*	*	1	*	*	*	*	*	*	*	
Oil-Fueled	1	<1%	2	*	5	1	3	2	1	1	*	*	3	
Furnace (incl. Boilers)	<1	<1%	2	*	5	1	3	2	1	1	*	*	1	
Unspecified Heater	<1	<1	*	*	*	*	*	*	*	*	*	*	1	
Diesel-Fueled	*	*	*	*	*	*	*	*	*	*	*	*	*	
Multiple Products – Liquid-Fueled	2	1%	1	*	1	1	*	3	*	1	5	2	*	

Table 2: Estimated Non-Fire Carbon Monoxide Poisoning Deaths Associated with Consumer Products Organized by Fuel Type, 2011–2021 (continued)

	2019–2021+		Annual Estimates										
Consumer Product	Average Estimate	Average Percent	2011	2012	2013	2014	2015	2016	2017	2018+	2019+	2020+	2021+
Gas-Fueled Products	78	34%	58	51	45	78	53	69	60	78	92	82	60
Natural Gas	18	8%	15	15	13	11	10	21	13	23	26	15	13
Furnace (incl. Boilers)*	8	3%	6	15	5	6	6	15	6	18	13	9	1
Pool Heater	<1	<1%	*	*	3	1	*	*	4	*	*	1	*
Portable Heater	*	*	*	*	*	1	*	*	*	*	*	*	*
Range/Oven	4	2%	3	*	2	*	3	6	*	2	3	3	7
Room/Space Heater	*	*	*	*	2	*	*	*	*	*	*	*	*
Wall/Floor Furnace	3	1%	*	*	*	2	1	*	*	1	4	1	4
Water Heater	2	1%	4	*	*	*	*	1	4	1	6	1	*
Unspecified Heater	*	*	1	*	*	*	*	*	*	*	*	*	*
Liquid Petroleum (LP) Gas	47	21%	23	22	20	52	27	22	24	41	55	51	35
Furnace (incl. Boilers)	5	2%	*	4	1	11	3	3	*	2	5	3	6
Generator	3	1%	*	*	*	*	*	7	*	1	*	5	3
Grill/Camp Stove	3	1%	2	*	*	2	4	3	6	1	1	9	*
Lantern	*	*	1	2	*	4	5	1	*	*	*	*	*
Portable Heater	24	10%	11	10	12	14	10	6	16	24	23	28	20
Range/Oven	1	<1%	1	1	1	*	3	*	1	1	*	*	3
Refrigerator	*	*	2	*	1	2	*	*	1	2	*	*	*
Room/Space Heater	2	<1%	1	4	3	7	*	*	*	*	6	*	*
Single Cooking Burner	<1	<1%	*	*	*	*	*	*	*	*	*	*	1
Wall/Floor Furnace	<1	<1%	*	*	*	*	*	1	*	*	1	*	*
Water Heater	4	2%	1	*	1	1	*	*	*	2	10	*	2
Unspecified Heater/System	3	1%	3	1	*	8	1	*	*	2	6	4	*
Other/Unknown Products	1	<1%	*	*	*	2	1	1	*	4	*	3	*
Unspecified Gas	7	3%	17	10	13	11	15	20	16	7	4	9	8
Furnace (incl. Boilers)	4	2%	10	4	10	6	8	11	4	*	1	5	7
Pool Heater	1	<1%	1	*	*	*	*	2	*	*	*	3	*
Portable Heater	*	*	*	*	*	*	*	1	*	*	*	*	*
Range/Oven	*	*	3	2	2	*	*	*	11	5	*	*	*
Room/Space Heater	<1	<1%	1	*	*	*	*	1	*	1	*	*	1
Wall/Floor Furnace	*	*	*	*	*	2	*	*	1	*	*	*	*
Water Heater	1	<1%	1	2	*	2	8	4	*	1	1	1	*
Unspecified Heater	<1	<1%	1	1	*	*	*	*	*	*	1	*	*
Multiple Products - Gas-Fueled	6	3%	3	4	*	5	1	6	6	6	8	6	4

Table 2: Estimated Non-Fire Carbon Monoxide Poisoning Deaths Associated with Consumer Products Organized by Fuel Type, 2011–2021 (continued)

	2019–2021+		Annual Estimates										
Consumer Product	Average Estimate	Average Percent	2011	2012	2013	2014	2015	2016	2017	2018 ⁺	2019 ⁺	2020 ⁺	2021 ⁺
Unspecified Fuel Products	31	14%	9	11	10	8	5	7	13	21	38	27	28
Chimney/Fireplace	1	<1%	*	1	1	*	*	*	*	*	3	1	*
Furnace (incl. Boilers)	3	1%	2	5	*	*	1	2	4	4	1	4	4
Generator	21	9%	*	*	1	1	*	*	6	11	23	20	20
Other EDTs (excl. generators)	<1	<1%	*	*	*	*	*	*	*	1	1	*	*
Grill/Camp Stove	*	*	*	*	1	2	*	*	*	1	*	*	*
Lantern	*	*	1	*	*	*	*	*	*	*	*	*	*
Pool Heater	*	*	*	*	*	1	*	*	*	*	*	*	*
Portable Heater	*	*	*	*	*	*	*	*	1	*	*	*	*
Range/Oven	*	*	*	*	5	*	*	1	*	*	*	*	*
Room/Space Heater	1	<1%	*	1	*	*	1	*	*	*	1	1	*
Unspecified Heater	2	<1%	2	*	1	1	1	3	1	2	3	*	3
Wall/Floor Furnace	*	*	1	*	*	*	*	*	1	*	*	*	*
Unidentified Product	2	<1%	1	1	*	1	*	*	*	1	5	*	*
Water Heater	<1	<1%	1	2	1	1	1	*	*	*	*	*	1
Multiple Product – Different Fuels	3	1%	3	4	3	1	8	10	*	5	3	6	1
Gas & Liquid	2	1%	2	2	3	1	6	8	*	5	3	4	*
Gas & Solid	<1	<1%	*	1	*	*	*	1	*	*	*	*	1
Liquid & Solid	*	*	1	*	*	*	*	*	*	*	*	*	*
Liquid & Unspecified	<1	<1%	*	*	*	*	1	1	*	*	*	1	*
Solid & Unspecified	<1	<1%	*	*	*	*	*	*	*	*	*	1	*

+ Data collection for 2018, 2019, 2020, and 2021 is only partially complete. The corresponding estimates for these 4 most recent years are shown in italics to emphasize the possibility of change in the future if more reports of deaths are received.

* No reports received by CPSC staff.

Source: U.S. Consumer Product Safety Commission/EPHA.

CPSC Death Certificate File, CPSC Injury or Potential Injury Incident File, CPSC In-Depth Investigation File, National Center for Health Statistics Mortality File, 2011–2021.

Note: Use of a natural gas water heater not as the product was intended with Liquid Petroleum (instead of natural gas) is associated with an estimated 4 deaths in 2019. Those deaths are classified based on product type under “natural gas” [water heater], even though LP gas was used.

Engine-Driven Tools

Table 3 shows a breakdown of the fatality estimates for the 11-year period from 2011 through 2021, in the *Engine-Driven Tools* category. In 2021, engine-driven tools were associated with an estimated 110 carbon monoxide poisoning deaths (54% of the 204 total consumer product-related CO death estimate).⁶ In the 3 most recent years (2019-2021), EDTs were associated with 51 percent of all consumer product-related CO fatalities (estimated annual average of 116 out of 227) either as the sole product involved or in combination with another CO-producing product. Of these EDT-associated fatalities, generators dominated, with an estimated annual average of 99 out of 116.

Lawnmowers were associated with 47 percent of the deaths listed in the *Other Engine-Driven Tools* category for the 11-year period (56 of 119 total fatalities). There was an estimated average of five lawnmower-related CO deaths per year from 2019 to 2021 (15 total deaths when excluding multiproduct deaths). There were multiple fatalities for three other sub-categories over the three-year period: power washers (an estimated 5 fatalities), OHV (5), and snow blowers (2).

⁶ For completeness, Table 3 includes deaths associated with *at least one* Engine-Driven Tool even if multiple products may be associated. This includes deaths associated with multiple different EDTs and deaths associated with the combination of an EDT some other type of product. Throughout this report, however, estimates for specific EDT product categories such as generators, other engine-driven tools, and subtypes exclude multiple product deaths.

Table 3: Estimated Non-Fire Carbon Monoxide Poisoning Deaths Associated with Engine-Driven Tools, 2011–2021

Consumer Product	2019–2021*		Annual Estimates										
	Average Estimate	Average Percent	2011	2012	2013	2014	2015	2016	2017	2018+	2019+	2020+	2021+
Total	116	51%	78	66	73	64	97	92	104	105	124	114	110
Generators	99	44%	64	57	56	54	84	67	95	83	101	95	102
Gasoline-fueled	76	33%	64	57	55	53	84	61	88	71	77	70	80
LP-fueled	3	1%	*	*	*	*	*	7	*	1	*	5	3
Unspecified Fuel	21	9%	*	*	1	1	*	*	6	11	23	20	20
Other Engine-Driven Tools (OEDTs)	12	5%	10	6	13	8	8	12	10	16	18	10	8
Lawn Mowers	5	2%	3	4	7	2	4	7	5	9	4	7	4
Riding Mowers (incl. Garden tractor)	3	1%	3	2	6	1	3	7	4	5	*	6	3
Unspecified Mowers	2	<1%	*	1	1	1	1	*	1	4	4	1	1
Antique Tractor	<1	<1%	*	*	*	*	*	*	1	*	*	*	1
OHV (e.g., ATV or UTV)	2	<1%	2	1	1	1	*	*	1	*	5	*	*
Dune Buggy	<1	<1%	*	*	*	*	*	*	*	*	*	*	1
Snowmobile	<1	<1%	*	*	*	*	*	*	*	*	1	*	*
Paint Sprayer	*	*	1	*	*	*	*	*	*	*	*	*	*
Power Washer	2	<1%	2	*	*	2	*	1	1	1	4	1	*
Snow Blower/Thrower	1	<1%	1	*	2	1	1	1	*	1	1	1	*
Water Pump	<1	<1%	*	*	1	*	*	*	*	*	1	*	*
Concrete Saw	<1	<1%	*	*	*	*	*	*	*	*	*	*	1
Welder	*	*	*	*	*	*	3	1	*	*	*	*	*
Tiller	*	*	*	*	*	*	*	*	*	1	*	*	*
Leaf Blower	*	*	*	*	*	*	*	1	*	2	*	*	*
Small Engine	*	*	*	*	*	*	*	1	*	*	*	*	*
Stump Grinder	*	*	*	*	1	*	*	*	1	*	*	*	*
Wood Splitter	*	*	*	1	*	1	*	*	*	*	*	*	*
Unspecified EDT	<1	<1%	*	*	*	*	*	*	*	1	1	*	*
Multiple Product: Engine-Driven Tools Involved	5	2%	4	2	5	2	5	12	*	6	5	9	*
Generator + OEDT	1	<1%	*	*	*	*	*	1	*	*	1	1	*
Generator + other Product	4	2%	3	2	3	2	4	10	*	6	4	8	*
Multiple OEDT	*	*	1	*	*	*	*	1	*	*	*	*	*
OEDT + other product	*	*	*	*	1	*	1	*	*	*	*	*	*

+ Data collection for 2018, 2019, 2020, and 2021 is only partially complete. The corresponding estimates for these 4 most recent years are shown in italics to emphasize the possibility of change in the future if more reports of deaths are received.

* No reports received by CPSC staff.

Source: U.S. Consumer Product Safety Commission/EPHA.

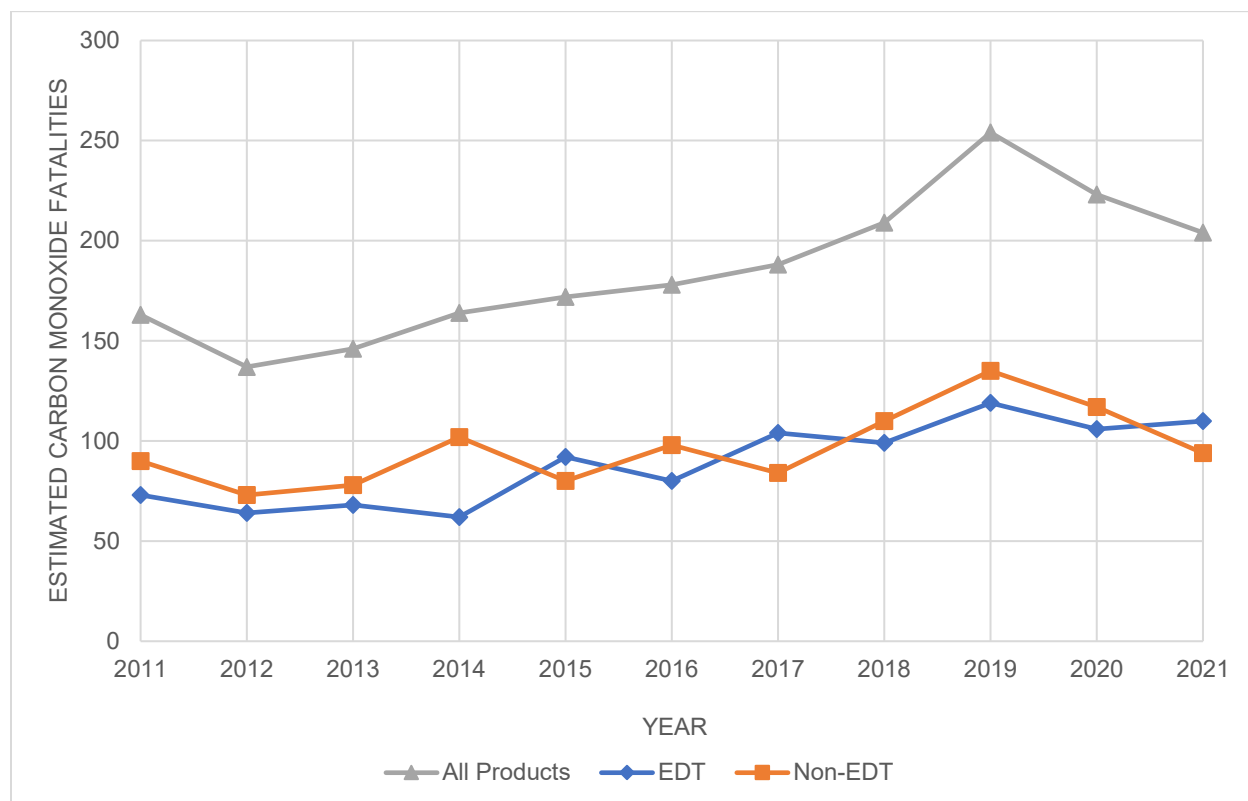
CPSC Death Certificate File, CPSC Injury or Potential Injury Incident File, CPSC In-Depth Investigation File, National Center for Health Statistics Mortality File, 2011–2021.

Note: Reported annual estimates and estimated averages and percentages may not add to subtotals or totals due to rounding.

Comparison of Trends

Figure 1 provides a graphic representation of the CO fatality trends related to (1) all consumer products; (2) engine-driven tools; and (3) non-engine-driven tool products. A regression analysis of the estimated number of all non-fire, consumer product-related CO poisoning deaths from 2011 to 2021 indicates evidence of a statistically significant trend (p-value = 0.0010). Between 2012 and 2019, the estimated CO fatalities from consumer products had risen for seven years straight. In 2018, the estimated number of CO fatalities had risen above 200 deaths for the first time since before the changeover from ICD-9 to ICD-10 in 1999, and the estimate peaked at 254 in the year 2019, before decreasing in 2020 and 2021. However, the 2020 estimate is higher in comparison with years prior to 2019. Although death certificate collection is ongoing, the currently available estimates for all of the most recent four years, 2018-2021, exceed all of the earlier estimates from 2011-2017. Part of the increase over the eleven years is associated with engine-driven tools, as well as other products. Regression analysis from 2011 to 2021 indicates evidence of a statistically significant trend both for Engine-Driven Tools (EDT; p-value = 0.0003) and for the remainder of deaths associated with other product types or multiple products (non-EDT; p-value = 0.0356).

Figure 1: Comparison of Trends in Consumer Product-Related Carbon Monoxide Deaths, 2011 to 2021



Source: U.S. Consumer Product Safety Commission/EPHA.

CPSC Death Certificate File, CPSC Injury or Potential Injury Incident File, CPSC In-Depth Investigation File, 2011–2021.

Note: EDT classification is limited to single-product deaths for which the one product identified was an Engine-Driven tool (which may include a generator or any other kind of engine-driven tool). Incidents involving multiple products are included under Non-EDT, even if one or more engine-driven tools may have been involved, because such incidents could not be directly attributed exclusively to one particular EDT as the only CO source.

Number of Deaths per Incident Reported to CPSC

Table 4 presents a summary of the incident data broken down by the number of deaths per incident. Staff notes that this table does not provide estimates; the numbers presented are counts observed in the CPSC databases. Therefore, the counts presented in Table 4 should not be expected to add up to the estimated deaths in other tables. Table 4 shows that in 2021, 141 of the 169 fatal CO incidents (83% of fatal CO incidents reported to the CPSC) involved a single death. Table 4 accounts for only the fatally injured victims in each CO poisoning incident. It is not uncommon for CO incidents involving one or more deaths to also result in one or more nonfatal CO poisoning injuries. However, the breakdown of these injuries was not quantified for analysis in this death-focused report.

Occasionally, even though CPSC records indicate that there was more than one fatality in a specific incident, not all the deaths are used in the estimation process. Deaths for which CPSC does not have a death certificate are not used in the analyses because the scaling estimation process accounts for missing records. Also, if an additional fatality is recorded as work related, that fatality is not counted in the estimation process because work-related deaths are out of scope for this report. However, both scenarios are included in Table 4 to highlight the danger of multiple deaths in CO poisoning cases.

Death certificates do not include information about other deaths for the same incident. The number of deaths for a particular incident is based primarily on CPSC In-Depth Investigation (IDI) records. Some additional multiple-fatality incidents were identified by matching the incident date of death and location of death to the death certificate, while others were identified from news articles contained in the CPSC Injury or Potential Injury Incident (IPII) database. CPSC records indicate that over the 11-year period covered by this report, 17 percent of the incidents resulted in multiple deaths. Twenty-three (23) incidents resulted in four or more CO deaths, including an incident in 2015 where eight people died, and an incident in 2016 in which six people died.

Table 4: Number of Carbon Monoxide Poisoning Incidents Reported to CPSC by Number of Deaths per Incident, and Resulting Total Reported Deaths, 2011–2021

		2019–2021 ⁺		Incident Year										
		Annual Average	Average Percent	2011	2012	2013	2014	2015	2016	2017	2018 ⁺	2019 ⁺	2020 ⁺	2021 ⁺
All Reported Incidents		171	100%	120	90	106	110	104	130	131	145	168	176	169
Number of Deaths Reported per Incident	1	145	85%	95	74	84	86	83	110	112	119	145	149	141
	2	20	12%	22	14	21	21	15	16	15	23	19	19	22
	3	3	2%	1	1	*	1	2	1	3	2	2	3	5
	4	2	1%	1	*	1	1	3	2	1	1	2	3	1
	5	1	<1%	1	1	*	1	*	*	*	*	*	2	*
	6	*	*	*	*	*	*	*	1	*	*	*	*	*
	7	*	*	*	*	*	*	*	*	*	*	*	*	*
	8	*	*	*	*	*	*	1	*	*	*	*	*	*
Resulting Total Reported Deaths		206	n/a	151	110	130	140	139	159	155	175	197	218	204

+ Data collection for 2018, 2019, 2020, and 2021 is only partially complete. The corresponding counts for these 4 most recent years are shown in italics to emphasize the possibility of change in the future if more reports of deaths are received.

Note: Percentages do not add to 100% due to rounding.

Numbers presented here are counts based on records available to CPSC staff. These do not represent national estimates and should not be expected to match estimates presented elsewhere in this document.

Source: U.S. Consumer Product Safety Commission/EPHA

CPSC Death Certificate File, CPSC Injury or Potential Injury Incident File, CPSC In-Depth Investigation File.

By Location of Exposure

Table 5 shows that in 2021, an estimated 178 CO poisoning deaths resulted from exposure to CO in home locations, including an estimated 24 deaths from CO in detached structures at residential locations (*i.e.*, sheds, detached garages). There were another 34 deaths from CO in structures not designed to be a permanent residence (*i.e.*, camper trailers, sea-land shipping containers). From 2019 to 2021, an estimated annual average of 176 deaths (78% of the annual average estimate for all CO deaths) resulted from exposure to CO in home locations. In 2021, an estimated 11 deaths resulted from CO in temporary shelters, such as cabins, campers or trailers used for shelter. For 2019 to 2021, an annual average of 20 deaths (9%) resulted from CO in temporary shelters. Deaths due to CO exposure in temporary shelters were most associated with heating sources or generators.

A small percentage of the CO poisoning deaths resulted from CO in vehicles (such as passenger vans, trucks, automobiles, or boats) where a consumer product was the CO-producing product in use. In 2021, there were an estimated 11 CO deaths in this category. For the 3-year period 2019 to 2021, an annual average of 17 deaths (8%) resulted from CO in vehicles. These vehicle location incidents in the 3-year period usually involved a generator, LP heater, grill, or the burning of charcoal inside the vehicle.

Table 5: Estimated Non-Fire Carbon Monoxide Poisoning Deaths by Location of Exposure, 2011–2021

Location of Exposure	2019–2021 ⁺		Annual Estimate										
	Average Estimate	Average Percent	2011	2012	2013	2014	2015	2016	2017	2018 ⁺	2019 ⁺	2020 ⁺	2021 ⁺
Total	227	100%	163	137	146	164	172	178	188	209	254	223	204
Home ¹	132	58%	122	107	104	100	113	135	142	107	154	124	119
Home – External Structure ²	21	9%	10	5	13	15	14	11	5	17	15	24	24
Home – But Not House ³	23	10%	5	1	3	12	4	3	11	23	12	24	34
Temporary Shelter	20	9%	15	21	16	21	24	19	13	33	25	24	11
Vehicles (including boats)	17	8%	9	*	7	6	12	4	10	22	27	14	11
Outdoors	0	<1%	*	*	*	*	*	1	*	1	1	*	*
Other	10	4%	1	*	2	8	5	1	7	4	17	9	4
Unknown	2	<1%	1	2	*	1	*	1	*	2	3	1	1

+ Data collection for 2018, 2019, 2020, and 2021 is only partially complete. The corresponding estimates for these 4 most recent years are shown in italics to emphasize the possibility change in the future if more reports of deaths are received.

* No reports received by CPSC staff.

Note: Percentages do not add to 100% due to rounding.

1 Traditional home (*e.g.*, detached house, townhouse, apartment, mobile home)

2 External structure at residential locations (*e.g.*, detached garage, shed)

3 Non-fixed structure or structure not originally designed for permanent occupation (*e.g.*, camper trailer, van, converted sea-land shipping container).

Source: U.S. Consumer Product Safety Commission/EPHA.

CPSC Death Certificate File, CPSC In-Depth Investigation File, CPSC Injury or Potential Injury Incident File,
National Center for Health Statistics Mortality File, 2011–2021.

By Time of Year

CPSC data indicate that there were more CO deaths attributable to incidents that occurred in the United States' cold months than in the warm months. This is most likely because of the use of furnaces and portable heaters in the cold months. Additionally, portable generators are often used in the cold months because of power outages due to snow and ice storms. Table 6 shows the annual estimated CO deaths categorized by month of death. In 2021, an estimated 120 of the 204 estimated CO deaths (59%) were attributable to deaths that occurred during the four coldest months of November, December, January, and February. Over the 11 years covered by this report, the average percentage of deaths occurring in these four colder months is 54 percent. In 2021, an estimated 41 deaths (20%) are attributable to incidents that occurred during the transition months of March, April, September, and October. This is slightly lower than the 11-year average of 29 percent for the same four months. And in the warmer months of May, June, July, and August, an estimated 43 CO deaths (21%) occurred in 2021 as compared with the 11-year annual average of 17%. Table 6 shows average percentages corresponding to the most recent 3 years (2019-2021).

Table 6: Estimated Non-Fire Carbon Monoxide Poisoning Deaths by Month and Year of the Fatality, 2011–2021

Month of Death	2019–2021 ⁺		Annual Estimate										
	Average Estimate	Average Percent	2011	2012	2013	2014	2015	2016	2017	2018 ⁺	2019 ⁺	2020 ⁺	2021 ⁺
Total	227	100%	163	137	146	164	172	178	188	209	254	223	204
Cold Months	128	56%	85	75	82	83	82	109	80	119	142	122	120
November	35	15%	34	26	16	20	10	32	17	27	30	33	42
December	26	11%	20	25	28	20	23	19	21	29	27	22	28
January	28	12%	24	10	22	26	24	28	27	38	40	30	15
February	39	17%	8	14	16	17	24	29	16	25	45	37	35
Transition Months	57	25%	55	46	43	44	62	49	65	56	71	60	41
March	20	9%	9	6	12	10	19	12	13	12	22	29	10
April	12	5%	11	14	6	14	28	13	14	15	18	6	11
September	8	3%	13	6	5	6	11	7	23	19	5	5	13
October	17	8%	23	20	21	14	4	17	14	10	26	19	7
Warm Months	129	18%	23	16	21	37	29	20	42	34	40	41	43
May	10	5%	9	2	4	17	4	5	9	11	10	10	11
June	8	3%	2	5	6	4	9	3	16	14	12	4	7
July	10	4%	4	7	7	13	11	6	10	1	10	6	13
August	14	6%	8	1	5	4	5	6	9	7	8	20	13

+ Data collection for 2018, 2019, 2020, and 2021 is only partially complete. The corresponding estimates for these 4 most recent years are shown in italics to emphasize the possibility of change in the future if more reports of deaths are received.

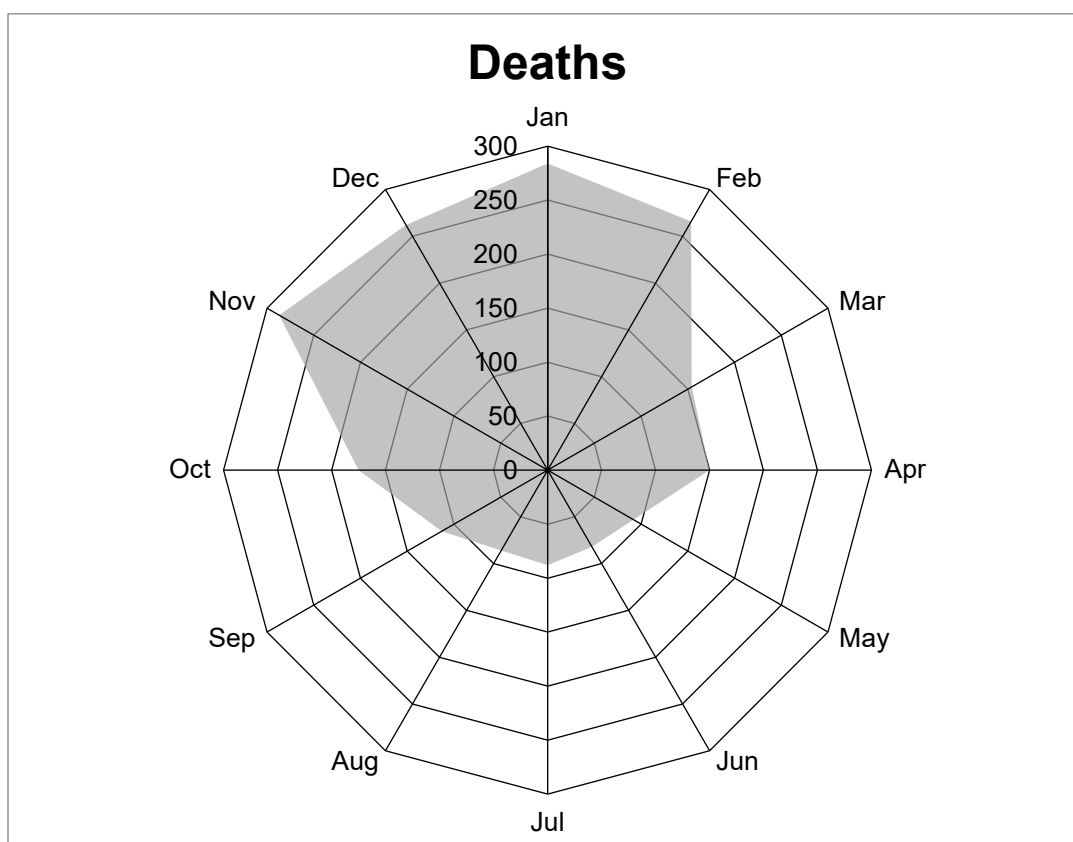
Source: U.S. Consumer Product Safety Commission / EPA.

CPSC Death Certificate File, CPSC In-Depth Investigation File, CPSC Injury or Potential Injury Incident File,
National Center for Health Statistics Mortality File, 2011–2021.

Note: Reported annual estimates and estimated averages and percentages may not add to subtotals or totals due to rounding.

Figure 2 graphically illustrates the relationship between the time of year and the estimated number of CO poisoning deaths from 2011 through 2021. The total estimated number of CO poisoning deaths is presented on the radar graph by month of death. The shaded area represents the estimated total number of deaths for the 11-year period, distributed by each month of a year. Notably, more CO deaths occur in the cold months, particularly November, December, January, and February, than in warm months. Fatalities increase as the winter months continue, until a slight drop off in February before the spring months come. Conversely, as time gets deeper into the warmer months, the number of deaths decreases, with the lowest number of fatalities occurring in July and August.

Figure 2: Estimated Number of Consumer Product-Related Carbon Monoxide Deaths by Month of Death, 2011–2021



Source: U.S. Consumer Product Safety Commission/EPHA.
CPSC Death Certificate File, CPSC In-Depth Investigation File, CPSC Injury or Potential Injury Incident File,
National Center for Health Statistics Mortality File, 2011–2021.

Victim Demographics from Non-Fire Carbon Monoxide Poisoning Deaths Associated with the Use of Consumer Products

Age of Victim

Table 7 shows the estimated number of CO poisoning deaths categorized by victim age for the 11 most recent years of data (2011–2021). From the data, it appears that consumer product-related CO deaths are skewed toward older individuals. For the 3 most recent years (2019–2021), children younger than 15 years of age accounted for an annual average of 4 percent (an estimated 9 deaths out of 227) of the yearly CO poisoning deaths, while this age group represents an average of about 18 percent of the U.S. population. For the same time frame, deaths among adults 45 years and older accounted for about 72 percent (161 of 227), while this age group represented about 42 percent of the U.S. population. Statistical tests confirm the significance of the age-related differences in CO poisoning deaths (see Appendix C for p-values). Percentages for children below the age of 15, as well as individuals 15 to 24 and 25 to 44, were, for each age group, identified as statistically significantly below population estimates. Conversely, the percentage of CO deaths among individuals 45 to 65, and those over age 65, were identified as statistically significantly greater than their population representation.

Table 7: Estimated Non-Fire Carbon Monoxide Poisoning Deaths by Age of Victim, 2011–2021

Age	2019–2021 ⁺		Estimated Percentage of U.S. Population [@]	Annual Estimate										
	Average Estimate	Average Percent		2011	2012	2013	2014	2015	2016	2017	2018 ⁺	2019 ⁺	2020 ⁺	2021 ⁺
Total	227	100%	100%	163	137	146	164	172	178	188	209	254	223	204
Under 5	3	1%	6%	*	1	*	2	*	1	2	4	4	5	*
5 - 14	6	2%	12%	4	4	5	7	17	6	9	1	6	5	6
15 - 24	13	6%	13%	9	6	11	8	15	6	17	7	14	9	15
25 - 44	44	19%	27%	36	37	34	35	45	54	55	55	43	43	45
45 - 64	101	44%	25%	63	56	62	67	65	83	55	88	127	94	81
65 and over	61	27%	17%	52	32	36	44	31	29	51	54	59	66	57

+ Data collection for 2018, 2019, 2020, and 2021 is only partially complete. The corresponding estimates for these 4 most recent years are shown in italics to emphasize the possibility of change in the future if more reports of deaths are received.

* No reports received by CPSC staff.

@ Based on estimated U.S. population statistics for the 3- year average (2019-2021). U.S. Census Bureau.

Source: U.S. Consumer Product Safety Commission/EPHA.

CPSC Death Certificate File, CPSC In-Depth Investigation File, CPSC Injury or Potential Injury Incident File, National Center for Health Statistics Mortality File, 2011-2021.

U.S. Census Bureau, Population Division. Annual Estimates of the Resident Population by Sex, Age, Race, and Hispanic Origin for the United States and States: April 1, 2020 to July 1, 2023. June 2024.

Note: Reported annual estimates and estimated averages and percentages may not add to subtotals or totals due to rounding.

Sex of Victim

Table 8 presents the distribution of estimated CO deaths categorized by sex. In 2021, an estimated 79 percent of CO poisoning victims were males and 21 percent were females. These percentages varied slightly from year to year over the 11 years of this report. However, every year there were many more male CO deaths than female. For 2019 through 2021, the average percentage of male CO victims was 76 percent, and the average percentage of female victims was 23 percent. By contrast, about 49 percent of the U.S. population is male, and 51 percent of the U.S. population is female.⁷ The sex-related differences in CO poisoning deaths were confirmed to be statistically significant (p-value < 0.0001).

Table 8: Estimated Non-Fire Carbon Monoxide Poisoning Deaths by Sex of Victim, 2011-2021

Sex	2019–2021 ⁺		Estimated Percentage of U.S. Population*	Annual Estimate										
	Average Estimate	Average Percent		2011	2012	2013	2014	2015	2016	2017	2018 ⁺	2019 ⁺	2020 ⁺	2021 ⁺
Total	227	100%	100%	163	137	146	164	172	178	188	209	254	223	204
Male	173	76%	49%	111	92	124	127	125	140	138	163	195	164	161
Female	53	23%	51%	52	45	22	37	48	38	50	46	58	59	43

+ Data collection for 2018, 2019, 2020, and 2021 is only partially complete. The corresponding estimates for these 4 most recent years are shown in italics to emphasize the possibility of change in the future if more reports of deaths are received.

* Based on estimated U.S. population statistics for the 3-year average (2019-2021).

Source: U.S. Consumer Product Safety Commission/EPHA.

CPSC Death Certificate File, CPSC In-Depth Investigation File, CPSC Injury or Potential Injury Incident File, National Center for Health Statistics

Mortality File, 2011–2021.

U.S. Census Bureau, Population Division. Annual Estimates of the Resident Population by Sex, Age, Race, and Hispanic Origin for the United States and States:

April 1, 2020 to July 1, 2023. June 2024.

Note: Reported annual estimates and estimated averages and percentages may not add to subtotals or totals due to rounding.

⁷ Three-year average, 2019 to 2021, from July U.S. Census estimates of the U.S. population. June 2024

Victim Race/Ethnicity

Table 9 provides a summary of CO fatality victims characterized by race/ethnicity for the years 2011 through 2021. Hispanic victims were categorized separately, irrespective of their race. Estimates of the percentage of the U.S. population categorized into the various race/ethnicity groupings were based on single-race characterizations, as represented in the U.S. Census Bureau reports. Non-Hispanic individuals reported as multiracial are included in the *Unknown/Other/Mixed* category.

The estimated percentages of the 2019 through 2021 annual average CO deaths did *not* demonstrate statistically significant differences among race/ethnicity groups and their corresponding population proportions. The proportion of the CO poisoning fatality victims who were of Hispanic ethnicity (approximately 14%) was below the percentage of Hispanics in the U.S. population (about 19%), but the difference is not found to be statistically significant. Non-Hispanic white decedents account for an estimated 63 percent of all CO poisoning deaths, which is not found to be significantly greater than their 60 percent proportion of the U.S. population. CO fatalities among non-Hispanic Black or African American victims represented 15 percent of all CO fatalities, while their representation in the U.S. population is 13 percent. That difference is not determined to be statistically significant. Similarly, for other races/ethnicities as grouped, no statistically significant differences were observed.

Table 9: Estimated Non-Fire Carbon Monoxide Poisoning Deaths by Race/Ethnicity, 2011–2021

Race/ Ethnicity	2019–2021 ⁺		Estimated Percentage of U.S. Population [@]	Annual Estimate										
	Average Estimate	Average Percent		2011	2012	2013	2014	2015	2016	2017	2018 ⁺	2019 ⁺	2020 ⁺	2021 ⁺
Total	227	100%	100%	163	137	146	164	172	178	188	209	254	223	204
Hispanic (All races)	33	14%	19%	9	11	13	18	14	13	19	26	32	41	25
White ¹	143	63%	60%	106	82	86	108	109	118	121	152	178	129	123
Black or African American ¹	34	15%	13%	38	31	35	26	47	32	24	18	26	40	35
Asian/Pacific ^{2,1}	8	3%	6%	3	5	7	6	*	7	7	4	5	8	10
American Indian ^{3,1}	5	2%	1%	1	*	1	1	*	1	7	4	5	4	7
Unknown/Other /More than one race ^{4,1}	3	2%	2%	6	7	5	5	3	6	9	6	6	3	4

+ Data collection for 2018, 2019, and 2020, and 2021 is only partially complete. The corresponding estimates for these 4 most recent years are shown in italics to emphasize the possibility of change in the future if more reports of deaths are received.

* No reports received by CPSC staff.

@ Based on estimated U.S. population statistics for the 3-year average (2019-2021). U.S. Census Bureau.

1 Only includes non-Hispanic ethnicities and decedents *unknown* whether Hispanic.

2 Includes Asian, Pacific Islander, and Native Hawaiian.

3 Includes American Indian, Native American, and Native Alaskan.

4 Includes non-Hispanic Unknown races, Other races, and Multiple races.

Source: U.S. Consumer Product Safety Commission/EPHA.

CPSC Death Certificate File, CPSC In-Depth Investigation File, CPSC Injury or Potential Injury Incident File,

National Center for Health Statistics Mortality File, 2011-2021.

U.S. Census Bureau, Population Division. Annual Estimates of the Resident Population by Sex, Age, Race, and Hispanic Origin for the United States and States:

States: April 1, 2020 to July 1, 2023. June 2024.

Note: Reported annual estimates and estimated averages and percentages may not add to subtotals or totals due to rounding.

Population Density of Place of Death

Table 10 provides a breakdown of the CO poisoning deaths characterized by population density of the incident location. The table is presented as three sections: (1) incidents occurring at all locations; (2) incidents occurring in locations identified as a permanent home (e.g., house, apartment, mobile home); and (3) incidents occurring only in non-home locations (e.g., camper trailer, tent, motel room). Please note that “Home Locations” and “Non-Home Locations” sum to “All Locations.”

All fatal incidents were designated as occurring in 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) in conjunction with the Center for Rural Health, School of Medicine and Health Sciences, University of North Dakota. The categories are based on theoretical concepts used by the U.S. Office of Management and Budget (OMB) to define county-level metropolitan and micropolitan areas.⁸ This 21-category classification system is based on measures of population density, urbanization, and daily commuting. The OMB methodology is based on a county-level delineation. ERS refined the methodology by applying it to smaller census tracts. ERS further delineated the characterization by cross-referencing each ZIP Code in the United States to its RUCA code classification.⁹ The update of the RUCAs to version 3.1 was developed by Center for Rural Health, School of Medicine and Health Sciences, University of North Dakota and ERS and is funded by the U.S. Department of Health and Human Services, Health Resources and Services Administration, Office of Rural Health Policy, and the USDA Economic Research Service. The ZIP Code cross-reference was used to characterize each of the CO deaths into one of four broad categories: Urban Core, Sub-Urban, Large Rural Town, and Small Town/Rural Isolated. The RUCA codes are updated approximately once every 10 years. The most recent available update applicable to years addressed in this report while most recently estimated in 2020 is regarding the distribution estimated for the year 2010. Although there may be some change in the urban-rural population distribution between 2010 and the more recent 3-year period average of 2019 through 2021, any such changes are unlikely to result in a major effect on the overall distribution of these estimates.

Table 10 also includes the estimated percentage of the U.S. population, per population density designation category. As can be seen in the *All Locations* section, the estimated average percentage of CO deaths during the 3-year period 2019 through 2021 in urban locations (51%) is smaller than the percentage of the U.S. population living in urban core locations (73%). The difference is offset by the larger percentages in the other three categories: sub-urban locations (16% versus 15% of the U.S. population), large rural town locations (14% versus 6%), and small town/rural isolated locations (18% versus 5%). CO deaths that occurred in small town/rural isolated locations were over three times the percentage of the U.S. population living in these isolated locations. Additionally, due to lack of detail in some of the death certificates that CPSC

⁸ OMB BULLETIN NO. 13-01: Revised Delineations of Metropolitan Statistical Areas, Micropolitan Statistical Areas, and Combined Statistical Areas, and Guidance on Uses of the Delineations of these Areas. February 28, 2013.

⁹ Version 3.10 of the ZIP Code Rural-Urban Commuting Areas (RUCAs) geographic taxonomy, August 4, 2014. Center for Rural Health, University of North Dakota School of Medicine and Health Sciences. Comparable data presently available from [USDA ERS - Rural-Urban Commuting Area Codes](#).

receives, the exact location of some incidents (1%) could not be ascertained. The 2019 through 2021 data do not generally show substantial differences between Home Locations and Non-Home Locations. The type with the largest observable difference between home and non-home locations is Sub-Urban locations where 18% of the in-home fatalities occurred vs. only 10% of the non-home location fatalities. All the unknown location incidents appear to have occurred outside of homes. For example, an estimated three non-home, unknown location deaths in 2020 were attributed to deaths either in a greenhouse or shed, but the ZIP Code or location of those enclosures was not found to be on record.

Table 10: Estimated Non-Fire Carbon Monoxide Poisoning Deaths by Population Density of Place of Incident or Death, 2011–2021

RUCA Population Density Designation	2019–2021*		Estimated Percentage of US Population@	Annual Estimates										
	Average Estimate	Average Percents%		2011	2012	2013	2014	2015	2016	2017	2018*	2019*	2020*	2021*
All Locations	227	100%	100%	163	137	146	164	172	178	188	209	254	223	204
Urban Core	115	51%	73%	95	79	84	73	77	108	103	107	127	111	108
Sub-Urban	37	16%	15%	33	25	27	34	41	25	39	51	43	36	32
Large Rural Town	32	14%	6%	14	9	12	19	14	20	13	24	29	35	31
Small Town/Rural Isolated	41	18%	5%	18	19	23	32	39	22	33	27	49	39	34
Unknown Location	3	1%	-	2	6	1	6	1	2	*	*	6	3	*
Home Locations	176	78% (100%)	100%	137	113	121	127	131	150	150	147	181	172	176
Urban Core	87	38% (50%)	73%	78	71	73	63	62	92	83	75	92	81	89
Sub-Urban	32	14% (18%)	15%	28	20	24	29	39	21	33	32	36	31	28
Large Rural Town	26	11% (15%)	6%	14	6	7	14	11	18	9	18	19	32	27
Small Town/Rural Isolated	31	14% (18%)	5%	15	11	15	21	18	18	27	22	34	28	32
Unknown Location	*	*	-	2	5	1	*	*	*	*	*	*	*	*
Non-Home Locations	50	22% (100%)	100%	26	24	26	37	41	28	38	62	72	51	28
Urban Core	27	12% (54%)	73%	18	7	11	11	14	16	21	32	34	29	18
Sub-Urban	5	2% (10%)	15%	5	5	2	5	1	3	6	19	6	5	4
Large Rural Town	5	2% (11%)	6%	*	2	5	5	3	2	5	6	9	3	4
Small Town/Rural Isolated	9	4% (19%)	5%	3	7	8	11	22	4	6	5	16	11	1
Unknown Location	3	1% (6%)	-	*	1	*	6	1	2	*	*	6	3	*

+ Data collection for 2018, 2019, 2020, and 2021 is only partially complete. The corresponding estimates for these 4 most recent years are shown in italics to emphasize the possibility of change in the future if more reports of deaths are received.

% To facilitate comparison of the proportions of RUCA population designations among Home Locations and Non-Locations, the percentages are presented both in relative to the overall all locations average and in parentheses relative to the average for just that subtype.

* No reports received by CPSC staff.

@ Estimated 2010 U.S. population categorized by Rural Urban Commuting Area (RUCA 3.1) designation. U.S. population estimates by RUCA classification were determined by cross-referencing the Center for Rural Health, School of Medicine and Health Sciences, University of North Dakota/Economic Research Service, Department of Agriculture RUCA3.1 ZIP Code table with the 2010 U.S. Census population estimates by ZIP Code area. Data collection for 2018, 2019, 2020, and 2021 may be only partially complete due to apparently incomplete reporting from various states. Italicized estimates may change in the future if more reports of deaths are received.

Source: U.S. Consumer Product Safety Commission / EPHA.

CPSC Death Certificate File, CPSC In-Depth Investigation File, CPSC Injury or Potential Injury Incident File,

National Center for Health Statistics Mortality File, 2011– 2021

Center for Rural Health, University of North Dakota School of Medicine and Health Sciences, ZIP Code RUCA Version 3.10.

Note: Reported annual estimates and estimated averages and percentages may not add to subtotals or totals due to rounding.

Geographical Region of Incident

Table 11 provides a breakout of the CO poisoning deaths characterized by geographic region where the incident occurred. As the table reflects, for the 3 most recent years (2019 to 2021), CO deaths in some of the regions appear to be different from what would be expected based on the percentage of the U.S. population living in these regions. This may indicate that geographic location influences the likelihood of fatal CO poisoning incidents; however, these results may be influenced due to incompleteness of the estimates for a few states. The regional estimates and proportions for recent years, therefore, are not assessed for statistical significance.

The states in each of the regions are set forth in Appendix D.

Table 11: Estimated Non-Fire Carbon Monoxide Poisoning Deaths by Geographical Region of Incident, 2011–2021

Region [‡]	2019–2021 ⁺		Estimated Percentage of US Population [@]	Annual Estimates										
	Average Estimate	Average Percent		2011	2012	2013	2014	2015	2016	2017	2018 ⁺	2019 ⁺	2020 ⁺	2021 ⁺
Total	227	100%	100%	163	137	146	164	172	178	188	209	254	223	204
Northeast	30	13%	17%	43	25	34	37	30	21	11	30	43	25	22
New England	7	3%	5%	16	1	14	8	13	8	4	12	12	3	7
Middle Atlantic	23	10%	13%	27	24	20	29	17	13	7	18	31	23	15
South	77	34%	38%	55	55	43	42	62	55	67	74	74	87	70
East South Central	18	8%	6%	13	7	3	9	11	10	10	20	18	15	20
South Atlantic	36	16%	20%	23	31	20	21	29	27	36	43	38	43	28
West South Central	23	10%	12%	19	17	20	12	22	18	21	11	18	28	22
Midwest	57	25%	21%	33	31	48	40	44	69	61	52	57	54	61
East North Central	42	18%	14%	27	26	27	22	27	44	40	25	41	31	53
West North Central	16	7%	7%	6	5	21	18	17	25	21	27	16	23	8
West	63	28%	24%	32	25	22	44	37	33	50	54	80	58	50
Mountain	23	10%	8%	9	13	8	26	14	18	12	35	32	17	21
Pacific	39	17%	16%	23	12	14	18	23	15	38	18	48	40	29

‡ Region designation is based on U.S. Census Bureau reporting practices. See Appendix D for identification of specific regional designation of state of occurrence.

+ Data collection for 2018, 2019, 2020, and 2021 may be only partially complete due to apparently incomplete reporting from some states. The corresponding estimates for these 4 most recent years are shown in italics to emphasize the possibility of change in the future if more reports of deaths are received from various states.

@ Based on estimated U.S. population statistics for the 3-year average (2019-2021).

Source: U.S. Consumer Product Safety Commission/EPHA.

Appendix A: Methodology

This appendix describes the data sources and methodology used to compute the national estimate of non-fire carbon monoxide (CO) poisoning deaths associated with the use of consumer products and the estimates by product, victim age, and incident location.

All death certificates filed in the United States are compiled by the National Center for Health Statistics (NCHS) into a multiple cause-of-mortality data file. The NCHS Mortality File contains demographic and geographic information as well as the International Statistical Classification of Diseases and Related Health Problems codes for the underlying cause of death. Data are compiled in accordance with the World Health Organization instructions, which request that member nations classify causes of death by the current Manual of the International Statistical Classification of Diseases and Related Health Problems. The International Classification of Diseases, Tenth Revision (ICD-10) was implemented in 1999. Although the NCHS data contain cause-of-death codes that are helpful in identifying deaths due to CO poisoning, the records do not contain any narrative information that might indicate the involvement of a consumer product.

CPSC staff purchases death certificates from the 50 states, New York City, the District of Columbia, and some U.S. territories. Specifically, CPSC staff purchases death certificates with certain cause-of-death codes for which a high probability exists that consumer products are involved. In addition to the cause-of-death codes and demographic and geographic information, the death certificate contains information about the incident location and a brief narrative describing the incident. Any references to consumer products are usually found in these narratives. As resources allow, CPSC staff conducts follow-up In-Depth Investigations (IDIs) on selected deaths to confirm and expand upon the involvement of consumer products. These data from CPSC complement the NCHS mortality data.

ICD-10 classifies deaths associated with CO poisoning with the codes listed below. The focus of this report is accidental CO poisoning deaths, and the report concentrates on deaths coded as X47 and Y17. Deaths coded under Code X67, intentional CO poisonings, are excluded from this analysis.

ICD-10 Code Definitions

X47	Accidental– Poisoning by and exposure to other gases and vapors. Includes: carbon monoxide, lacrimogenic gas, motor (vehicle) exhaust gas, nitrogen oxides, sulfur dioxide, utility gas.
X67	Intentional– Poisoning by and exposure to other gases and vapors. Includes: carbon monoxide, lacrimogenic gas, motor (vehicle) exhaust gas, nitrogen oxides, sulfur dioxide, utility gas.
Y17	Undetermined intent– Poisoning by and exposure to other gases and vapors. Includes: carbon monoxide, lacrimogenic gas, motor (vehicle) exhaust gas, nitrogen oxides, sulfur dioxide, utility gas.

The first step in compiling the annual estimates is computing the total estimates of CO poisoning deaths associated with consumer products. The CPSC's Death Certificate (DTHS) File and the CPSC's Abbreviated Death Certificate (ABDT) File were searched for cases associated with ICD-10 codes X47 and Y17.

Each case in the CPSC's DTHS File that was coded as X47 or Y17 was reviewed by an analyst and categorized as in-scope, out-of-scope, or source of CO unknown or questionable. In-scope cases are unintentional, non-fire CO poisoning deaths associated with a consumer product under the jurisdiction of the CPSC. Out-of-scope cases are cases that involve CO sources that are not under the jurisdiction of the CPSC, fire- or smoke-related exposures, or intentional CO poisonings. Examples of out-of-scope cases include poisonings due to gases other than CO (*i.e.*, natural gas, ammonia, butane); motor vehicle exhaust- or boat exhaust-related poisonings; and work-related exposures. The source of CO was classified as unknown or questionable in cases where a consumer product was possibly associated with the incident, but the exact source of CO was unknown.

The CPSC's ABDT File contains death certificates for CO poisonings (X47 and Y17) that involve motor vehicle exhaust, cases where the source of the CO is unknown, or where the death certificate does not mention a consumer product. Other examples of cases that may appear in the abbreviated file are cases associated with farm accidents, smoke inhalation from a structural fire, or other gas poisonings. Occasionally, newer information from CPSC IDIs may be matched with ABDT cases that were originally classified as having no known source or did not mention a consumer product. If information from IDIs indicated that an ABDT case should be considered in scope, then it was included with the DTHS database files. For 2010 and 2011, no ABDT records were reclassified as in scope. From 2012 through 2017, thirteen cases were reclassified: three cases for 2012; one case for 2013; four cases for 2014; two cases for 2015; one case for 2016; and two cases for 2017. No cases were reclassified for 2018. For 2019, only one ABDT record was reclassified as in scope. So far, no 2020 or 2021 ABDT records have been reclassified as in scope.

In 2016, and to a slightly lesser extent in 2017, the way the state of Texas designated death certificates with the Y17 code seems to have changed. Before 2016, the maximum number of Y17-coded death certificates from any individual state was 21 (Texas itself, in 2013). In 2016, CPSC received 56 Y17-coded death certificates from Texas, and 129 from the entire country. In 2016, Michigan, the second highest number of Y17, had 13. In 2017, death certificates from Texas with the Y17 code dropped to 34 but were still much higher than any state for any year. In 2017, the second highest number of Y17-coded death certificates was only six by Oklahoma and Oregon. NCHS records indicate 94 Y17s in 2016, and 85 in 2017. For these two years, CPSC has 90 Y17-coded death certificates from Texas, more than the rest of the country combined. Clearly, in 2016 and 2017, some discrepancy exists with the way Texas codes Y17 death certificates compared to the rest of the states in the country. As noted in last year's report, it appeared as though there were many 2018 death certificates missing from the CPSC database as of that report's search date cutoff. That report anticipated additional collection from particular states, but only a few additional death certificates have been received—one of which is of unknown scope (a CO fatality for which it is unknown whether the source was a consumer product) and the remainder are out of scope. CPSC data for 2019 also appears to remain incomplete from some states, even if most are complete with no additional death certificates received after September 2023. Therefore, the total count of death certificates remains unchanged since last year's report. And with reporting still incomplete for 2018, 2019, 2020, and 2021, no comparable adjustments are made for these four years.

Thus far, Texas, Washington, and Wisconsin have reported considerably fewer relevant deaths for the years 2018 through 2021 than typical of previous years. Therefore, the death certificate data available to CPSC for 2018 through 2021 likely underrepresent the distribution of deaths among those three states (*i.e.*, Texas, Washington, and Wisconsin). Estimation methodologies in this report generally assume randomized non-reporting, which does not appear to represent an accurate assumption at the individual state level for 2018 through 2021. To a lesser degree, incomplete estimates *by region* may also merit some skepticism for the incomplete years 2018 through 2020. Despite these caveats, the incomplete estimates for 2018 through 2021 nevertheless provide valuable information in assessing the U.S. as a whole.

To compensate for the apparent anomalies in 2016 and 2017, this report maintains the previous report's substitution of the average yearly number of Y17 reports from the prior 10 years for Texas, in place of the 2016 and 2017 count of Texas Y17s in the scaling calculations. The average number of Y17-coded death certificates from the previous 10 years is 7.6. However, no similar compensation appears appropriate yet for more recent years, 2018 through 2020, because data collection remains incomplete.

Since the release of the previous annual report, additional records have been entered into the CPSC databases, resulting in recalculations for 2018, 2020, and 2021 (there was no substantial change in reporting of additional 2019 death certificates). The initial categorizations for 2018, 2020, and 2021 have been recalculated and are presented in Table A.1.a, Table A.1.b, and Table A.1.c. For 2018, no new in-scope fatalities were found; however, one unknown scope death certificate and several additional death certificates found to be out of scope produce only a slight change in the weighting factors for 2018 estimates and, consequently, a slight reduction for that year (from last year's calculation of 210 deaths) to a currently updated estimate of 209 deaths for 2018. Substantial additional information regarding 2020 incidents supported changes in classification. Last year's report

presented an estimate of only 211 deaths in 2020; however, these updates result in a current estimate of 223 deaths in 2020. The current estimate for 2021 is extrapolated based on presently available data; however, it may be especially affected by substantial delays in reporting from various states.

Table A.1.a: Initial Categorization for 2018 Data

ICD-10 Code	NCHS Total	CPSC DTHS File & ABDT File				Number of Cases to be Imputed
		In-Scope	Unknown Scope	Out-of-Scope	Total	
X47	896	164	29	570	763	162
Y17	106	8	11	91	110	7
Total	1,002	172	40	661	873	169

¹ "NCHS Total" cases, minus "Total in CPSC Database," plus "Unknown Scope" from DTHS (e.g., for X47, 896-763+29 = 162).

Source: U.S. Consumer Product Safety Commission/EPHA.

CPSC Death Certificate File, CPSC In-Depth Investigation File, Abbreviated Death Certificate File, National Center for Health Statistics Mortality File, 2018.

Table A.1.b: Initial Categorization for 2020 Data

ICD-10 Code	NCHS Total	CPSC DTHS File & ABDT File				Number of Cases to be Imputed
		In-Scope	Unknown Scope	Out-of-Scope	Total	
X47	983	171	33	599	803	213
Y17	93	4	1	82	87	7
Total	1,076	175	34	681	890	220

¹ "NCHS Total" cases, minus "Total in CPSC Database," plus "Unknown Scope" from DTHS.

Source: U.S. Consumer Product Safety Commission/EPHA.

CPSC Death Certificate File, CPSC In-Depth Investigation File, Abbreviated Death Certificate File, National Center for Health Statistics Mortality File, 2020.

Table A.1.c: Initial Categorization for 2021 Data

ICD-10 Code	NCHS Total	CPSC DTHS File & ABDT File				Number of Cases to be Imputed
		In-Scope	Unknown Scope	Out-of-Scope	Total	
X47	1,021	146	37	594	777	281
Y17	131	0	7	90	97	41
Total	1,152	146	44	684	874	322

¹ "NCHS Total" cases, minus "Total in CPSC Database," plus "Unknown Scope" from DTHS.

Source: U.S. Consumer Product Safety Commission/EPHA.

CPSC Death Certificate File, CPSC In-Depth Investigation File, Abbreviated Death Certificate File, National Center for Health Statistics Mortality File, 2021.

The proportion of death certificates found in the CPSC database associated with non-fire, unintentional X47 or Y17 deaths and associated with consumer products was applied to the NCHS totals to calculate the total estimated number of non-fire CO poisoning deaths associated with consumer products. In theory, the NCHS totals comprise all death certificates in the United States, and the same proportion of in-scope cases should exist in the death certificates that are missing from the combined CPSC Death Certificate and Abbreviated Death Certificate files or are from an unknown source. Applying the proportion of in-scope cases to the NCHS database totals, therefore, should provide an estimate of in-scope cases nationwide. This was done in the following way for ICD-10 codes X47 and Y17, separately:

1. The number of in-scope deaths in the CPSC's two death certificate files coded under the specific ICD-10 code that were associated with an accidental non-fire CO poisoning and a consumer product were identified (n_1).
2. The total number of deaths (i.e., in-scope and out-of-scope) in the CPSC's Death Certificate File and the Abbreviated Death Certificate File coded under the specific ICD-10 code were summed separately, excluding cases with an unknown or highly questionable source (n_2).
3. The total number of deaths in the NCHS data coded under the specific ICD-10 code was counted (n_3).
4. The estimate of the number of non-fire CO poisoning deaths associated with consumer products under the specific ICD-10 code was calculated, using the formula:

$$N = (n_1 / n_2) * n_3$$

The proportion (n_1 / n_2) represents the number of in-scope cases found in the CPSC's files, divided by the total of in-scope and out-of-scope cases.

5. The estimates of the number of non-fire CO poisoning deaths associated with consumer products under the specific ICD-10 codes were summed to calculate the total estimate of non-fire CO poisoning deaths.

$$\text{Total Estimate} = N_{X47} + N_{Y17}$$

The ratio (n_3 / n_2) represents the weighting factor used to calculate the annual estimates. The CPSC's Death Certificate File does not contain death certificates for all deaths listed in the NCHS file; therefore, this weighting factor was calculated to account for death certificates that are missing, thereby allowing the computation of national estimates of CO deaths by consumer products and by other characteristics collected by CPSC about each death.

Tables A.2.a, A.2.b, and A.2.c contain the values for the variables used in the calculation, as well as the resulting computed estimates of CO poisoning deaths, for 2018, 2020, and 2021, respectively.

Table A.2.a: Calculation Detail of the Final Computed 2018 Estimate of Non-Fire CO Poisoning Deaths Associated with Consumer Products

Variable	ICD-10 Code	
	X47	Y17
n_1	164	8
n_2	$763 - 29 = 734$	$110 - 11 = 99$
n_3	896	106
<i>Weighting Factor (n_3 / n_2)</i>	1.2207	1.0707
N	200.1969	8.5657
Total Estimate	$\{200.1969 + 8.5657 = 208.7618 \approx 209\}$	

Source: U.S. Consumer Product Safety Commission/EPHA. CPSC Death Certificate File, CPSC In-Depth Investigation File, Abbreviated Death Certificate File, National Center for Health Statistics Mortality File 2018.

Table A.2.b: Calculation Detail of the Final Computed 2020 Estimate of Non-Fire CO Poisoning Deaths Associated with Consumer Products

Variable	ICD-10 Code	
	X47	Y17
n ₁	171	4
n ₂	803 – 33 = 770	87 – 1 = 86
n ₃	983	93
<i>Weighting Factor (n₃ / n₂)</i>	1.2766	1.0814
N	218.3026	4.3256
Total Estimate	{218.3026 + 4.3256 = 222.6328 ≈ 223}	

Source: U.S. Consumer Product Safety Commission/EPHA. CPSC Death Certificate File, CPSC In-Depth Investigation File, Abbreviated Death Certificate File, National Center for Health Statistics Mortality File 2020.

Table A.2.c: Calculation Detail of the Final Computed 2021 Estimate of Non-Fire CO Poisoning Deaths Associated with Consumer Products

Variable	ICD-10 Code	
	X47	Y17
n ₁	146	0
n ₂	777 – 37 = 740	97 – 7 = 90
n ₃	1,021	131
<i>Weighting Factor (n₃ / n₂)</i>	1.3797	1.4556
N	201.4405	0
Total Estimate (before correction)	{201.4405 + 0 = 201.4405 ≈ 201}	

Source: U.S. Consumer Product Safety Commission/EPHA. CPSC Death Certificate File, CPSC In-Depth Investigation File, Abbreviated Death Certificate File, National Center for Health Statistics Mortality File 2021.

Comparing the total estimate shown in Table A.2.c against counts of *reported* deaths observed earlier in this report suggests underestimation in the final result of Table A.2.c. Table 4 showed that CPSC is aware of 204 reported deaths (204 deaths related to 169 distinct incidents, with some incidents involving multiple deaths). The count of reported deaths can include deaths for which CPSC does not have any death certificate, so it is possible (even if uncommon) for the count of reported deaths to exceed the initial death estimate such as it does for 2021. To avoid the logical contradiction of *estimating* fewer deaths than reported, estimates are further adjusted for the year 2021 in this report so that the overall total estimate equals 204 (consistent with the count of reported deaths). As no Y17 ICD-10 Coded death certificates were found in scope for year 2021, the Y17 weighting factor for 2021 can be disregarded as inconsequential within this report. This leaves only the X47 weighting factor to affect estimates and other associated statistics. Consequently, dividing the number of reported deaths in 2021 (204) by the number of reported in scope death certificates (146) produces an X47 weighting factor of 1.3973 (204/146) that would have resulted in an estimate of 204 deaths. Substituting this in place of the initial weighting factor calculation changes the initially computed X47 weighting factor for 2021 by slightly more than one percent ($1.3973/1.3797-1= 0.012756$), while avoiding an apparently contradictory result.

Death certificates received by NCHS are routinely checked for accuracy of state personnel-identified ICD-10 coding. On occasion, NCHS staff will correct codes before entering the data into their databases. CPSC staff, however, does not have access to NCHS records that would allow CPSC to harmonize its records with NCHS's records. CPSC receives death certificate facsimiles or electronic death certificates directly from the states before any possible corrections are deemed necessary per NCHS procedures. Consequently, there may be slight discrepancies between final NCHS counts and CPSC records. For this report, CPSC staff has assumed that, over time, the number of death certificates with ICD-10 codes changed by NCHS staff to the codes of interest (X47 and Y17), would equal approximately those changed to codes other than X47 or Y17, thereby having little long-term effect on the estimates.

Table A.3 shows the weighting factors used to calculate the estimates for the years 2011–2021, based on the information available to CPSC staff. For the most recent year 2021, the X47 weighting factor is adjusted so that the 2021 estimate is not exceeded by the number of reported deaths for 2021 (resulting in a change from 1.3797 to 1.3973).

Table A.3: CO Fatality Cases and Weighting Factors Used to Calculate the Estimates for the Years 2011–2021

Year	NCHS Total	Total in CPSC Databases*	In-Scope Cases	Weighting Factor
2011				
X47	786	730	143	1.0767
Y17	89	76	8	1.1711
2012				
X47	736	591	109	1.2453
Y17	114	84	1	1.3571
2013				
X47	704	608	123	1.1579
Y17	76	60	3	1.2667

2014				
X47	803	679	137	1.1826
Y17	106	61	1	1.7377
2015				
X47	847	665	134	1.2737
Y17	91	53	1	1.7170
2016				
X47	921	822	154	1.1204
Y17	94	72.6	4	1.2948
2017				
X47	936	770	150	1.2156
Y17	85	75.6	5	1.1243
2018				
X47	896	734	164	1.2207
Y17	106	99	8	1.0707
2019				
X47	1,002	761	193	1.2979
Y17	112	112	3	1.0000
2020				
X47	983	747	160	1.3159
Y17	93	85	4	1.0941
2021				
X47	1,021	740	146	1.3973
Y17	131	90	0	1.4556

* This is the total number of deaths in the Death Certificate File and Abbreviated Death Certificate File, excluding deaths associated with an unknown or questionable source of CO.

Source: U.S. Consumer Product Safety Commission/EPHA. CPSC Death Certificate File, CPSC In-Depth Investigation File, Abbreviated Death Certificate File, National Center for Health Statistics Mortality File, 2011–2021.

Incidents with unknown or highly questionable CO sources were excluded from the denominator (the number of deaths in the CPSC databases) of the weighting factor. The group of cases with unknown or highly questionable sources was assumed to contain the same proportion of cases associated with a consumer product as the group of cases within the CPSC database with known CO sources (this is the same assumption that is made for cases where the death certificate is missing). To include these cases within the denominator assumes that these cases can be classified as in-scope or out-of-scope cases when their scope status is unknown. Therefore, for weighting purposes, cases with unknown or questionable sources were treated in the same way as missing cases.

In-scope cases were examined further to determine which product was associated with the incident. Additional information on the CO deaths was obtained from review of the CPSC's IDI File.

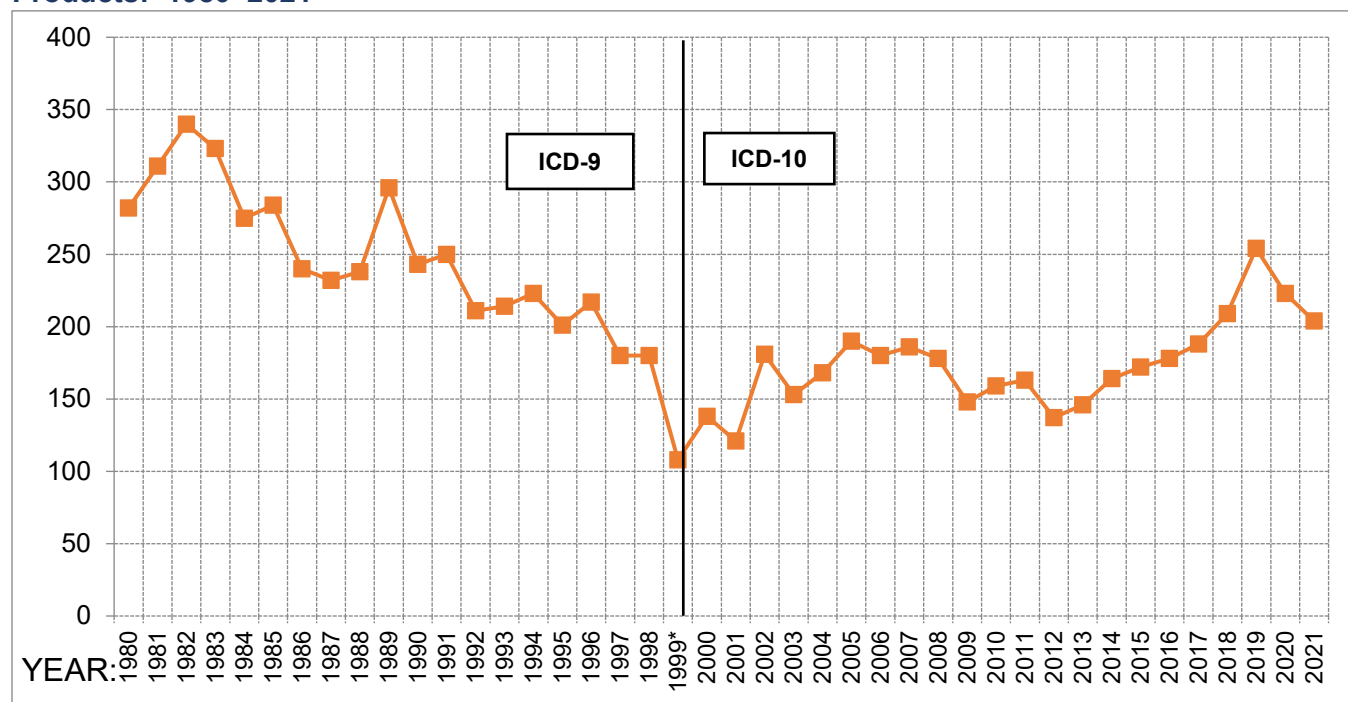
Reports of non-fire CO poisoning deaths were retrieved from the DTHS and ADBT files, based on the following criteria: date of death between January 1, 2011 and December 31, 2021, and ICD-10 code of X47 or Y17. Death certificates entered in the CPSC's database before September 20, 2024 were included in this analysis. Whenever possible, each CO death was reviewed and coded according to the consumer product and type of fuel involved, incident location, and whether multiple deaths were associated with the same incident.

In Table 1 of this report, the *Heating Systems* category includes CO poisoning deaths from subcategories for furnaces and boilers (combined under the heading of *Furnaces*), vented floor and wall heaters, unvented room/space heaters, unvented portable heaters, and other miscellaneous heating systems. Each subcategory is further delineated by fuel type used. Deaths associated with charcoal burned alone and in the absence of an appliance (e.g., in a pail or in the sink) were presented with *Charcoal/Charcoal Grills*, even though this practice typically is done for heating purposes. Examples of products historically included in the *Other Products* category include LP gas refrigerators and gas pool heaters. LP gas grill, LP fish cooker, and other LP gas portable cooking appliance incidents are classified in the *Grills, Camp Stoves* category. Deaths where multiple fuel-burning products were used simultaneously, such that a single source of the fatal CO could not be determined, were classified under *Multiple Products*. *Engine-Driven Tools* included generators and power gardening equipment, such as power lawn mowers, garden tractors, concrete cutters, gasoline-powered water pumps, and snow blowers. Generators that were original equipment installed on a recreational vehicle (RV), trailer, camper, or boat were considered out of scope because they are likely outside the jurisdiction of the CPSC.

Appendix B: National Estimates and Mortality Rates of Consumer Product-Related CO Poisoning Deaths, 1980 to 2021

Figure B.1 below graphically depicts trends of the estimated CO deaths from 1980 to 2021. Before the implementation of the ICD-10 coding in 1999, the estimated number of non-fire, consumer product-related CO poisoning deaths decreased from the early 1980s to the late 1990s, from a high of 340 in 1982, to a low of 180 in both 1997 and 1998. In 1999, there were an estimated 108 consumer product-related CO deaths, well below the estimated 180 deaths in each of the two previous years. The difference may be due, in part, to the change from ICD-9 coding to ICD-10 coding, where product identification could be assessed more accurately. As can be seen in the graph below, 2018 was the first year since ICD-10 was implemented in 1999 to exceed 200 CO fatalities before increasing to an estimated 254 such fatalities in 2019. Although the 2020 estimate decreased relative to the high in 2019, the 2020 estimate otherwise exceeds all prior estimates since ICD-10 implementation. Although based on only partially completed reporting, the currently available estimate of 204 deaths for the year 2021 similarly exceeds all the years between 1999 and 2017. Some part of the longer-term increase may be contributed to by population growth. According to the U.S. Census, the U.S. population grew by about 19 percent between 1999 and 2021.

Figure B.1: Estimated Non-Fire CO Poisoning Deaths Associated with Consumer Products: 1980–2021



*Implementation of ICD-10.

Source: U.S. Consumer Product Safety Commission/EPHA. CPSC Death Certificate File, CPSC Injury or Potential Injury Incident File, CPSC In-Depth Investigation File, 1980–2021.

Estimated 3-Year CO Mortality Trends

Table B.1 presents 3-year centered moving averages of mortality rates from 1980 and 2021. The 3-year centered moving average mortality rate is presented in the table for the mid-point year, requiring estimates for the year before and after for calculation. Consequently, although annual fatality estimates are included for the most recent year 2021, the corresponding 3-year centered moving average mortality rate cannot yet be calculated for 2021. The estimated 3-year centered moving average mortality rate decreased from the 1982 high of 14.02 per 10 million population to 4.34 per 10 million in 2000, a reduction of 69 percent. Subsequently, it increased annually through 2006, to a rate of 6.21. Since 2006, the rate slowly dropped to the 2013 estimate of 4.71, before reversing the trend and rising in the 2019 estimate to a rate of 6.95 and staying similarly high at 6.87 in the most recent calculable year of 2020. The 2019 and 2020 rate estimates both exceed the 2006 estimate of 6.21, which included the effects of the devastation of Hurricane Katrina and other 2005 hurricanes.

Table B.1: Estimated Non-Fire Carbon Monoxide Poisoning Death Rates Associated with Consumer Products, 1980–2021*

Year	Estimate	U.S. Population Estimates (thousands)	3-Year Centered Moving Average Mortality Rate per 10 Million Population
1980	282	227,225	-
1981	311	229,466	13.55
1982	340	231,664	14.02
1983	323	233,792	13.38
1984	275	235,825	12.47
1985	284	237,924	11.19
1986	240	240,133	10.49
1987	232	242,289	9.77
1988	238	244,499	10.44
1989	296	246,819	10.49
1990	243	249,623	10.53
1991	250	252,981	9.27
1992	211	256,514	8.77
1993	214	259,919	8.31
1994	223	263,126	8.08
1995	201	266,278	8.02
1996	217	269,394	7.40
1997	180	272,647	7.05
1998	180	275,854	5.66
1999*	108	279,040	5.09

2000	138	282,172	4.34
2001	121	285,082	5.15
2002	181	287,804	5.27
2003	153	290,326	5.76
2004	168	293,046	5.81
2005	190	295,753	6.06
2006	180	298,593	6.21
2007	186	301,580	6.01
2008	178	304,375	5.61
2009	148	307,007	5.27
2010	159	309,322	5.07
2011	163	311,557	4.91
2012	137	313,831	4.74
2013	146	315,994	4.71
2014	164	318,301	5.05
2015	172	320,635	5.34
2016	178	322,941	5.55
2017	188	324,986	5.90
2018	209	326,688	6.64
2019	254	328,240	6.95
2020	223	331,512	6.87
2021	204	332,032	-

Note: The 3-year centered moving average mortality rate is reported at the mid-point year.

* The Tenth Revision of the International Statistical Classification of Diseases and Related Health Problems (ICD-10) was implemented.

Source: U.S. Consumer Product Safety Commission/EPHA.

U.S. Census Bureau, Population Division. Annual Estimates of the Resident Population by Sex, Age, Race, and Hispanic Origin for the United States and States: April 1, 2010 to July 1, 2020. June 2021.

U.S. Census Bureau, Population Division. Annual Estimates of the Resident Population by Sex, Age, Race, and Hispanic Origin for the United States and States: April 1, 2020 to July 1, 2023. June 2024.

Before implementation of ICD-10 in 1999, generating estimates for generators and other engine-driven tools was not possible.¹⁰ With the advent of ICD-10 coding, generating estimates of deaths associated with generators and other engine-driven tools is now possible.

¹⁰ See Appendix B of Mah (2001) for details.

Table B.2 presents a summary of the mortality rates associated with generators, which steadily increased from 1999 through 2006 but retracted until 2011. However, the rate generally increased after 2013, with the recent 3-year centered moving average for 2019 to 2021 as the highest level (2.97) so far, exceeding the previously highest rate of 2.69 in 2006, which included the Hurricane Katrina impact of 2005. This most recent calculable 3-year centered moving average mortality rate in 2020 for generators alone is more than five times greater than that in 2000.

**Table B.2: Estimated Non-Fire Carbon Monoxide Poisoning Death Rates
Associated with Generators, 1999–2021***

Year	Estimate ⁺	U.S. Population (thousands)	3-Year Centered Moving Average Mortality Rate per 10 Million Population
1999	7	279,040	-
2000	19	282,172	0.54
2001	20	285,082	0.95
2002	42	287,804	1.29
2003	49	290,326	1.52
2004	41	293,046	2.02
2005	88	295,753	2.41
2006	85	298,593	2.69
2007	68	301,580	2.53
2008	76	304,375	2.28
2009	64	307,007	1.98
2010	42	309,322	1.83
2011	64	311,557	1.74
2012	57	313,831	1.88
2013	56	315,994	1.76
2014	54	318,301	2.03
2015	84	320,635	2.13
2016	67	322,941	2.54
2017	95	324,986	2.51
2018	83	326,688	2.85
2019	101	328,240	2.80
2020	92	331,512	2.97
2021	102	332,032	-

* Estimates are based on single-source product incidents as multiple-source incidents could be included in multiple categories.

+ Estimates in this table do not include multiple product-related deaths because a generator was not the sole product associated with the fatality.

Note 1: The 3-year centered moving average mortality rate is reported using the mid-year population estimates.

Note 2: Mortality rate changes from last year's report are due to changes in CPSC CO death estimates and changes in U.S. Census population estimates.

Table B.3 shows the CO poisoning mortality rates associated with all consumer products, excluding generators. The data indicate that, when generators are excluded, there does not appear to be a trend in the mortality rate for consumer product-related CO deaths. The 2000, 3-year centered moving annual average mortality rate was 3.60. The 2020, 3-year centered moving average mortality rate was 3.71 and has risen each year since the 2016 low of 2.66.

Table B.3: Estimated Non-Fire Carbon Monoxide Poisoning Death Rates Associated with Consumer Products (Excluding Generator-Related Deaths),* 1999-2021

Year	Estimate ⁺	U.S. Population (thousands)	3-Year Centered Moving Average Mortality Rate per 10 Million Population
1999	95	279,040	-
2000	117	282,172	3.60
2001	93	285,082	3.93
2002	126	287,804	3.65
2003	96	290,326	3.93
2004	120	293,046	3.48
2005	90	295,753	3.35
2006	87	298,593	3.07
2007	98	301,580	3.04
2008	90	304,375	2.86
2009	73	307,007	2.88
2010	102	309,322	2.87
2011	91	311,557	2.87
2012	75	313,831	2.67
2013	85	315,994	2.77
2014	103	318,301	2.80
2015	79	320,635	2.85
2016	92	322,941	2.66
2017	87	324,986	3.01
2018	114	326,688	3.47
2019	139	328,240	3.85
2020	127	331,512	3.71
2021	102	332,032	-

* Estimates are based on single-source product incidents as multiple-source incidents could be included in multiple categories.

+ Excludes estimates of deaths associated with a generator only.

Note 1: The 3-year centered moving average mortality rate is reported using the mid-year population estimates.

Note 2: Mortality rate changes from last year's report are due to changes in CPSC CO death estimates and changes in U.S. Census population estimates.

Table B.4 shows the 3-year centered moving average mortality rates of all engine-driven tools, including generators. Although the average mortality rates for 2007 through 2011 have dropped slightly since the 2006 high (3.18), recent mortality rates have exceeded that prior high for each the three most recent calculable years 2018 (3.29), 2019 (3.28), and 2020 (3.38). The table shows that the 3-year centered moving average mortality rate has more than quadrupled from the rate in 2000 (0.71), to 2020 (3.38).

Table B.4: Estimated Non-Fire Carbon Monoxide Poisoning Death Rates Associated with Generators and Other Engine-Driven Tools, 1999–2021*

Year	Estimate ⁺	U.S. Population (thousands)	3-Year Centered Moving Average Mortality Rate per 10 Million Population
1999	13	279,040	-
2000	26	282,172	0.71
2001	21	285,082	1.16
2002	52	287,804	1.49
2003	56	290,326	1.88
2004	56	293,046	2.43
2005	102	295,753	2.95
2006	104	298,593	3.18
2007	79	301,580	2.93
2008	82	304,375	2.60
2009	76	307,007	2.32
2010	56	309,322	2.21
2011	73	311,557	2.06
2012	64	313,831	2.18
2013	68	315,994	2.05
2014	62	318,301	2.32
2015	92	320,635	2.43
2016	80	322,941	2.85
2017	104	324,986	2.90
2018	99	326,688	3.29
2019	119	328,240	3.28
2020	106	331,512	3.38
2021	110	332,032	-

* Estimates are based on single-source product incidents as multiple-source incidents could be included in multiple categories.

+ Estimates in this table do not include multiple product-related deaths because an EDT was not the sole product associated with the fatality. The one exception to this is the 2001 estimate that includes one estimated death associated with a generator and another EDT.

Note 1: The 3-year centered moving average mortality rate is reported using the mid-year population estimates.

Note 2: Mortality rate changes from last year's report are due to changes in CPSC CO death estimates and changes in U.S. Census population estimates.

Table B.5 shows the CO mortality rates associated with all consumer products, excluding generators and other engine-driven tools. The data indicate that the 3-year centered moving average mortality rate decreased by about 8 percent for non-engine-driven tool consumer products (*i.e.*, excluding generators and other engine-driven tools), from the 2000 rate of 3.44, to the 2020 rate of 3.19. However, over the 11-year period from 2006 to 2017, the associated non-EDT CO average mortality rates remained relatively consistent, fluctuating in a narrow band between 2.35 and 2.64 per 10 million population. The most recent calculable rates of 2018 (3.02), 2019 (3.24), and 2020 (3.19) each exceed all of the mortality rates observed throughout that period by at least 14percent or more.

Table B.5: Estimated Non-Fire Carbon Monoxide Poisoning Death Rates Associated with Consumer Products (Excluding Generator- and Other Engine-Driven Tool-Related Deaths), 1999–2021*

Year	Estimate ⁺	U.S. Population (thousands)	3-Year Average Mortality Rate per 10 Million Population
1999	89	279,040	-
2000	110	282,172	3.44
2001	92	285,082	3.72
2002	116	287,804	3.44
2003	89	290,326	3.56
2004	105	293,046	3.07
2005	76	295,753	2.81
2006	68	298,593	2.58
2007	87	301,580	2.64
2008	84	304,375	2.54
2009	61	307,007	2.53
2010	88	309,322	2.49
2011	82	311,557	2.55
2012	68	313,831	2.37
2013	73	315,994	2.49
2014	95	318,301	2.50
2015	71	320,635	2.55
2016	79	322,941	2.35
2017	78	324,986	2.62
2018	98	326,838	3.02
2019	120	328,330	3.24
2020	102	331,527	3.19
2021	94	332,049	-

* Estimates are based on single-source product incidents as multiple-source incidents could be included in multiple categories.

+ Excludes estimates of deaths associated with EDTs only. Multiproduct-associated incidents are included here because an EDT could not be identified as the only product involved. The one exception to this is the 2001 estimate, which excludes one estimated death associated with a generator and another EDT.

Note 1: The 3-year centered moving average mortality rate is reported using the mid-year population estimates.

Note 2: Mortality rate changes from last year's report are due to changes in CPSC CO death estimates and changes to U.S. Census estimates.

Summary of Tables B.1 – B.5

When all consumer products are considered, there has been a 58-percent increase in the CO mortality rate, from a 3-year centered moving average mortality rate of 4.34 in 2000 to 6.87 in 2020, as shown in Table B.1. Engine-driven tools and generators have had a substantial impact on the increase in the CO poisoning mortality rate involving consumer products. But, in recent years, non-generator-related CO fatalities have also been on the rise.

Appendix C: Chi-Squared Test Results

Age Group Test Result

Table 7 shows the estimated number of CO poisoning deaths categorized by victim age for the 11 most recent years of data (2011–2021). For the Chi-Square statistical analysis, the two younger groups (“Under 5” and “5–14”) were combined due to their small estimated averages. Chi-Square goodness-of-fit test results indicate a statistically significant difference between the proportion of CO victims in each age group from the general U.S. population. Each age group was analyzed separately, versus the expected proportion of the respective age group, based on U.S. population figures (assuming there was no age group effect on the CO poisoning fatality rate), to determine which age group proportions were significantly different from expectations. Binomial tests indicate that all five individual groups were found to be significantly different from what would be expected if there was no population group effect:

1. The “Under 15” group¹¹ was significantly lower (< 0.0001).
2. The “15–24” group was significantly lower (< 0.0009).
3. The “25–44” group was significantly lower (< 0.0131).
4. The “45–64” group was significantly higher (< 0.0001).
5. The “65 and over” group was also significantly higher (< 0.0001).

Sex Group Test Result

Table 8 presents the distribution of estimated CO deaths categorized by sex. For 2019–2021, the average percentage of male CO victims was about 76 percent, and the average percentage of female victims was about 23 percent. By contrast, about 49 percent of the U.S. population is male, and 51 percent of the U.S. population is female.¹² The sex-related differences in CO Poisoning deaths were confirmed to be statistically significant (p -value < 0.0001).

Ethnicity/Race Group Test Result

Table 9 provides a summary of CO fatality victims characterized by race/ethnicity for the years 2011 through 2021. Estimates of the percentage of the U.S. population categorized into the various race/ethnicity groupings were based on single-race characterizations, as represented in the U.S. Census Bureau reports. Individuals reported as multi-race are included in the *Unknown/Other/Mixed* category.

Chi-square goodness-of-fit test results do *not* indicate significant statistical differences between the proportion of CO victims categorized by race/ethnicity from that of the general U.S. population. Each race/ethnicity group was analyzed separately, versus the expected proportion of the respective race/ethnicity group based on U.S. population figures, assuming there was no

¹¹ “Under 5” and “5–14” groups were combined due to small sample sizes.

¹² Three-year average, 2019 to 2021, from July U.S. Census estimates of the U.S. population. June 2024

race/ethnicity group effect on the CO poisoning fatality rate. A Chi-Square statistical analysis was performed to determine which race/ethnicity group proportions were significantly greater than or less than the expectation. For the Chi-Square analysis, the three smaller groups (“Asian/Pacific,” “American Indian,” and “Unknown/Other/Mixed”) were combined due to their relatively small proportion of the U.S. population. Binomial tests do not indicate any race/ethnicity groups were statistically significantly different from the expected proportion based on the U.S. population. Although the estimated proportion of Hispanic CO deaths was lower than the proportion of Hispanics in the U.S. population, the difference is not statistically significant. Although the proportion of non-Hispanic White CO deaths was higher than the proportion of non-Hispanic White Americans in the U.S. population, the difference is not statistically significant. Although non-Hispanic Black or African Americans (15% of CO deaths) were estimated to be involved in a slightly higher proportion of deaths than their U.S. population proportion (13%), the difference is not statistically significant. Similarly, no significant differences were found when comparing the proportion of CO deaths and population proportion for the group of remaining race/ethnicities.

Appendix D: Regional Definitions

- 1) The Northeast region comprises New England and Middle Atlantic states.
 - a) New England: Maine, New Hampshire, Vermont, Massachusetts, Rhode Island, and Connecticut.
 - b) Middle Atlantic: New York, New Jersey, and Pennsylvania.
- 2) The Midwest region comprises East North Central and West North Central states.
 - a) East North Central: Ohio, Indiana, Illinois, Michigan, and Wisconsin.
 - b) West North Central: Minnesota, Iowa, Missouri, North Dakota, South Dakota, Nebraska, and Kansas.
- 3) The South region comprises South Atlantic, East South Central and West South-Central states.
 - a) South Atlantic: Delaware, Maryland, District of Columbia, Virginia, West Virginia, North Carolina, South Carolina, Georgia, and Florida.
 - b) East South Central: Kentucky, Tennessee, Alabama, and Mississippi.
 - c) West South Central: Arkansas, Louisiana, Oklahoma, and Texas.
- 4) The West region comprises Mountain and Pacific states.
 - a) Mountain: Montana, Idaho, Wyoming, Colorado, New Mexico, Arizona, Utah, and Nevada.
 - b) Pacific: Washington, Oregon, California, Alaska, and Hawaii.

Source: U.S. Census Bureau 2012 Statistical Abstract <http://www.census.gov/compendia/statab/cats/population.html>

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