United States
Consumer Product Safety Commission

Non-Fire Carbon Monoxide Deaths Associated with the Use of Consumer Products 2022 Annual Estimates

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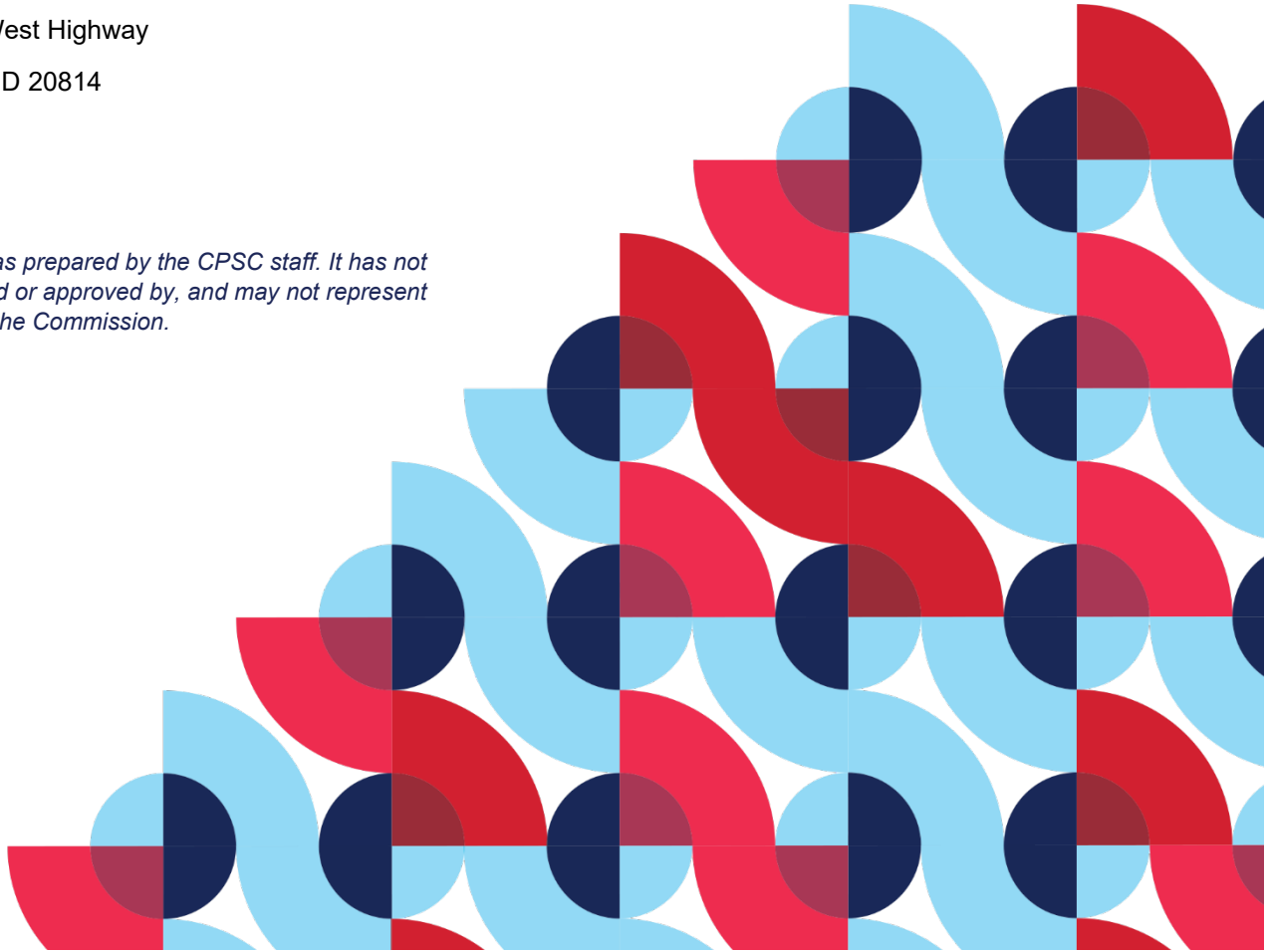

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Executive Summary

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 2022, along with companion statistics since 2012. Because the U.S. Consumer Product Safety Commission (CPSC) has not received reports of deaths from every state for 2018, 2019, 2020, 2021, and 2022, the estimates for those years may change in subsequent reports.

Some of the key findings[1] in this report are:

For 2022:

- CPSC has records from 182 reported incidents resulting in an estimated 274 unintentional, non-fire CO poisoning deaths associated with the use of consumer products under the CPSC's jurisdiction.
- Twenty-one percent of the 182 reported incidents involved multiple deaths, including 3 incidents where three people died, and 35 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. A substantial proportion (107 or 39%) of the *estimated* 274 non-fire CO poisoning deaths associated with consumer products involved an EDT.[2] Ninety-three (93) of the 107 estimated EDT-associated deaths involved generators.[3]
- Heating Systems were associated with the second largest percentage of non-fire CO poisoning deaths. An estimated 76 deaths (28%) were associated with some type of heating appliance.
- Sixty-four percent of the estimated 274 CO deaths in 2022 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.

[1] Note that the estimates for individual categories may not sum to that of the broader category due to rounding.
[2] Estimate for EDTs above excludes multiple product-associated incidents. Including incidents associated with *multiple* products, EDTs are estimated associated with *almost* half of the deaths (129 or 47%).
[3] Similarly, these estimates exclude incidents associated with multiple products, such as carbon monoxide poisonings associated with the combination of a generator and other carbon monoxide-emitting products.

- In 2022, males constituted an estimated 78 percent of CO poisoning victims. Among reported single-fatality incidents, males constituted 87 percent of victims; among reported multiple-fatality incidents, males constituted 58 percent of victims.

For 2020-2022:

- The estimated annual average from 2020 to 2022 was 238 unintentional, non-fire CO poisoning deaths.
- Most CO deaths occurred in the colder months of the year, with more than half (59%) of the deaths occurring during the four cold months of November, December, January, and February.
- Almost half (46%) of the estimated average number of CO deaths in these years were associated with an engine-driven tool (and no other products).
- Adults 45 years and older constituted on average about 67 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 3 percent of the yearly CO poisoning.

For 2012-2022:

- Staff found evidence of a statistically significant upward trend in non-fire CO deaths for the 11-year period from 2012 to 2022. The estimated number of consumer product-related CO deaths peaked in 2022, the final year of this 11-year period.
- Since 2012, generators alone have been associated with an estimated 892 non-fire CO poisoning deaths, accounting for 41 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.

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

[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.

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 received and entered into a CPSC database no later than September 23, 2025. These reports are then compared to mortality data from the National Center for Health Statistics (NCHS), which 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, particularly the Y17 code. 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, 2021, and 2022 data. Measured in terms of the number of months/states with at least one death certificate (of any ICD-10-code type) reported to CPSC and entered by or before September 23, 2025, completeness is measured at 98% for 2018, 97% for 2019, 98% for 2020, 95% for 2021 and 90% for 2022. More recent years excluded from this report include 2023 at 83% complete and 2024 at 73%. As of September 23, 2025 Washington state had not reported a single death certificate to CPSC regarding any of the years 2018, 2019, 2020, 2021, or 2022 (or thereafter). Subsequently, Washington State has reported deaths to CPSC for the years 2020, 2021, 2022, and 2023, however, such data was received too recently to inform the overall analysis of this report. The year 2023 is excluded from this report in part because even as recently as April 30, 2026 four other states (Missouri, Mississippi, North Carolina, and South Carolina) have not yet reported even a single death certificate to CPSC, and reporting from other states for these years is still ongoing. Consequently, this report excludes years 2023 and afterwards as substantially incomplete, whereas it includes years 2018 through 2022 as at least proportionally more complete than 2023 and later.

There may also be anomalies in reporting from various states even among those observed to report at least some death certificates to CPSC for each month/state combination. For example, although overall death certificate reporting is not considered incomplete from Wisconsin and Texas in this period, there were anomalies even prior to this 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, 2021, and 2022 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 5 years. However, with the benefit of additional investigations and newly reported deaths from years 2021, 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 2022, an estimated 274 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 (2012-2021) of 189 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, was solely from a motor vehicle, or was 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. Finally, 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 2012 through 2022 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 (2020 through 2022), 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, 2021, and 2022. Accordingly, although reporting for those years is complete from most states through 2022, estimates may change if additional data become available from non-reporting states. Therefore, data for 2018, 2019, 2020, 2021, and 2022 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. This is because this report estimates the number of actual incidents, which accounts for incidents not reported to CPSC but which were 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 2020 to 2022 as well as the annual estimated CO deaths for the individual years from 2012 through 2022. The annual average for 2020 through 2022 is estimated to be 238 (with a standard error of approximately 18.8). 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 2022.

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 2022, products in the Heating Systems category were associated with an estimated 76 deaths (28% of the total 274 CO poisoning deaths from consumer products). Of the 76, the majority (88% or 67 deaths) were known to have involved gas heating systems or devices. Natural gas heating was associated with an estimated 15 deaths (18% of all heating system-related deaths). LP gas heating was associated with an estimated 43 deaths (57% of heating system-related deaths); and unspecified gas heating was associated with an estimated 9 deaths (12% 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 2022, such devices included charcoal/charcoal grills (an estimated 18 deaths) and gas ranges (16 deaths).

Of the estimated 15 deaths in 2022 associated with natural gas (NG) heating systems, the majority (73% or 11 deaths) involved installed NG furnaces. About 70 percent of the estimated 43 deaths in 2022 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.

Additionally, in 2022:

- An estimated 18 CO deaths (7% of the 274 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 33 deaths were associated with multiple products (12% 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 (EDT) 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. Almost half (46%) of the estimated average number of CO deaths in the three most recent years (2020 through 2022) were associated with *only* engine-driven tools (110 of 238).[5] Over the 11 years covered in this report, the total number of estimated CO deaths associated *exclusively* with an engine-driven tool (1,017) exceeds the estimated number for heating systems exclusively (622). Similarly, estimated generator-related CO deaths alone exceed those for heating systems alone over these 11 years (892 generator-related deaths versus 622 heating system-related deaths). Deaths associated with a generator alone compose most EDT-related CO deaths, accounting for 88 percent of all single product EDT-related deaths over the entire 11 years covered by this report.[6]

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.

[5] Multiple-product associated incidents are excluded from the above 110 EDT-related statistics. An estimated additional 9 deaths involved a combination of multiple products including at least one EDT, for a total of 119 deaths (50% of all deaths in the 2020-2022 period).
[6] These comparisons exclude multiple-product incidents. For statistics related to multiple-product incidents involving generators or other EDTs see the section “Engine Driven Tools” and Table 3.

Table 1: Estimated Non-Fire Carbon Monoxide Poisoning Deaths by Associated Fuel-Burning Consumer Product, 2012–2022

Consumer Product	2020–2022+		Annual Estimates										
	Average Estimate	Average Percent	2012	2013	2014	2015	2016	2017	2018+	2019+	2020+	2021+	2022+
Total	**238**	**100%**	**137**	**146**	**164**	**172**	**178**	**188**	***209***	***254***	***223***	***216***	***274***
Heating Systems	**68**	**29%**	**46**	**43**	**64**	**37**	**50**	**41**	***63***	***73***	***63***	***66***	***76***
Furnaces (incl. Boilers)	23	10%	**27**	**21**	**24**	**20**	**34**	**17**	***27***	***22***	***23***	***26***	**20**
Coal	2	1%	*	*	*	*	*	2	*1*	*1*	*3*	*4*	*
Liquid Petroleum (LP) Gas	4	2%	4	1	11	3	3	*	*2*	*5*	*3*	*5*	5
Natural Gas	7	3%	15	5	6	6	15	6	*18*	*13*	*9*	*1*	11
Oil	*	*	*	5	1	3	2	1	*1*	*	*	*1*	*
Unspecified Gas	5	2%	4	10	6	8	11	4	*	*1*	*5*	*10*	1
Unspecified Fuel	4	2%	5	*	*	1	2	4	*4*	*1*	*4*	*4*	3
Portable Heaters	**31**	**13%**	**11**	**12**	**18**	**11**	**11**	**19**	***24***	***25***	***33***	***26***	**34**
Kerosene	6	2%	1	*	2	1	4	2	*	*1*	*5*	*8*	4
Liquid Petroleum (LP) Gas	25	11%	10	12	14	10	6	16	*24*	*23*	*28*	*18*	30
Natural Gas	*	*	*	*	1	*	*	*	*	*	*	*	*
Unspecified Gas	*	*	*	*	*	*	1	*	*	*	*	*	*
Unspecified Fuel	*	*	*	*	*	*	*	1	*	*	*	*	*
Wall/Floor Furnaces	**2**	**<1%**	*****	*****	**5**	**1**	**1**	**2**	***1***	***5***	***1***	***4***	***1***
Liquid Petroleum (LP) Gas	*	*	*	*	*	*	1	*	*	*1*	*	*	*1*
Natural Gas	2	<1%	*	*	2	1	*	*	*1*	*4*	*1*	*4*	*
Unspecified Gas	*	*	*	*	2	*	*	1	*	*	*	*	*
Unspecified Fuel	*	*	*	*	*	*	*	1	*	*	*	*	*
Room/Space Heaters	**4**	**2%**	**5**	**9**	**8**	**1**	**1**	**1**	***6***	***10***	***1***	***3***	**9**
Coal	*	*	*	1	1	*	*	*	*1*	*1*	*	*	*
Kerosene	*	*	*	*	*	*	*	*	*	*	*	*1*	*
Liquid Petroleum (LP) Gas	*	*	4	3	7	*	*	*	*	*6*	*	*	*1*
Natural Gas	1	<1%	*	2	*	*	*	*	*	*	*	*	*3*
Wood	*	*	*	2	*	*	*	1	*4*	*1*	*	*	*
Unspecified Gas	2	<1%	*	*	*	*	1	*	*1*	*	*	*1*	*4*
Unspecified Fuel	1	<1%	1	*	*	1	*	*	*	*1*	*1*	*	*1*
Unspecified Heater/System	**8**	**3%**	**2**	**1**	**9**	**3**	**3**	**1**	***5***	***10***	***4***	***8***	**12**
Oil	*	*	*	*	*	*	*	*	*	*	*	*1*	*
Liquid Petroleum (LP) Gas	3	1%	1	*	8	1	*	*	*2*	*6*	*4*	*1*	*5*
Natural Gas	*	*	*	*	*	*	*	*	*	*	*	*	*1*
Unspecified Gas	*	*	1	*	*	*	*	*	*	*1*	*	*1*	*
Unspecified Fuel	3	1%	*	1	1	1	3	1	*2*	*3*	*	*4*	*5*
Charcoal/Charcoal Grills	**14**	**6%**	**6**	**11**	**7**	**11**	**7**	**10**	***10***	***14***	***15***	***9***	***18***

Table 1: Estimated Non-Fire Carbon Monoxide Poisoning Deaths by Associated Fuel-Burning Consumer Product, 2012–2022 (continued)

Consumer Product	2020–2022+		Annual Estimates										
	Average Estimate	Average Percent	2012	2013	2014	2015	2016	2017	2018+	2019+	2020+	2021+	2022+
Engine-Driven Tools	**110**	**46%**	**64**	**68**	**62**	**92**	**80**	**104**	***99***	***119***	***106***	***116***	***107***
Generators – Gasoline	73	31%	57	55	53	84	61	88	*71*	*77*	*70*	*78*	*71*
Generators – LP	4	2%	*	*	*	*	7	1	*1*	*	*5*	*3*	*5*
Generators – Unspecified Fuel	21	9%	*	1	1	*	*	6	*11*	*23*	*20*	*26*	*17*
Other Engine-Driven Tools	11	4%	6	13	8	8	12	10	*16*	*18*	*10*	*9*	*13*
Ranges or Ovens	**10**	**4%**	**4**	**10**	*	**5**	**7**	**12**	***9***	***3***	***3***	***11***	**16**
Liquid Petroleum (LP) Gas	4	2%	1	1	*	3	*	1	*1*	*	*	*3*	8
Natural Gas	5	2%	*	2	*	3	6	*	*2*	*3*	*3*	*8*	4
Unspecified Gas	2	<1%	2	2	*	*	*	11	*5*	*	*	*1*	4
Unspecified Fuel	*	*	*	5	*	*	1	*	*	*	*	*	*
Water Heaters	**5**	**2%**	**5**	**2**	**5**	**9**	**6**	**4**	***5***	***18***	***3***	***4***	**9**
Liquid Petroleum (LP) Gas	1	<1%	*	1	1	*	*	*	*2*	*10*	*	*3*	1
Natural Gas	1	<1%	*	*	*	*	1	4	*1*	*6*	*	*	3
Oil	*	*	*	*	*	*	*	*	*	*	*	*	0
Unspecified Gas	2	1%	2	*	2	8	4	*	*1*	*1*	*3*	*	4
Unspecified Fuel	1	<1%	2	1	1	1	*	*	*	*	*	*1*	1
Pool Heaters	**1**	**<1%**	*	**3**	**2**	*	**2**	**4**	*	*	***4***	*	*
Liquid Petroleum (LP) Gas	*	*	*	*	*	*	*	*	*	*	*	*	*
Natural Gas	*	*	*	3	1	*	*	4	*	*	*1*	*	*
Unspecified Gas	1	<1%	*	*	*	*	2	*	*	*	*3*	*	*
Unspecified Fuel	*	*	*	*	1	*	*	*	*	*	*	*	*
Lanterns	*	*	**2**	*	**5**	**5**	**1**	*	*	*	*	*	*
Liquid Petroleum (LP) Gas	*	*	2	*	4	5	1	*	*	*	*	*	*
Kerosene	*	*	*	*	1	*	*	*	*	*	*	*	*
Unspecified Fuel	*	*	*	*	*	*	*	*	*	*	*	*	*
Grills, Camp Stoves	**8**	**3%**	*	**1**	**6**	**4**	**3**	**6**	***4***	***4***	***12***	***1***	**11**
Liquid Petroleum (LP) Gas	6	3%	*	*	2	4	3	6	*1*	*1*	*9*	*	9
Coal	*	*	*	*	*	*	*	*	*1*	*	*	*	*
Wood	2	<1%	*	*	1	*	*	*	*	*3*	*3*	*1*	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, 2012–2022 (continued)

Consumer Product	2020–2022+		Annual Estimates										
	Average Estimate	Average Percent	2012	2013	2014	2015	2016	2017	2018+	2019+	2020+	2021+	2022+
Other Products	**3**	**1%**	**2**	**2**	**7**	**1**	**2**	**1**	***7***	***8***	***4***	***1***	***4***
Chimney/Fireplace – Coal	*	*	*	*	*	*	*	*	*	*	*	*	*
Chimney/Fireplace – Unspecified Fuel	*	*	1	1	*	*	*	*	*	*3*	*1*	*	*
Fire Pit – Wood	*	*	*	*	*	*	1	*	*	*	*	*	*
Other Products – LP Gas	**1**	**<1%**	*	1	4	1	*	1	*4*	*	*	*1*	*3*
Other Products – Natural Gas	*	*	*	*	*	*	*	*	*	*	*	*	*
Other Products – Unspecified Fuel	*	*	*	*	1	*	*	*	*	*	*	*	*
Unidentified Product	*	*	1	*	1	*	*	*	*1*	*5*	*	*	*
Unidentified Product – LP Gas	**1**	**<1%**	*	*	1	*	1	*	*2*	*	*3*	*	*1*
Multiple Products	**18**	**8%**	**5**	**5**	**7**	**9**	**19**	**6**	***12***	***16***	***14***	***7***	***33***

\+ Data collection for 2018, 2019, 2020, 2021, and 2022 is only partially complete. The corresponding estimates for these 5 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, 2012–2022.

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 20 (7%) CO deaths in 2022; *Liquid-Fueled Products* were associated with an estimated 91 (33%) deaths; and *Gas-Fueled Products* were associated with 91 of the 274 (33%). There were also 26 fatalities (9%) where the fuel type could not be identified for any suspected CO emitting device.

In 2022, of the estimated 20 deaths in the *Solid-Fueled Products* category, 18 were associated with charcoal or charcoal grills.

Most of the estimated 93 liquid-fueled, appliance-related deaths in 2022 were associated with engine-driven tools (*e.g.*, generators, lawn mowers/garden tractors). An estimated 71 deaths were associated with gasoline-fueled generators alone. An estimated 13 deaths were associated with other engine-driven tools alone. Only an estimated 13 of the 91 liquid-associated deaths had no generator or engine-driven tool involvement, all related to heaters or heating systems. Four involved kerosene portable heaters.

In the *Gas-Fueled Products* category in 2022, an estimated 75 of the 112 gas-fueled appliance deaths (67%) were associated with heating systems or heaters, including furnaces, portable heaters, and room or space heaters. Additionally, all of the *Multiple Gas-Fueled Products* fatalities were associated with a heating-related product and another product.[7]

[7] "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, 2012–2022

Consumer Product	2020–2022+		Annual Estimates										
	Average Estimate	Average Percent	2012	2013	2014	2015	2016	2017	2018+	2019+	2020+	2021+	2022+
Total	**238**	**100%**	**137**	**146**	**164**	**172**	**178**	**188**	***209***	***254***	***223***	***216***	***274***
Solid-Fueled Products	**18**	**8%**	**6**	**14**	**9**	**11**	**8**	**13**	***17***	***21***	***20***	***14***	**20**
Charcoal-Fueled	**14**	**6%**	**6**	**11**	**7**	**11**	**7**	**10**	***10***	***14***	***15***	***9***	**18**
Charcoal/Charcoal Grills	14	6%	6	11	7	11	7	10	*10*	*14*	*15*	*9*	18
Coal-Fueled	**2**	**1%**	*****	**1**	**1**	*****	*****	**2**	***4***	***3***	***3***	***4***	*
Furnace (incl. Boilers)	2	1%	*	*	*	*	*	2	*1*	*1*	*3*	*4*	*
Room/Space Heater	*	*	*	1	1	*	*	*	*1*	*1*	*	*	*
Coal Grill/Coal	*	*	*	*	*	*	*	*	*1*	*	*	*	*
Wood-Fueled	**2**	**<1%**	*****	**2**	**1**	*****	**1**	**1**	***4***	***4***	***3***	***1***	***1***
Fire Pit	*	*	*	*	*	*	1	*	*	*	*	*	*
Grill/Stove	2	<1%	*	*	1	*	*	*	*	*3*	*3*	*1*	*1*
Room/Space Heater	*	*	*	2	*	*	*	1	*4*	*1*	*	*	*
Liquid-Fueled Products	**92**	**39%**	**65**	**73**	**67**	**96**	**83**	**102**	***88***	***100***	***87***	*99*	**91**
Gasoline-Fueled	**84**	**35%**	**64**	**67**	**61**	**92**	**73**	**98**	***86***	***94***	***80***	***87***	**84**
Generator	73	31%	57	55	53	84	61	88	*71*	*77*	*70*	*78*	71
Other Engine-Driven Tools	11	4%	6	13	8	8	12	10	*14*	*17*	*10*	*9*	13
Kerosene-Fueled	**6**	**3%**	**1**	*****	**4**	**1**	**4**	**2**	*******	***1***	***5***	***9***	**4**
Portable Heater	6	2%	1	*	2	1	4	2	*	*1*	*5*	*8*	4
Space Heater	<1	<1%	*	*	*	*	*	*	*	*	*	*1*	*
Lantern	*	*	*	*	1	*	*	*	*	*	*	*	*
Oil-Fueled	**1**	**<1%**	*****	**5**	**1**	**3**	**2**	**1**	***1***	*******	*******	***3***	*
Furnace (incl. Boilers)	<1	<1%	*	5	1	3	2	1	*1*	*	*	*1*	*
Unspecified Heater	<1	<1%	*	*	*	*	*	*	*	*	*	*1*	*
Diesel-Fueled	*	*	*	*	*	*	*	*	*	*	*	*	*
Multiple Products – Liquid-Fueled	**2**	**<1%**	*****	**1**	**1**	*****	**3**	*****	***1***	***5***	***2***	*******	***3***

Table 2: Estimated Non-Fire Carbon Monoxide Poisoning Deaths Associated with Consumer Products Organized by Fuel Type, 2012–2022 (continued)

Consumer Product	2020–2022+		Annual Estimates										
	Average Estimate	Average Percent	2012	2013	2014	2015	2016	2017	2018+	2019+	2020+	2021+	2022+
Gas-Fueled Products	**87**	**37%**	**51**	**45**	**78**	**53**	**69**	**60**	***78***	***92***	***82***	***67***	***112***
Natural Gas	17	7%	**15**	**13**	**11**	**10**	**21**	**13**	***23***	***26***	***15***	***13***	***22***
Furnace (incl. Boilers)*	7	3%	15	5	6	6	15	6	*18*	*13*	*9*	*1*	***11***
Pool Heater	<1	<1%	*	3	1	*	*	4	*	*	*1*	*	*
Portable Heater	*	*	*	*	1	*	*	*	*	*	*	*	*
Range/Oven	5	2%	*	2	*	3	6	*	*2*	*3*	*3*	*8*	*4*
Room/Space Heater	1	<1%	*	2	*	*	*	*	*	*	*	*	*3*
Wall/Floor Furnace	2	<1%	*	*	2	1	*	*	*1*	*4*	*1*	*4*	*
Water Heater	2	<1%	*	*	*	*	1	4	*1*	*6*	*1*	*	*4*
Unspecified Heater	<1	<1%	*	*	*	*	*	*	*	*	*	*	*1*
Liquid Petroleum (LP) Gas	**52**	**22%**	**22**	**20**	**52**	**27**	**22**	**24**	***41***	***55***	***51***	***33***	***71***
Furnace (incl. Boilers)	4	2%	4	1	11	3	3	*	*2*	*5*	*3*	*5*	*5*
Generator	4	2%	*	*	*	*	7	*	*1*	*	*5*	*3*	*5*
Grill/Camp Stove	6	3%	*	*	2	4	3	6	*1*	*1*	*9*	*	*9*
Lantern	*	*	2	*	4	5	1	*	*	*	*	*	*
Portable Heater	25	11%	10	12	14	10	6	16	*24*	*23*	*28*	*18*	*30*
Range/Oven	4	2%	1	1	*	3	*	1	*1*	*	*	*3*	*8*
Refrigerator	1	<1%	*	1	2	*	*	1	*2*	*	*	*	*3*
Room/Space Heater	<1	<1%	4	3	7	*	*	*	*	*6*	*	*	*1*
Single Cooking Burner	<1	<1%	*	*	*	*	*	*	*	*	*	*1*	*
Wall/Floor Furnace	<1	<1%	*	*	*	*	1	*	*	*1*	*	*	*1*
Water Heater	1	<1%	*	1	1	*	*	*	*2*	*10*	*	*3*	*1*
Unspecified Heater/System	3	1%	1	*	8	1	*	*	*2*	*6*	*4*	*1*	*5*
Other/Unknown Products	1	<1%	*	*	2	1	1	*	*4*	*	*3*	*	*1*
Unspecified Gas	**12**	**5%**	**10**	**13**	**11**	**15**	**20**	**16**	***7***	***4***	***9***	***14***	***13***
Furnace (incl. Boilers)	5	2%	4	10	6	8	11	4	*	*1*	*5*	***10***	*1*
Pool Heater	1	<1%	*	*	*	*	2	*	*	*	*3*	*	*
Portable Heater	*	*	*	*	*	*	1	*	*	*	*	*	*
Range/Oven	2	<1%	2	2	*	*	*	11	*5*	*	*	***1***	*4*
Room/Space Heater	2	<1%	*	*	*	*	1	*	*1*	*	*	*1*	*4*
Wall/Floor Furnace	*	*	*	*	2	*	*	1	*	*	*	*	*
Water Heater	2	<1%	2	*	2	8	4	*	*1*	*1*	*1*	*	*4*
Unspecified Heater	<1	<1%	1	*	*	*	*	*	*	*1*	*	*1*	*
Multiple Products - Gas-Fueled	**6**	**2%**	**4**	*****	**5**	**1**	**6**	**6**	***6***	***8***	***6***	***6***	***5***

Table 2: Estimated Non-Fire Carbon Monoxide Poisoning Deaths Associated with Consumer Products Organized by Fuel Type, 2012–2022 (continued)

Consumer Product	2020–2022+		Annual Estimates										
	Average Estimate	Average Percent	2012	2013	2014	2015	2016	2017	2018+	2019+	2020+	2021+	2022+
Unspecified Fuel Products	**29**	**12%**	**11**	**10**	**8**	**5**	**7**	**13**	***21***	***38***	***27***	***35***	***26***
Chimney/Fireplace	<1	<1%	1	1	*	*	*	*	*	*3*	*1*	*	*
Furnace (incl. Boilers)	4	2%	5	*	*	1	2	4	*4*	*1*	*4*	*4*	*3*
Generator	21	9%	*	1	1	*	*	6	*11*	*23*	*20*	*26*	*17*
Other EDTs (excl. generators)	*	*	*	*	*	*	*	*	*1*	*1*	*	*	*
Grill/Camp Stove	*	*	*	1	2	*	*	*	*1*	*	*	*	*
Lantern	*	*	*	*	*	*	*	*	*	*	*	*	*
Pool Heater	*	*	*	*	1	*	*	*	*	*	*	*	*
Portable Heater	*	*	*	*	*	*	*	1	*	*	*	*	*
Range/Oven	*	*	*	5	*	*	1	*	*	*	*	*	*
Room/Space Heater	1	<1%	1	*	*	1	*	*	*	*1*	*1*	*	*1*
Unspecified Heater	3	1%	*	1	1	1	3	1	*2*	*3*	*	*4*	*5*
Wall/Floor Furnace	*	*	*	*	*	*	*	1	*	*	*	*	*
Unidentified Product	*	*	1	*	1	*	*	*	*1*	*5*	*	*	*
Water Heater	<1	<1%	2	1	1	1	*	*	*	*	*	*1*	*
Multiple Product – Different Fuels	**11**	**4%**	**4**	**3**	**1**	**8**	**10**	*	***5***	***3***	***6***	***1***	***25***
Gas & Liquid	6	3%	2	3	1	6	8	*	*5*	*3*	*4*	*	*14*
Gas & Solid	2	<1%	1	*	*	*	1	*	*	*	*	*1*	*4*
Gas & Unspecified	<1	<1%	*	*	*	*	*	*	*	*	*	*	*1*
Liquid & Solid	1	<1%	*	*	*	*	*	*	*	*	*	*	*4*
Liquid & Unspecified	<1	<1%	*	*	*	1	1	*	*	*	*1*	*	*
Solid & Unspecified	<1	<1%	*	*	*	*	*	*	*	*	*1*	*	
Gas & Liquid & Solid	<1	<1%	*	*	*	*	*	*	*	*	*	*	*1*

\+ Data collection for 2018, 2019, 2020, 2021, and 2022 is only partially complete. The corresponding estimates for these 5 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, 2012–2022.

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 2012 through 2022, in the *Engine-Driven Tools* category. Including multiple-product deaths, in 2022 engine-driven tools were associated with an estimated 128 carbon monoxide poisoning deaths (47% of the 274 total consumer product-related CO death estimate).[8] In the 3 most recent years (2020-2022), EDTs were associated with 46 percent of all consumer product-related CO fatalities (estimated annual average of 119 out of 238) either as the sole product involved or in combination with another CO-producing product. Of these EDT-associated fatalities, generator-only associated fatalities dominated, with an estimated annual average of 98 out of 119.

Lawnmowers were associated with 49 percent of the deaths listed in the *Other Engine-Driven Tools* category for the 11-year period (60 of 123 total fatalities). Over the three-year period of 2020 to 2022, there was an estimated annual average of 6 lawnmower-only related deaths (18 total in three years). Two other EDT sub-categories also resulted in multiple deaths over the same three years: concrete saws (an estimated 4 deaths from 2020-2022) and power washers (3).

[8] 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 most of this report, however, estimates for specific EDT product categories such as generators, other engine-driven tools, and subtypes exclude all multiple product deaths.

Table 3: Estimated Non-Fire Carbon Monoxide Poisoning Deaths Associated with Engine-Driven Tools, 2012–2022

Consumer Product	2020–2022+		Annual Estimates										
	Average Estimate	Average Percent	2012	2013	2014	2015	2016	2017	2018+	2019+	2020+	2021+	2022+
Total	**119**	**100%**	**66**	**73**	**64**	**97**	**92**	**104**	***105***	***124***	***114***	***116***	***128***
Generators	**98**	**53%**	**57**	**56**	**54**	**84**	**67**	**95**	***83***	***101***	***95***	**107**	***93***
Gasoline-fueled	73	61%	57	55	53	84	61	88	*71*	*77*	*70*	*78*	*71*
LP-fueled	4	4%	*	*	*	*	7	*	*1*	*	*5*	*3*	*5*
Unspecified Fuel	21	18%	*	1	1	*	*	6	*11*	*23*	*20*	*26*	*17*
Other Engine-Driven Tools (OEDTs)	**11**	**9%**	**6**	**13**	**8**	**8**	**12**	**10**	***16***	***18***	***10***	***9***	***13***
Lawn Mowers	6	5%	**4**	**7**	**2**	**4**	**7**	**5**	***9***	***4***	***7***	***4***	***7***
Riding Mowers (incl. Garden tractor)	4	4%	2	6	1	3	7	4	*5*	*	*6*	*3*	*4*
Unspecified Mowers	2	1%	1	1	1	1	*	1	*4*	*4*	*1*	*1*	*3*
Antique Tractor	*	*	*	*	*	*	*	1	*	*	*	*	*
OHV (*e.g.*, ATV or UTV)	<1	<1%	1	1	1	*	*	1	*	*5*	*	*	*1*
Dune Buggy	<1	<1%	*	*	*	*	*	*	*	*	*	*1*	*
Snowmobile	*	*	*	*	*	*	*	*	*	*1*	*	*	*
Paint Sprayer	*	*	*	*	*	*	*	*	*	*	*	*	*
Power Washer	1	1%	*	*	2	*	1	1	*1*	*4*	*1*	*1*	*1*
Snow Blower/Thrower	<1	<1%	*	2	1	1	1	*	*1*	*1*	*1*	*	*
Water Pump	*	*	*	1	*	*	*	*	*	*1*	*	*	*
Concrete Saw	1	1%	*	*	*	*	*	*	*	*	*	*3*	*1*
Welder	<1	<1%	*	*	*	3	1	*	*	*	*	*	*1*
Tiller	*	*	*	*	*	*	*	*	*1*	*	*	*	*
Leaf Blower	*	*	*	*	*	*	1	*	*2*	*	*	*	*
Small Engine	*	*	*	*	*	*	1	*	*	*	*	*	*
Stump Grinder	*	*	*	1	*	*	*	1	*	*	*	*	*
Wood Splitter	*	*	1	*	1	*	*	*	*	*	*	*	*
Unspecified EDT	*	*	*	*	*	*	*	*	*1*	*1*	*	*	*
Multiple Product: Engine-Driven Tools Involved	**10**	**8%**	**2**	**5**	**2**	**5**	**12**	*****	***6***	***5***	***9***	*****	***21***
Generator + OEDT	6	5%	*	*	*	*	1	*	*	*1*	*1*	*	*16*
Generator + other Product	3	2%	2	3	2	4	10	*	*6*	*4*	*8*	*	*
Multiple OEDT	*	*	*	*	*	*	1	*	*	*	*	*	*
OEDT + other product	2	1%	*	1	*	1	*	*	*	*	*	*	*5*

\+ Data collection for 2018, 2019, 2020, 2021, and 2022 is only partially complete. The corresponding estimates for these 5 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.

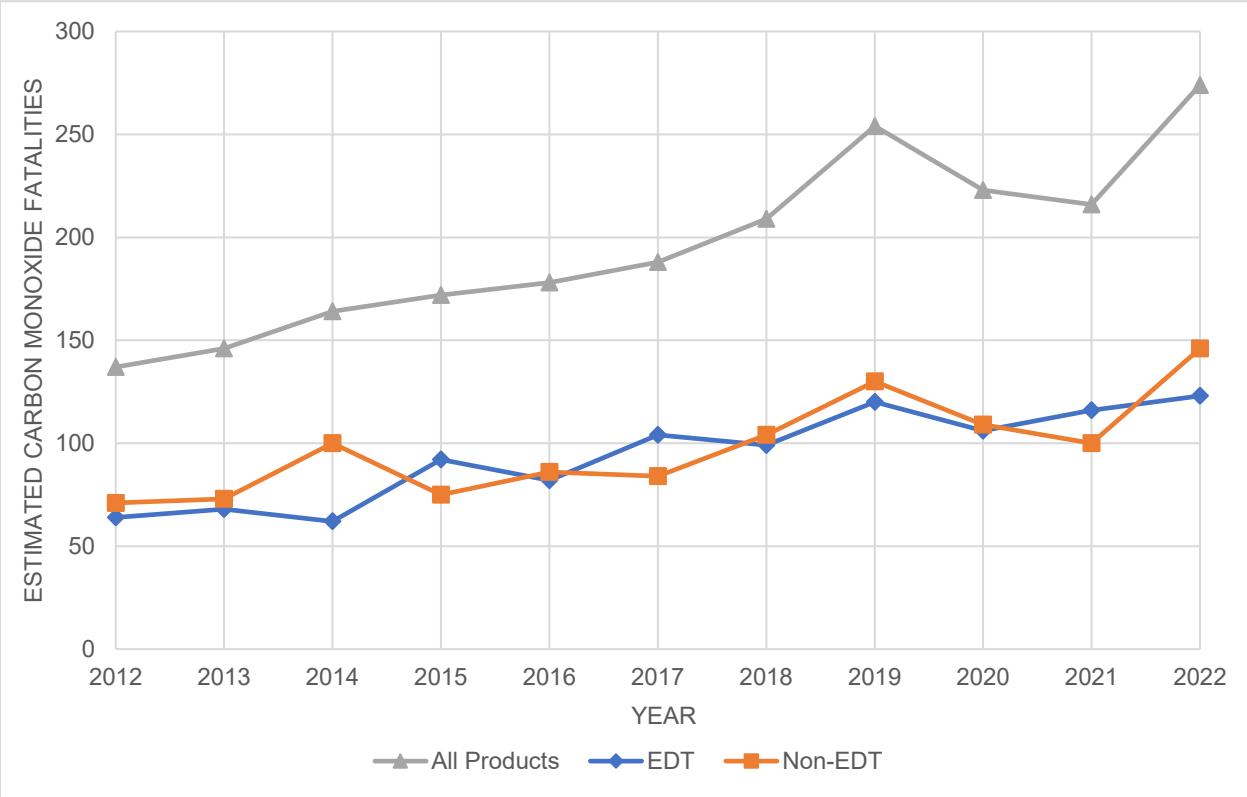
Source: U.S. Consumer Product Safety Commission/EPHA. CPSC Death Certificate File, CPSC Injury or Potential Injury Incident File, CPSC In-Depth Investigation File, National Center for Health Statistics Mortality File, 2012–2022.

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 2012 to 2022 indicates evidence of a statistically significant trend (p-value < 0.0001). 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 initially peaked at 254 in the year 2019, before decreasing in 2020 and 2021. Although death certificate collection is ongoing, the currently available estimates for 2022 exceeds the prior years including even the previous peak in 2019. Each of the currently available estimates for any given year in the most recent five years, 2018-2022, exceed every estimate found in any of the prior 6 years from 2012-2017. Part of the increase over the eleven years is associated with engine-driven tools, as well as other products. Regression analysis from 2012 to 2022 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 = 0.0038).

Figure 1: Comparison of Trends in Consumer Product-Related Carbon Monoxide Deaths, 2012 to 2022



Source: U.S. Consumer Product Safety Commission/EPHA.
CPSC Death Certificate File, CPSC Injury or Potential Injury Incident File, CPSC In-Depth Investigation File, 2012–2022.

Note: Some multiple-product incidents are excluded from EDTs and non-EDTs in this graph if they involve a mix of both EDT and Non-EDT type products. However, multiple products are included in the All Products part of this graph, or in the respective EDT or Non-EDT graph so long as all the multiple products suspected as CO source in the incident are of the same type (either all EDTs or all non-EDTs). The "EDT" deaths in this graph includes single-product deaths and multiple product deaths for which every involved product was an Engine-Driven tool (*e.g.*, a generator, lawn mower, and/or any other kind of engine-driven tool). The "Non-EDT" deaths in this graph includes single-product incidents and multiple-product incidents *without any* EDTs among the suspected CO sources. Over the 11-year period the multiple-product incidents that do not fit either category due to a mix of EDTs and non-EDTs as suspected CO sources represent, on average, only about an estimated 2% of the annual average deaths (ranging from 0% to 6% among all 11 years).

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 2022, 144 of the 182 fatal CO incidents (79% 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, 18 percent of the incidents resulted in multiple deaths. Twenty-one (21) 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, 2012–2022

		2020–2022+		Incident Year										
		Annual Average	Average Percent	2012	2013	2014	2015	2016	2017	*2018+*	*2019+*	*2020+*	*2021+*	*2022+*
All Reported Incidents		***176***	***100%***	**90**	**106**	**110**	**104**	**130**	**131**	***145***	***168***	***176***	***169***	***182***
Number of Deaths Reported per Incident	1	*145*	*82%*	74	84	86	83	110	112	*119*	*145*	*149*	*141*	*144*
	2	*25*	*14%*	14	21	21	15	16	15	*23*	*19*	*19*	*22*	*35*
	3	*4*	*2%*	1	*	1	2	1	3	*2*	*2*	*3*	*5*	*3*
	4	*1*	*<1%*	*	1	1	3	2	1	*1*	*2*	*3*	*1*	*
	5	*1*	*<1%*	1	*	1	*	*	*	*	*	*2*	*	*
	6	*	*	*	*	*	*	1	*	*	*	*	*	*
	7	*	*	*	*	*	*	*	*	*	*	*	*	*
	8	*	*	*	*	*	1	*	*	*	*	*	*	*
Resulting Total Reported Deaths		***215***	***n/a***	**110**	**130**	**140**	**139**	**159**	**155**	***175***	***197***	***218***	***204***	***223***

\+ Data collection for 2018, 2019, 2020, 2021, and 2022 is only partially complete. The corresponding counts for these 5 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 2022, an estimated 174 CO poisoning deaths resulted from exposure to CO in home locations, including an estimated 34 deaths from CO in detached structures at residential locations (*i.e.*, sheds, detached garages). There were another 14 deaths from CO in structures not designed to be a permanent residence (*i.e.*, camper trailers, sea-land shipping containers). From 2020 to 2022, an estimated annual average of 174 deaths (74% of the annual average estimate for all CO deaths) resulted from exposure to CO in home locations. In 2022, an estimated 57 deaths resulted from CO in temporary shelters, such as cabins, campers or trailers used for shelter. For 2020 to 2022, an annual average of 31 deaths (13%) resulted from CO in temporary shelters. Deaths due to CO exposure in temporary shelters were most associated with heating sources or generators.

Some 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 2022, there were an estimated 32 CO deaths in this category. For the 3-year period 2020 to 2022, an annual average of 19 deaths (8%) resulted from CO in vehicles. These vehicle location incidents in this 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, 2012–2022

Location of Exposure	*2020–2022+*		Annual Estimate										
	Average Estimate	Average Percent	2012	2013	2014	2015	2016	2017	*2018+*	*2019+*	*2020+*	*2021+*	*2022+*
Total	***238***	***100%***	**137**	**146**	**164**	**172**	**178**	**188**	***209***	***254***	***223***	***216***	***274***
Home[1]	*126*	*53%*	107	104	100	113	135	142	*107*	*154*	*124*	*130*	*125*
Home – External Structure[2]	*27*	*11%*	5	13	15	14	11	5	*17*	*15*	*24*	*22*	*34*
Home – But Not House[3]	*23*	*10%*	1	3	12	4	3	11	*23*	*12*	*24*	*31*	*14*
Temporary Shelter	*31*	*13%*	21	16	21	24	19	13	*33*	*25*	*24*	*12*	*57*
Vehicles (including boats)	*19*	*8%*	*	7	6	12	4	10	*22*	*27*	*14*	*12*	*32*
Outdoors	*<1*	*<1%*	*	*	*	*	1	*	*1*	*1*	*	*	*1*
Other	*9*	*4%*	*	2	8	5	1	7	*4*	*17*	*9*	*6*	*11*
Unknown	*2*	*<1%*	2	*	1	*	1	*	*2*	*3*	*1*	*4*	*

\+ Data collection for 2018, 2019, 2020, 2021, and 2022 is only partially complete. The corresponding estimates for these 5 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.

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, 2012–2022.

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 2022, an estimated 174 of the 274 estimated CO deaths (64%) 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 55 percent. In 2022, an estimated 63 deaths (23%) 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 28 percent for the same four months. And in the warmer months of May, June, July, and August, an estimated 37 CO deaths (14%) occurred in 2022 as compared with the 11-year annual average of 17%. Table 6 shows average percentages corresponding to the most recent 3 years (2020-2022).

Table 6: Estimated Non-Fire Carbon Monoxide Poisoning Deaths by Month and Year of the Fatality, 2012–2022

Month of Death	*2020–2022+*		Annual Estimate										
	Average Estimate	Average Percent	2012	2013	2014	2015	2016	2017	*2018+*	*2019+*	*2020+*	*2021+*	*2022+*
Total	***238***	***100%***	**137**	**146**	**164**	**172**	**178**	**188**	***209***	***254***	***223***	***216***	***274***
Cold Months	***141***	***59%***	**75**	**82**	**83**	**82**	**109**	**80**	***119***	***142***	***122***	***127***	***174***
November	*31*	*13%*	26	16	20	10	32	17	*27*	*30*	*33*	*23*	*37*
December	*39*	*16%*	25	28	20	23	19	21	*29*	*27*	*22*	*33*	*62*
January	*39*	*16%*	10	22	26	24	28	27	*38*	*40*	*30*	*40*	*47*
February	*32*	*13%*	14	16	17	24	29	16	*25*	*45*	*37*	*31*	*28*
Transition Months	***56***	***24%***	**46**	**43**	**44**	**62**	**49**	**65**	***56***	***71***	***60***	***45***	**63**
March	*21*	*9%*	6	12	10	19	12	13	*12*	*22*	*29*	*13*	21
April	*10*	*4%*	14	6	14	28	13	14	*15*	*18*	*6*	*10*	14
September	*6*	*3%*	6	5	6	11	7	23	*19*	*5*	*5*	*13*	*
October	*19*	*8%*	20	21	14	4	17	14	*10*	*26*	*19*	*9*	28
Warm Months	***41***	***17%***	**16**	**21**	**37**	**29**	**20**	**42**	***34***	***40***	***41***	***44***	**37**
May	*11*	*4%*	2	4	17	4	5	9	*11*	*10*	*10*	*10*	12
June	*7*	*3%*	5	6	4	9	3	16	*14*	*12*	*4*	*6*	12
July	*9*	*4%*	7	7	13	11	6	10	*1*	*10*	*6*	*14*	7
August	*13*	*6%*	1	5	4	5	6	9	*7*	*8*	*20*	*13*	7

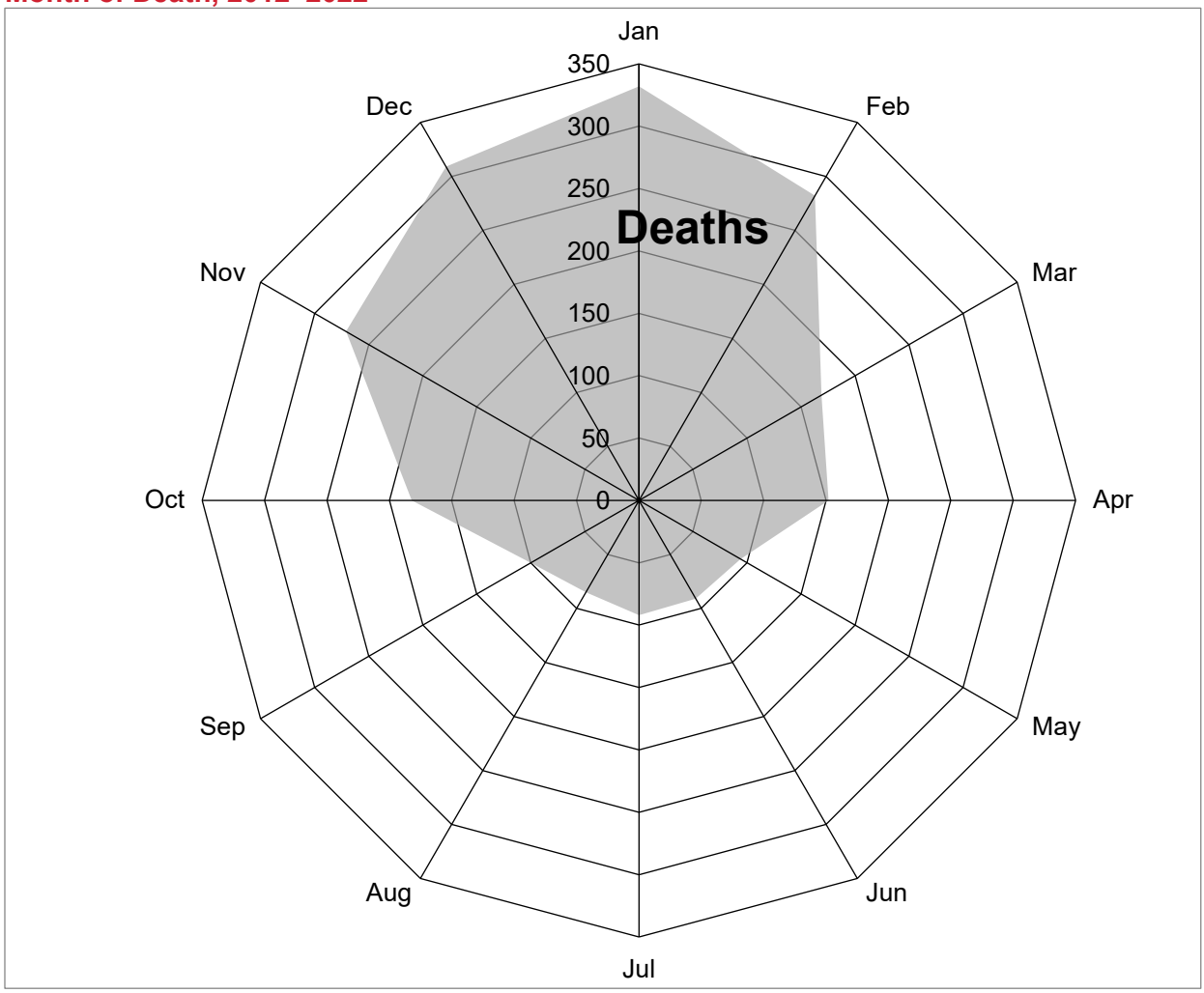
\+ Data collection for 2018, 2019, 2020, 2021, and 2022 is only partially complete. The corresponding estimates for these 5 most recent years are shown in italics to emphasize the possibility of change in the future if more reports of deaths are received.

Source: U.S. Consumer Product Safety Commission / EPHA.
CPSC Death Certificate File, CPSC In-Depth Investigation File, CPSC Injury or Potential Injury Incident File, National Center for Health Statistics Mortality File, 2012–2022.

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 2012 through 2022. 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, 2012–2022



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, 2012–2022.

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 (2012–2022). From the data, it appears that consumer product-related CO deaths are skewed toward older individuals. For the 3 most recent years (2020-2022), children younger than 15 years of age accounted for an annual average of 3 percent (an estimated 7 deaths out of 238) 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 68 percent (163 of 238), 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, 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. The 25 to 44 age group percentage of deaths was not found to be significantly different than population estimates.

Table 7: Estimated Non-Fire Carbon Monoxide Poisoning Deaths by Age of Victim, 2012–2022

Age	*2020–2020+*		Estimated Percentage of U.S. Population@	Annual Estimate										
	Average Estimate	Average Percent		2012	2013	2014	2015	2016	2017	*2018+*	*2019+*	*2020+*	*2021+*	*2022+*
Total	***238***	***100%***	**100%**	**137**	**146**	**164**	**172**	**178**	**188**	**209**	***254***	***223***	***216***	**274**
Under 5	*2*	*<1%*	6%	1	*	2	*	1	2	*4*	*4*	*5*	*	*
5 - 14	*5*	*2%*	13%	4	5	7	17	6	9	*1*	*6*	*5*	*5*	5
15 - 24	*11*	*5%*	13%	6	11	8	15	6	17	*7*	*14*	*9*	*17*	8
25 - 44	*56*	*24%*	27%	37	34	35	45	54	55	*55*	*43*	*43*	*46*	79
45 - 64	*98*	*41%*	25%	56	62	67	65	83	55	*88*	*127*	*94*	*83*	116
65 and over	*65*	*27%*	17%	32	36	44	31	29	51	*54*	*59*	*66*	*64*	66

\+ Data collection for 2018, 2019, 2020, 2021, and 2022 is only partially complete. The corresponding estimates for these 5 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 (2020-2022). 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, 2012-2022.
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 2022, an estimated 78 percent of CO poisoning victims were males and 22 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 2020 through 2022, the average percentage of male CO victims was 77 percent, and the average percentage of female victims was 23 percent. By contrast, about 50 percent of the U.S. population is male, and 50 percent of the U.S. population is female.[9] 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, 2012-2022

Sex	*2020–2022+*		Estimated Percentage of U.S. Population *	Annual Estimate										
	Average Estimate	Average Percent		2012	2013	2014	2015	2016	2017	*2018+*	*2019+*	*2020+*	*2021+*	*2022+*
Total	***238***	***100%***	**100%**	**137**	**146**	**164**	**172**	**178**	**188**	***209***	***254***	***223***	**216**	***274***
Male	*182*	*77%*	50%	92	124	127	125	140	138	*163*	*195*	*164*	*170*	*213*
Female	*55*	*23%*	50%	45	22	37	48	38	50	*46*	*58*	*59*	*46*	*61*

\+ Data collection for 2018, 2019, 2020, 2021, and 2022 is only partially complete. The corresponding estimates for these 5 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 (2020-2022).

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, 2012–2022.
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.

[9] Three-year average, 2020 to 2022, from July U.S. Census estimates of the U.S. population. June 2024

Population Density of Place of Death

Table 9 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.[10] 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.[11] 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 9 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 2020 through 2022 in urban locations (49%) 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 (23% versus 15% of the U.S. population), large rural town locations (13% versus 6%), and small town/rural isolated locations (15% versus 5%). CO deaths that occurred in small town/rural isolated locations were 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 receives,

[10] 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.
[11] 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.

the exact location of some incidents (<1%) could not be ascertained. The 2020 through 2022 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 Large Rural Town locations, where 14% 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 9: Estimated Non-Fire Carbon Monoxide Poisoning Deaths by Population Density of Place of Incident or Death, 2012–2022

RUCA Population Density Designation	2020–2022+		Estimated Percentage of US Population @	Annual Estimates										
	Average Estimate	Average Percents%		2012	2013	2014	2015	2016	2017	2018+	2019+	2020+	2021+	2022+
All Locations	***238***	***100%***	**100%**	**137**	**146**	**164**	**172**	**178**	**188**	***209***	***254***	***223***	***216***	***274***
Urban Core	*116*	*49%*	73%	79	84	73	77	108	103	*107*	*127*	*111*	*107*	*129*
Sub-Urban	*55*	*23%*	15%	25	27	34	41	25	39	*51*	*43*	*36*	*41*	*87*
Large Rural Town	*31*	*13%*	6%	9	12	19	14	20	13	*24*	*29*	*35*	*35*	*24*
Small Town/Rural Isolated	*35*	*15%*	5%	19	23	32	39	22	33	*27*	*49*	*39*	*32*	*34*
Unknown Location	*1*	*<1%*	-	6	1	6	1	2	*	*	*6*	*3*	*1*	*
Home Locations	***176***	***74% (100%)***	**100%**	**113**	**121**	**127**	**131**	**150**	**150**	***147***	***181***	***172***	***182***	***174***
Urban Core	*84*	*35% (48%)*	73%	71	73	63	62	92	83	*75*	*92*	*81*	*89*	*83*
Sub-Urban	*40*	*17% (23%)*	15%	20	24	29	39	21	33	*32*	*36*	*31*	*32*	*56*
Large Rural Town	*25*	*11% (14%)*	6%	6	7	14	11	18	9	*18*	*19*	*32*	*31*	*13*
Small Town/Rural Isolated	*27*	*11% (15%)*	5%	11	15	21	18	18	27	*22*	*34*	*28*	*31*	*21*
Unknown Location	*<1*	*<1% (<1%)*	-	5	1	*	*	*	*	*	*	*	***1***	*
Non-Home Locations	***62***	***26% (100%)***	**100%**	**24**	**26**	**37**	**41**	**28**	**38**	***62***	***72***	***51***	***34***	***100***
Urban Core	*31*	*13% (50%)*	73%	7	11	11	14	16	21	*32*	*34*	*29*	*18*	*46*
Sub-Urban	*14*	*6% (23%)*	15%	5	2	5	1	3	6	*19*	*6*	*5*	*8*	*30*
Large Rural Town	*6*	*3% (10%)*	6%	2	5	5	3	2	5	*6*	*9*	*3*	*4*	*11*
Small Town/Rural Isolated	*8*	*4% (14%)*	5%	7	8	11	22	4	6	*5*	*16*	*11*	*1*	*13*
Unknown Location	*1*	*<1% (2%)*	-	1	*	6	1	2	*	*	*6*	*3*	*	*

\+ Data collection for 2018, 2019, 2020, 2021, and 2022 is only partially complete. The corresponding estimates for these 5 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, 2021, and 2022 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, 2012– 2022
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 10 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 (2020 to 2022), 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 10: Estimated Non-Fire Carbon Monoxide Poisoning Deaths by Geographical Region of Incident, 2012–2022

Region‡	*2020–2022+*		Estimated Percentage of US Population@	Annual Estimates										
	Average Estimate	Average Percent		2012	*2013*	2014	2015	2016	2017	*2018+*	*2019+*	*2020+*	*2021+*	*2022+*
Total	**238**	**100%**	**100%**	**137**	**146**	**164**	**172**	**178**	**188**	***209***	***254***	***223***	***216***	***274***
Northeast	**28**	**12%**	**17%**	**25**	**34**	**37**	**30**	**21**	**11**	***30***	***43***	***25***	***28***	**31**
New England	6	3%	5%	1	14	8	13	8	4	*12*	*12*	*3*	*6*	9
Middle Atlantic	22	9%	13%	24	20	29	17	13	7	*18*	*31*	*23*	*22*	22
South	**84**	**35%**	**38%**	**55**	**43**	**42**	**62**	**55**	**67**	***74***	***74***	***87***	***72***	**92**
East South Central	20	9%	6%	7	3	9	11	10	10	*20*	*18*	*15*	*21*	25
South Atlantic	37	16%	20%	31	20	21	29	27	36	*43*	*38*	*43*	*31*	38
West South Central	26	11%	12%	17	20	12	22	18	21	*11*	*18*	*28*	*21*	29
Midwest	**59**	**25%**	**21%**	**31**	**48**	**40**	**44**	**69**	**61**	***52***	***57***	***54***	***60***	**63**
East North Central	44	19%	14%	26	27	22	27	44	40	*25*	*41*	*31*	*51*	51
West North Central	15	6%	7%	5	21	18	17	25	21	*27*	*16*	*23*	*9*	12
West	**69**	**29%**	**24%**	**25**	**22**	**44**	**37**	**33**	**50**	***54***	***80***	***58***	***55***	**94**
Mountain	33	14%	8%	13	8	26	14	18	12	*35*	*32*	*17*	*26*	57
Pacific	36	15%	16%	12	14	18	23	15	38	*18*	*48*	*40*	*30*	37

‡ 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, 2021, and 2022 may be only partially complete due to apparently incomplete reporting from some states. The corresponding estimates for these 5 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 (2020-2022).

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 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. 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 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 but without substantial new incoming reporting (such as from Washington State).

Since the release of the previous annual report, additional records have been entered into the CPSC databases, resulting in recalculation for 2021. The initial categorizations for 2021 have been recalculated and are presented in Table A.1.a. Substantial additional information regarding 2021 incidents supported changes in classification. Last year's report presented an estimate of only 204 deaths in 2021; however, these updates result in a current estimate of 216 deaths in 2021. The current estimate for 2022 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 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	165	52	630	847	226
Y17	131	3	6	93	102	35
Total	**1,152**	**168**	**58**	**759**	**949**	**225**

[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.

Table A.1.b: Initial Categorization for 2022 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	966	204	38	531	773	231
Y17	83	7	6	60	73	16
Total	**1,049**	**211**	**44**	**591**	**846**	**247**

[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, 2022.

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.

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.

Tables A.2.a and A.2.b contain the values for the variables used in the calculation, as well as the resulting re-adjusted estimates of CO poisoning deaths 2021 and new estimates for 2022, respectively.

Table A.2.a: 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	165	3
n_2	847 – 52 = 795	102 – 6 = 96
n_3	1,021	131
Weighting Factor (n_3 / n_2)	1.2843	1.3646
N	211.9057	4.0938
Total Estimate	{211.9057 + 4.0938 = 215.9994 ≈ 216}	

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.

Table A.2.b: Calculation Detail of the Final Computed 2022 Estimate of Non-Fire CO Poisoning Deaths Associated with Consumer Products

Variable	ICD-10 Code	
	X47	Y17
n_1	203	5
n_2	773 – 39 = 734	73 – 8 = 65
n_3	966	82
Weighting Factor (n_3 / n_2)	1.3161	1.2615
N	267.1635	6.3846
Total Estimate (before correction)	{267.1635 + 267.1635 = 273.5481031 ≈ 274}	

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 2022.

Table A.3 shows the weighting factors used to calculate the estimates for the years 2012–2022, based on the information available to CPSC staff.

Table A.3: CO Fatality Cases and Weighting Factors Used to Calculate the Estimates for the Years 2012–2022

Year	NCHS Total	Total in CPSC Databases*	In-Scope Cases	Weighting Factor
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	795	165	1.2843
Y17	131	96	3	1.3646
2022				
X47	966	734	203	1.3161
Y17	82	65	5	1.2615

* 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, 2012–2022.

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.

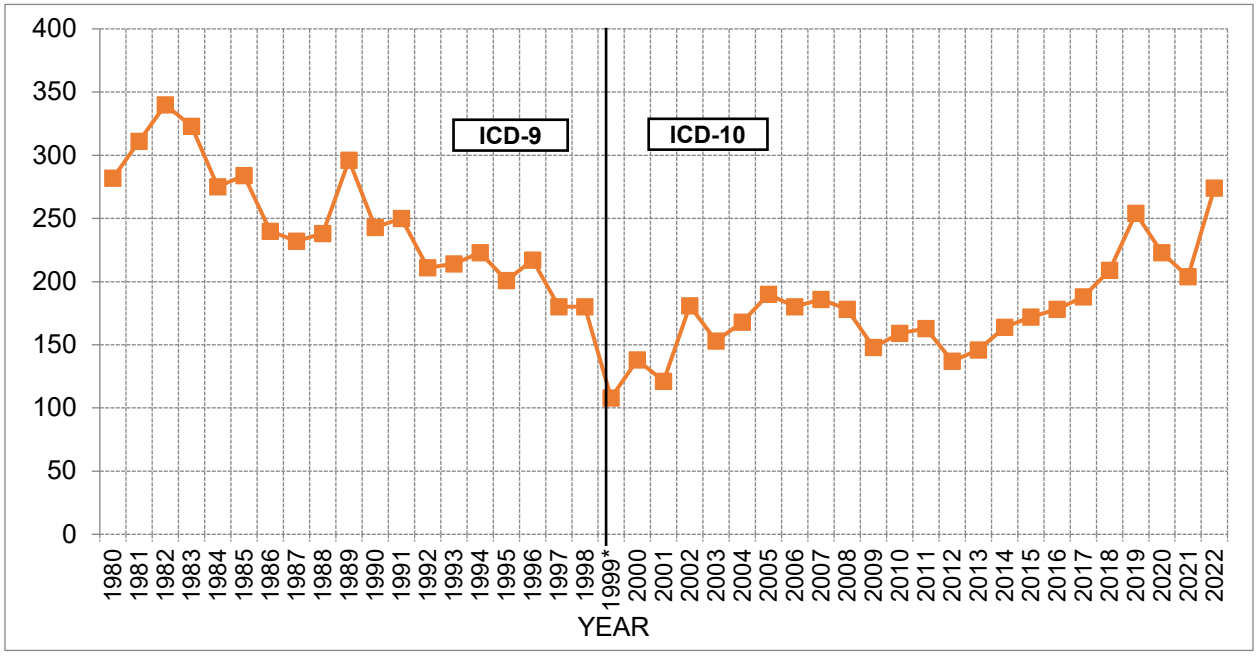
Reports of non-fire CO poisoning deaths were retrieved from the DTHS and ABDT files based on the following criteria: date of death between January 1, 2012 and December 31, 2022, and ICD-10 code of X47 or Y17. Death certificates entered in the CPSC's database before September 23, 2025 were included in 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 2022

Figure B.1 below graphically depicts trends in the estimated CO deaths from 1980 to 2022. Before the implementation of 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 and 2021 estimates otherwise exceed all prior estimates since ICD-10 implementation. Although based on only partially completed reporting, the currently available estimate of 274 exceeds all the years since 1999 (including the prior high in 2019). Some part of the longer-term increase may be attributable to population growth. According to the U.S. Census, the U.S. population grew by about 19 percent between 1999 and 2022.

Figure B.1: Estimated Non-Fire CO Poisoning Deaths Associated with Consumer Products: 1980–2022



*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, 1980–2022.

Estimated 3-Year CO Mortality Trends

Table B.1 presents 3-year centered moving averages of mortality rates from 1980 to 2022. 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 2022, the corresponding 3-year centered moving average mortality rate cannot yet be calculated for 2022. 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 6.99 in the subsequent year before rising to 7.15 in 2021. The 2019, 2020, and 2021 rates each exceed the 2006 estimate of 6.21, which reflected the impact of Hurricane Katrina and other 2005 hurricanes.

Table B.1: Estimated Non-Fire Carbon Monoxide Poisoning Death Rates Associated with Consumer Products, 1980−2022*

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	*6.99*
2021	*216*	332,032	*7.15*
2022	*274*	333,288	-

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.
Sources: 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.[12] With the advent of ICD-10 coding, generating estimates of deaths associated with generators and other engine-driven tools is now possible.

[12] 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 averages for 2020 as the highest level (3.06) so far, which, like each of other three most recent calculable such averages (2018, 2019, and 2021), exceeds the previously highest rate of 2.69 in 2006, which included the impact of Hurricane Katrina in 2005. This most recent calculable 3-year centered moving average mortality rate in 2021 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, 1999−2022*

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	2.83
2020	95	331,512	3.06
2021	107	332,032	2.96
2022	93	333,288	-

* 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 simple linear trend over the entire period in the mortality rate for consumer product-related CO deaths. However, there does appear to be an overall decreased mortality rate in the middle of this period with generally higher mortality rates at the beginning and end of this the 2000-2021 period. The 3-year centered moving annual average mortality rate in 2000 was 3.60, which dipped to around 2.9 between 2008 and 2016, before increasing again back to 2000-era highs, with the most recent calculable centered moving average mortality rate of 3.65 in 2021.

Table B.3: Estimated Non-Fire Carbon Monoxide Poisoning Death Rates Associated with Consumer Products (Excluding Generator-Related Deaths), 1999-2022*

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	3.45
2019	137	328,240	3.70
2020	114	331,512	3.56
2021	102	332,032	3.65
2022	148	333,288	-

* 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 of the four most recent calculable years 2018 (3.29), 2019 (3.28), 2020 (3.44), and 2021 (3.30). The table shows that the 3-year centered moving average mortality rate has more than quadrupled from the rate in 2000 (0.71), to 2021 (3.30).

Table B.4: Estimated Non-Fire Carbon Monoxide Poisoning Death Rates Associated with Generators and Other Engine-Driven Tools, 1999–2022*

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	3.42
2021	116	332,032	3.30
2022	107	333,288	-

* 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 4 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 2021 rate of 3.31. 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 (3.01), 2019 (3.24), 2020 (3.18), and 2021 (3.31) each exceed all of the mortality rates observed throughout that period by at least 14 percent 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), 1999−2022*

Year	Estimate+	U.S. Population (thousands)	3-Year Centered Moving 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	3.01
2019	119	328,330	3.24
2020	103	331,527	3.18
2021	93	332,049	3.31
2022	134	333,288	-

* 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 not 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 65-percent increase in the CO mortality rate, from a 3-year centered moving average mortality rate of 4.34 in 2000 to 7.15 in 2021, 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 (2012–2022). 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 statistically significant differences between the proportion of CO victims in most age groups from the general U.S. population except for the 25-44 age group where no such differences were found significant. Each age group was analyzed separately versus the expected proportion of the respective age group, based on U.S. population figures (and under the assumption 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 four individual groups were found to be significantly different from what would be expected if there was no population group effect:

1. The "Under 15" group[13] was significantly lower than its population in both 2012-2022 and in the most recent 3 years 2020-2022 (< 0.0001 for either period).
2. The "15–24" group was significantly lower than its population in both 2012-2022 and in the most recent 3 years 2020-2022 (< 0.0001 for either period).
3. The "25–44" group was not found significantly different than its population in either2012-2022 (0.4097) or in the most recent 3 years 2020-2022 (0.2730).
4. The "45–64" group was significantly higher than its population in both 2012-2022 and in the most recent 3 years 2020-2022 (< 0.0001 for either period).
5. The "65 and over" group was also significantly higher than its population in both 2012-2022 and in the most recent 3 years 2020-2022 (< 0.0001 in either period).

[13] "Under 5" and "5–14" groups were combined due to small sample sizes.

Sex Group Test Result

Table 8 presents the distribution of estimated CO deaths categorized by sex. For 2020–2022, the average percentage of male CO victims was about 77 percent, and the average percentage of female victims was about 23 percent. By contrast, about 50 percent of the U.S. population is male, and 50 percent of the U.S. population is female.[14] The sex-related differences in CO Poisoning deaths were confirmed to be statistically significant for both the recent 3 years 2020-2022 and for the entire 11 years 2021-2022 (p-value < 0.0001 for both periods).

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

[14] Three-year average, 2020 to 2022, from July U.S. Census estimates of the U.S. population. June 2024.

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