Non-Fire Carbon Monoxide Deaths Associated with the Use of Consumer Products
2017 Annual Estimates

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

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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 2017, along with companion statistics since 2007. Because U.S. Consumer Product Safety Commission (CPSC) staff continues to receive reports of CO poisoning deaths for 2017, the 2017 estimates may change in subsequent reports.

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

For 2017:

- CPSC has records from 131 incidents resulting in an estimated 190 unintentional non-fire CO poisoning deaths associated with the use of consumer products under the CPSC's jurisdiction.
- Fifteen percent of the 131 incidents involved multiple deaths, including one incident where four people died, and another three incidents where three people died.
- Engine-Driven Tools (EDTs) were associated with the largest percentage of non-fire CO poisoning deaths than any other category. This category includes generators, the single product associated with the most CO deaths under CPSC's jurisdiction. An estimated 104 deaths (55%) were associated with EDTs alone.[2] Ninety-five of the 104 estimated EDT-associated deaths involved generators.
- Heating Systems were associated with the second largest percentage of non-fire CO poisoning deaths. An estimated 42 deaths (22%) were associated with some type of heating appliance. This estimate increases to 48 deaths (25%) when multiple-product incidents are considered, and at least one of the products among the multiple products was a heating appliance. Gas heating accounted for the largest share of the deaths, and within the gas-heating equipment, liquid petroleum (LP or propane) and natural gas heating equipment were the major contributors.
- Products other than EDTs, or those specifically designed for heating purposes, were associated with an estimated 37 CO deaths (19%) in 2017. Staff notes that a number of the involved products, although not designed specifically as heating devices, were being used for, or were suspected as being used for, heating purposes, such as gas ranges, camp stoves, and charcoal grills.
- Eighty-four percent of the estimated 190 CO deaths in 2017 occurred in a home location. Within incidents coded as home locations, a few deaths occurred in an external structure at a residence (*e.g.*, detached garage), a non-fixed location domicile used as home (*e.g.*, camper trailers), a structure not designed for habitation used as a home (*e.g.*, metal shed),

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

[2] Numbers presented in this document represent national estimates of unintentional non-fire deaths attributed to CO poisoning that were associated with the use of consumer products and not observed counts as presented in the CPSC report, *Fatal and Nonfatal Incidents Associated with Non-Fire Carbon Monoxide from Engine-Driven Generators and Other Engine-Driven Tools, 2009–2019.*

as well as tents, or temporary shelters.

- In 2017, males constituted 73 percent of CO poisoning victims.

For 2015-2017:

- The estimated annual average from 2015 to 2017 was 180 deaths.
- The majority of CO deaths occurred in the colder months of the year, with more than half of the deaths occurring during the four cold months of November, December, January, and February.
- Adults 45 years and older comprised an annual average of 58 percent of all non-fire, consumer product-related CO deaths, which was disproportionately higher than their representation in the U.S. population. Conversely, children younger than 15 years of age accounted for a disproportionately lower annual average of only 7 percent of the yearly CO poisoning deaths.
- In the period 2015-2017, some statistical evidence demonstrates that the proportion of deaths by race/ethnicity differs from the proportions of race/ethnicity in the U.S. population. The proportion of Hispanic victims (irrespective of race) is significantly lower than the proportion of Hispanic Americans in the U.S. population; while the proportion of Black or African American victims was significantly greater than their percentage in the U.S. population.
- Among deaths with a known location, during 2015-2017, an estimated 46 percent of all CO poisoning deaths occurred in non-urban locations. This is larger than the proportion of the U.S. population living in these areas.

For 2007-2017:

- Staff found no evidence of a statistically significant trend in non-fire CO deaths for the 11-year period from 2007 to 2017. However, we note that if the data are limited to the most recent 9 years (2009 to 2017), statistical evidence demonstrates an upward trend. The estimated number of consumer product-related CO deaths in 2017, is greater than any other year in this report, and the number has increased for the fifth straight year.
- Since 2007, portable generators have been associated with an estimated 727 non-fire, CO poisoning deaths, accounting for 40 percent of all CO deaths related to consumer product 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.[3] Staff notes that 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 that prevent exposed individuals from leaving the CO environment.

Some symptoms of CO poisoning may mimic common illnesses, such as influenza or colds. Thus, a 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 an irritating smoke that can alert the victim to a potentially hazardous situation. EDTs powered by gasoline engines produce large amounts of CO, even in locations where sufficient oxygen is available for combustion. However, EDTs may not emit an irritating exhaust smoke. 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 exhaust pathways, natural and LP gas appliances may emit potentially lethal amounts of CO without any irritating fumes. Again, many victims may be unaware of a potential problem.

[3] 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.

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 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 2017 and updated 2016 estimates of consumer product-related CO poisoning deaths presented in this report are based on reporting as of August 24, 2020. The National Center for Health Statistics (NCHS) has records of every death certificate filed in the United States and its territories. Before 2017, there was evidence that CPSC records contained a large portion of the records reported to NCHS. For the 9 years, 2007 through 2015, CPSC records contain approximately 82 percent of all the fatal CO poisoning deaths that occurred in the United States reported to NCHS. However, in 2016, and to a slightly lesser extent in 2017, there appears to be an anomaly with the method used by Texas in assigning ICD-10 codes used in this analysis, in particular, the Y17 code (see Appendix A for details on the methodology used to determine estimates). The estimates presented here are based on the number of deaths for which CPSC has records, scaled to the NCHS totals, to adjust for missing records. Appendix A of this report describes the detailed process used to generate the national estimates presented in this report.

During 2017, an estimated 190 non-fire CO poisoning deaths were associated with the use of a consumer product under the jurisdiction of the CPSC. This report does not include CO poisoning deaths involving products outside CPSC's jurisdiction, such as incidents where the CO gas resulted from a fire or solely from a motor vehicle, were intentional in nature, or were directly work related. Over the prior 10 years, the annual average was 163 estimated non-fire CO deaths from consumer products. Please note that during the 11 years covered in this report, there were four incidents (one in 2007, one in 2013, one in 2015, and one in 2016) where the exhaust from a motor vehicle engine may have contributed to the victim's CO poisoning death, in addition to a consumer product. Additionally, in a 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.

Although multiple factors may contribute to a CO poisoning fatality, the source of CO is virtually always a fuel-burning product. As mentioned, poor product maintenance by professionals or consumers, inadequate ventilation, faulty exhaust pathways, and poor user understanding of the hazard, or poor judgment in operating these products can result in fatal scenarios. 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 2007 through 2017, 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 (2015 through 2017), followed by yearly estimates for each of the 11 years covered by this report. As noted, data collection was only partially complete for 2017, and estimates for this year may change if additional data become available. Therefore, data for 2017 are reported using italic font in the tables.

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, 2009–2019."

By Product Category

Table 1 shows the estimated average annual number of CO poisoning deaths associated with various consumer products for 2015 to 2017, as well as the annual estimated CO deaths for the individual years from 2007 through 2017. The annual average for this 3-year period is estimated to be 180 (with a standard error of approximately 5.3). The 95 percent confidence interval[4] for this estimated average ranged from 157 to 203 deaths. Appendix B contains a graph and the data point values for the annual estimates of CO poisoning deaths associated with a consumer product for 1980 through 2017.

The estimate for *Heating Systems*, which historically accounts 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 further distributed between generators and other engine-driven tools. The consumer product-related estimate and estimate-by-product distributions were derived using the methodology described in Appendix A.

In 2017, products in the *Heating Systems* category were associated with an estimated 42 deaths (22% of the total 190 CO poisoning deaths associated with consumer products). Of the 42, the majority (64% or 27 deaths) involved gas heating systems. Natural gas heating systems were associated with an estimated six deaths (14% of all heating system-related deaths). LP gas[5] heating was associated with an estimated 16 deaths (38% of heating system-related deaths); and unspecified gas heating was associated with an estimated 5 deaths (12% of heating system-related deaths).

Staff notes that a number of other fuel-burning devices not specifically designed for heating purposes were known or suspected to have been used for heating an enclosed space where a victim died of CO poisoning. Such devices include charcoal/charcoal grills (an estimated 10 deaths) and gas ranges (12 deaths). In one of these cases in 2017, which involved three victims, it is unclear whether the oven was used to help heat the house, or was simply left on after cooking.

All of the estimated six deaths in 2017 that were associated with natural gas heating systems involved installed freestanding furnaces. All of the estimated 16 deaths in 2017 that were associated with LP gas heating systems involved unvented portable propane heaters. These unvented portable propane heaters were fueled by a propane tank and were not a component of an installed heating system. The portable LP heaters are intended as camping heaters or heaters for other temporary spaces and use disposable, refillable or exchangeable propane tanks.

There were also an estimated two deaths (10% of furnace-related deaths) associated with

[4] The confidence interval is based on a t-distribution with two degrees of freedom.
[5] In this document, references to LP gas also include propane and butane gases, the two primary components of LP gas.

coal-burning furnaces and one death associated with an oil-burning furnace. There were an estimated two fatalities associated with kerosene-burning portable heaters (10%) and one from a wood-burning stove used for heating purposes. Additionally, in 2017, there were an estimated five CO deaths (12% of heating system-related deaths) associated with heating systems with unspecified gas fuel sources (four of these were furnaces), and an estimated seven deaths were associated with some type of heating system; it was unknown whether the fuel was gas, liquid, or solid.

In recent years, the *Engine-Driven Tools* category has been associated with more CO deaths than any other category. More than half of the estimated average number of CO deaths in the three most recent years (2015 through 2017) were associated with engine-driven tools (91 of 180, not including multiple-product incidents). This category is more than double the average number associated with heating systems (43 deaths), which is the category with the second highest average number. Over the 11 years covered in this report, the total number of estimated CO deaths associated with engine-driven tools (834) exceeds the estimates for heating systems (554). Estimated generator-related CO deaths alone exceed those for heating systems over these 11 years (726 generator-related deaths, versus 554 heating system-related deaths). When a single CO-producing product is involved, generator-related deaths comprise the majority of engine-driven tools-related CO deaths, accounting for 87 percent of all engine-drive tools-related deaths over the entire 11 years covered by this report.

In 2017, an estimated 10 CO deaths (5% of the 190 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 as being used for heating purposes, often in temporary spaces like inside a vehicle. An estimated six CO deaths were associated with the use of a portable LP cooking device. In four of these deaths, the victims were attempting to use the LP cooking device as a source of heat; in all of these cases, the incident occurred in a temporary location (automobile or camper).

That same year, an estimated four deaths (2%) were associated with residential natural gas water heaters, and an additional four deaths resulted from natural gas pool heaters at hotels.

In 2017, an estimated six deaths were associated with multiple appliances (3% of the total estimated deaths). The multiple-products category includes all incidents where multiple fuel-burning products were used simultaneously, such that a single source of the CO could not be determined. In all of these cases, the products involved were a furnace and/or a water heater.

The largest category in this year's report is the category of *Engine-Driven Tools*, which includes generators, lawn mowers, welding equipment, power washers, and snow blowers/throwers. An estimated 104 CO poisoning deaths (55% of the 190 estimated total deaths) were associated with engine-driven tools. An estimated 95 CO poisoning deaths were associated with a generator in 2017 (91% of all engine-driven tool deaths, and 50% of the total consumer product estimate).

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

Table 1: Estimated Non-Fire Carbon Monoxide Poisoning Deaths by Associated Fuel-Burning Consumer Product, 2007–2017

	2015–*2017*+		Annual Estimates										
Consumer Product	**Average Estimate**	**Average Percent**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	***2017*+**
Total	**180**	**100%**	**186**	**178**	**148**	**159**	**163**	**137**	**146**	**164**	**172**	**178**	***190***
Heating Systems	**43**	**24%**	**66**	**58**	**41**	**58**	**49**	**46**	**43**	**64**	**37**	**50**	***42***
Furnaces (incl. Boilers)	**24**	**13%**	**29**	**29**	**16**	**30**	**22**	**27**	**21**	**24**	**20**	**34**	***17***
Coal	1	1%	*	*	*	*	1	*	*	*	*	*	*2*
Liquid Petroleum (LP) Gas	2	1%	*	3	1	7	*	4	1	11	3	3	*
Natural Gas	9	5%	20	18	10	15	6	15	5	6	6	15	*6*
Oil	2	1%	5	1	3	1	2	*	5	1	3	2	*1*
Unspecified Gas	8	4%	4	2	1	4	10	4	10	6	8	11	*4*
Unspecified Fuel	2	1%	*	5	1	2	2	5	*	*	1	2	*4*
Portable Heaters	**14**	**8%**	**17**	**13**	**8**	**19**	**13**	**11**	**12**	**18**	**11**	**11**	***20***
Kerosene	2	1%	3	4	*	1	2	1	*	2	1	4	*2*
Liquid Petroleum (LP) Gas	11	6%	14	9	8	18	11	10	12	14	10	6	*16*
Natural Gas	*	*	*	*	*	*	*	*	*	1	*	*	*
Unspecified Gas	< 1	< 1%	*	*	*	*	*	*	*	*	*	1	*
Unspecified Fuel	< 1	< 1%	*	*	*	*	*	*	*	*	*	*	*1*
Wall/Floor Furnaces	**1**	**1%**	**9**	**3**	**6**	**5**	**1**	*****	*****	**5**	**1**	**1**	***2***
Liquid Petroleum (LP) Gas	< 1	< 1%	4	1	5	1	*	*	*	*	*	1	*
Natural Gas	< 1	< 1%	5	2	1	2	*	*	*	2	1	*	*
Unspecified Gas	< 1	< 1%	*	*	*	*	*	*	*	2	*	*	*1*
Unspecified Fuel	< 1	< 1%	*	*	*	1	1	*	*	*	*	*	*1*
Room/Space Heaters	**1**	**1%**	**6**	**5**	**9**	**1**	**5**	**5**	**9**	**8**	**1**	**1**	***1***
Coal	*	*	*	*	*	*	2	*	1	1	*	*	*
Liquid Petroleum (LP) Gas	*	*	4	2	5	1	1	4	3	7	*	*	*
Natural Gas	*	*	*	2	2	*	*	*	2	*	*	*	*
Wood	< 1	< 1%	*	1	2	*	1	*	2	*	*	*	*1*
Unspecified Gas	< 1	< 1%	2	*	*	*	1	*	*	*	*	1	*
Unspecified Fuel	< 1	< 1%	*	*	*	*	*	1	*	*	1	*	*
Unspecified Heater/System	**2**	**1%**	**5**	**8**	**2**	**4**	**8**	**2**	**1**	**9**	**3**	**3**	***1***
Liquid Petroleum (LP) Gas	< 1	< 1%	1	2	*	1	3	1	*	8	1	*	*
Natural Gas	*	*	3	*	*	*	1	*	*	*	*	*	*
Unspecified Gas	*	*	*	2	1	1	1	1	*	*	*	*	*
Unspecified Fuel	2	1%	1	4	1	1	2	*	1	1	1	3	*1*
Charcoal Grills, Charcoal	**9**	**5%**	**8**	**7**	**7**	**17**	**10**	**6**	**11**	**7**	**11**	**6**	***10***

Table 1: Estimated Non-Fire Carbon Monoxide Poisoning Deaths by Associated Fuel-Burning Consumer Product, 2007–2017

(continued)

Consumer Product	2015–*2017*+		Annual Estimates										
	Average Estimate	Average Percent	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	*2017*+
Engine-Driven Tools	**91**	**51%**	**79**	**82**	**76**	**56**	**73**	**64**	**68**	**62**	**92**	**77**	***104***
Generators – Gasoline	78	43%	68	76	64	40	64	57	55	53	84	61	*89*
Generators – LP	2	1%	*	*	*	2	*	*	*	*	*	7	*
Generators - Unspecified Fuel	2	1%	*	*	*	*	*	*	1	1	*	*	*6*
Other Engine-Driven Tools	10	6%	11	6	12	14	10	6	13	8	8	11	*10*
Ranges or Ovens	**8**	**4%**	**6**	*****	**4**	**5**	**8**	**4**	**10**	*****	**5**	**7**	***12***
Liquid Petroleum (LP) Gas	1	1%	1	*	*	1	1	1	1	*	3	*	*1*
Natural Gas	3	2%	2	*	2	2	3	*	2	*	3	6	*
Unspecified Gas	4	2%	3	*	2	1	3	2	2	*	*	*	*11*
Unspecified Fuel	< 1	< 1%	*	*	*	*	*	*	5	*	*	1	*
Water Heaters	**6**	**3%**	**2**	**6**	**5**	**2**	**8**	**5**	**2**	**5**	**9**	**6**	***4***
Liquid Petroleum (LP) Gas	*	*	1	1	2	*	1	*	1	1	*	*	*
Natural Gas	2	< 1%	*	1	1	2	4	*	*	*	*	1	*4*
Oil	*	*	*	1	*	*	*	*	*	*	*	*	*
Unspecified Gas	4	2%	1	1	1	*	1	2	*	2	8	4	*
Unspecified Fuel	< 1	< 1%	*	2	1	*	1	2	1	1	1	*	*
Pool Heaters	**2**	**1%**	*****	*****	*****	**1**	**1**	*****	**3**	**2**	*****	**2**	***4***
Liquid Petroleum (LP) Gas	*****	*****	*****	*****	*****	**1**	*****	*****	*****	*****	*****	*****	*****
Natural Gas	**1**	**1%**	*****	*****	*****	*****	*****	*****	**3**	**1**	*****	*****	***4***
Unspecified Gas	**1**	**1%**	*****	*****	*****	*****	**1**	*****	*****	*****	*****	**2**	*****
Unspecified Fuel	*****	*****	*****	*****	*****	*****	*****	*****	*****	**1**	*****	*****	*****
Lanterns	**2**	**1%**	*****	**4**	**1**	*****	**2**	**2**	*****	**5**	**5**	**1**	*****
Liquid Petroleum (LP) Gas	2	1%	*	4	1	*	1	2	*	4	5	1	*
Kerosene	*	*	*	*	*	*	*	*	*	1	*	*	*
Unspecified Fuel	*	*	*	*	*	*	1	*	*	*	*	*	*
Grills, Camp Stoves	**4**	**2%**	**2**	*****	*****	*****	**2**	*****	**1**	**6**	**4**	**3**	***6***
Liquid Petroleum (LP) Gas	4	2%	1	*	*	*	2	*	*	2	4	3	*6*
Wood	*	*	*	*	*	*	*	*	*	1	*	*	*
Unspecified Fuel	*	*	1	*	*	*	*	*	1	2	*	*	*

Table 1: Estimated Non-Fire Carbon Monoxide Poisoning Deaths by Associated Fuel-Burning Consumer Product, 2007–2017 (continued)

	2015–*2017*+		Annual Estimates										
Consumer Product	**Average Estimate**	**Average Percent**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	***2017***+
Other Products	**1**	**1%**	**2**	**5**	**2**	**5**	**3**	**2**	**2**	**7**	**1**	**2**	***1***
Chimney – Unspecified Fuel	*	*	*	*	*	*	*	1	1	*	*	*	*
Fire Pit – Wood	< 1	< 1%	*	*	*	*	*	*	*	*	*	1	*
Fireplace – Unspecified Gas	*	*	1	*	*	*	*	*	*	*	*	*	*
Fireplace – Wood	*	*	1	*	*	*	*	*	*	*	*	*	*
Fireplace – Coal	*	*	*	*	*	1	*	*	*	*	*	*	*
Other Products – LP Gas	1	1%	*	3	1	1	2	*	1	4	1	*	*1*
Other Products – Natural Gas	*	*	*	*	1	*	*	*	*	*	*	*	*
Other Products – Unspecified Fuel	*	*	*	*	*	*	*	*	*	1	*	*	*
Unidentified Product	*	*	*	*	*	2	1	1	*	1	*	*	*
Unidentified Product – LP Gas	< 1	< 1%	*	2	*	*	*	*	*	1	*	1	*
Multiple Products	**11**	**6%**	**20**	**12**	**11**	**15**	**8**	**5**	**5**	**7**	**9**	**19**	***6***

\+ Data collection for 2017 is only partially complete, and data are shown in italics. Italicized estimates may 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, 2007–2017.
Note: Reported annual estimates and estimated averages and percentages may not add to subtotals or totals due to rounding.

By Fuel Type

Table 2 (beginning on page 15) organizes the estimates by product within fuel type. The three major fuel types include: *Gas-Fueled Products* (natural gas and liquid petroleum—LP including propane and butane—gas); *Solid-Fueled Products* (charcoal, coal, and wood); and *Liquid-Fueled Products* (gasoline, kerosene, and oil). Of these fuel types, *Gas-Fueled Products* were associated with 60 of the 190 (32%) estimated CO deaths in 2017. *Liquid-Fueled Products* were associated with an estimated 103 (54%) deaths; and *Solid-Fueled Products* were associated with an estimated 13 (7%) deaths in the same period. In 2017, all of the estimated six deaths (3%) associated with the *Multiple Products* category used some type of gas as a fuel source: natural gas, LP gas, or an unspecified gas type.

In the *Gas-Fueled Products* category in 2017, an estimated 27 of the 60 gas-fueled appliance deaths (45%) were associated with heating systems or heaters, including furnaces, portable heaters, and room or space heaters. Additionally, all six of the *Multiple Gas-Fueled Products* fatalities were associated with a heating-related product and another product, raising the total number of incidents involving heating-related products to 33 of the 60 *Gas-Fueled Products* category. It is suspected that the majority of the estimated 12 gas range fatalities were also associated with attempts to heat the incident location.

All but three of the estimated 103 liquid-fueled appliance-related deaths in 2017 were associated with engine-driven tools (*e.g.*, generators, lawn mowers/garden tractors). An estimated 89 deaths were associated with gasoline-fueled generators.

In 2017, the estimated 13 deaths that occurred fit within the *Solid-Fueled Products* category. All but three were associated with charcoal or charcoal grills.

Table 2: Estimated Non-Fire Carbon Monoxide Poisoning Deaths Associated with Consumer Products Organized by Fuel Type, 2007–2017

	2015–*2017*+		Annual Estimates										
Consumer Product	**Average Estimate**	**Average Percent**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	***2017*+**
Total	**180**	**100%**	**186**	**178**	**148**	**159**	**163**	**137**	**146**	**164**	**172**	**178**	***190***
Gas-Fueled Products	**61**	**34%**	**80**	**58**	**53**	**70**	**58**	**51**	**45**	**78**	**53**	**69**	***60***
Natural Gas	**15**	**8%**	**30**	**28**	**17**	**23**	**15**	15	13	11	10	21	***13***
Furnace (incl. Boilers)	9	5%	20	18	10	15	6	15	5	6	6	15	*6*
Pool Heater	1	1%	*	*	*	*	*	*	3	1	*	*	*4*
Portable Heater	*	*	*	*	*	*	*	*	*	1	*	*	*
Range/Oven	3	2%	2	*	2	2	3	*	2	*	3	6	*
Room/Space Heater	*	*	*	3	2	*	*	*	2	*	*	*	*
Wall/Floor Furnace	< 1	< 1%	5	3	1	2	*	*	*	2	1	*	*
Water Heater	2	1%	*	1	1	2	4	*	*	*	*	1	*4*
Unspecified Heater	*	*	3	*	*	*	1	*	*	*	*	*	*
Other Appliance	*	*	*	*	1	*	*	*	*	*	*	*	*
Liquid Petroleum (LP) Gas	**25**	**14%**	**26**	**31**	**23**	**35**	**23**	**22**	**20**	**52**	**27**	**22**	***25***
Furnace (incl. Boilers)	2	1%	*	3	1	7	*	4	1	11	3	3	*
Generator	2	1%	*	*	*	2	*	*	*	*	*	7	*
Grill/Camp Stove	4	2%	1	*	*	*	2	*	*	2	4	3	*6*
Lantern	2	1%	*	4	1	*	1	2	*	4	5	1	*
Other Products/Unknown	1	1%	*	3	1	*	*	*	*	2	1	1	*
Pool Heater	*	*	*	*	*	1	*	*	*	*	*	*	*
Portable Heater	11	6%	14	9	8	18	11	10	12	14	10	6	*16*
Range/Oven	1	1%	1	*	*	1	1	1	1	*	3	*	*1*
Refrigerator	< 1	< 1%	*	*	*	1	2	*	1	2	*	*	*1*
Room/Space Heater	*	*	4	3	5	1	1	4	3	7	*	*	*
Unspecified Heater/System	< 1	< 1%	1	3	*	1	3	1	*	8	1	*	*
Wall/Floor Furnace	*	*	4	1	5	1	*	*	*	*	*	*	*
Water Heater	< 1	< 1%	1	1	2	*	1	*	1	1	*	1	*
Unspecified Gas	**17**	**9%**	**11**	**3**	**5**	**6**	**17**	**10**	**13**	**11**	**15**	**20**	***16***
Furnace (incl. Boilers)	8	4%	4	2	1	4	10	4	10	6	8	11	*4*
Pool Heater	1	1%	*	*	*	*	1	*	*	*	*	2	*
Portable Heater	< 1	< 1%	*	*	*	*	*	*	*	*	*	1	*
Range/Oven	4	2%	3	*	2	1	3	2	2	*	*	*	*11*
Room/Space Heater	< 1	< 1%	2	*	*	*	1	*	*	*	*	1	*
Fireplace	*	*	1	*	*	*	*	*	*	*	*	*	*
Wall/Floor Furnace	< 1	< 1%	*	*	*	*	*	*	*	2	*	*	*1*
Water Heater	4	2%	1	2	1	*	1	2	*	2	8	4	*
Unspecified Heater	*	*	*	1	1	1	1	1	*	*	*	*	*

Table 2: Estimated Non-Fire Carbon Monoxide Poisoning Deaths Associated with Consumer Products Organized by Fuel Type, 2007–2017 (continued)

	2015–*2017*+		Annual Estimates										
Consumer Product	**Average Estimate**	**Average Percent**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	***2017*+**
Multiple Gas-Fueled Products	**4**	**2%**	**13**	**2**	**8**	**6**	**3**	**4**	*****	**5**	**1**	**6**	***6***
Liquid-Fueled Products	**94**	**52%**	**89**	**95**	**81**	**60**	**79**	**65**	**73**	**67**	**96**	**83**	***103***
Gasoline-Fueled	88	49%	**78**	**82**	**77**	**53**	**73**	**64**	**67**	**61**	**92**	**73**	***99***
Generator	78	43%	68	76	64	40	64	57	55	53	84	61	*89*
Other Engine-Driven Tools	10	6%	11	6	12	14	10	6	13	8	8	12	*10*
Kerosene-Fueled	**2**	**1%**	**3**	**4**	*****	**1**	**2**	**1**	*****	**4**	**1**	**4**	***2***
Portable Heater	2	1%	3	4	*	1	2	1	*	2	1	4	*2*
Lantern	*	*	*	*	*	*	*	*	*	1	*	*	*
Oil-Fueled	**2**	**1%**	**5**	**2**	**3**	**1**	**2**	*****	**5**	**1**	**3**	**2**	***1***
Furnace (incl. Boilers)	2	1%	5	1	3	1	2	*	5	1	3	2	*1*
Water Heater	*	*	*	1	*	*	*	*	*	*	*	*	*
Diesel-Fueled	*****	*****	*****	**1**	*****	*****	*****	*****	*****	*****	*****	*****	*****
Water Heater	*	*	*	1	*	*	*	*	*	*	*	*	*
Multiple Liquid-Fueled Products	**1**	**1%**	**2**	**5**	**1**	**5**	**1**	*****	**1**	**1**	*****	**3**	*****
Solid-Fueled Products	**11**	**6%**	**9**	**8**	**9**	**18**	**14**	**5**	**14**	**9**	**11**	**8**	***13***
Charcoal-Fueled	9	5%	**8**	**7**	**7**	**17**	**10**	5	11	7	11	7	***10***
Charcoal / Charcoal Grills	9	5%	8	7	7	17	10	5	11	7	11	7	*10*
Coal-Fueled	**1**	**1%**	*****	*****	*****	**1**	**3**	*****	**1**	**1**	*****	*****	***2***
Furnace (incl. Boilers)	1	1	*	*	*	*	1	*	*	*	*	*	*2*
Room/Space Heater	*	*	*	*	*	*	2	*	1	1	*	*	*
Chimney / Fireplace	*	*	*	*	*	1	*	*	*	*	*	*	*
Wood-Fueled	**1**	**1%**	**1**	**1**	**2**	*****	**1**	*****	**2**	**1**	*****	**1**	***1***
Chimney/Fireplace	*	*	1	*	*	*	*	*	*	*	*	*	*
Fire Pit	< 1	< 1%	*	*	*	*	*	*	*	*	*	1	*
Grill/Stove	*	*	*	*	*	*	*	*	*	1	*	*	*
Room/Space Heater	< 1	< 1%	*	1	2	*	1	*	2	*	*	*	*1*

Table 2: Estimated Non-Fire Carbon Monoxide Poisoning Deaths Associated with Consumer Products Organized by Fuel Type, 2007–2017 (continued)

	2015–*2017*+		Annual Estimates										
Consumer Product	**Average Estimate**	**Average Percent**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	***2017***+
Unspecified Fuel Products	**8**	**4%**	**2**	**11**	**3**	**7**	**9**	**11**	**10**	**8**	**5**	**7**	***13***
Chimney	*	*	*	*	*	*	*	1	1	*	*	*	*
Furnace (incl. Boilers)	2	1%	*	5	1	2	2	5	*	*	1	2	*4*
Generator	2	1%	*	*	*	*	*	*	1	1	*	*	*6*
Grill/Camp Stove	*	*	1	*	*	*	*	*	1	2	*	*	*
Lantern	*	*	*	*	*	*	1	*	*	*	*	*	*
Pool Heater	*	*	*	*	*	*	*	*	*	1	*	*	*
Portable Heater	< 1	< 1%	*	*	*	*	*	*	*	*	*	*	*1*
Range/Oven	< 1	< 1%	*	*	*	*	*	*	5	*	*	1	*
Room/Space Heater	< 1	< 1%	*	*	*	*	*	1	*	*	1	*	*
Unspecified Heater	2	1%	1	4	1	1	2	*	1	1	1	3	*1*
Wall/Floor Furnace	< 1	< 1%	*	*	*	1	1	*	*	*	*	*	*1*
Unidentified Product	*	*	*	*	*	2	1	1	*	1	*	*	*
Water Heater	< 1	< 1%	*	2	1	*	1	2	1	1	1	*	*
Multiple Product - Different Fuels	**6**	**3%**	**5**	**5**	**2**	**4**	**3**	**4**	**3**	**1**	**8**	**10**	*****
Gas & Liquid	5	3%	5	3	1	1	2	2	3	1	6	8	*
Gas & Solid	< 1	< 1%	*	*	1	*	*	1	*	*	*	1	*
Liquid & Solid	*	*	*	1	*	2	1	*	*	*	*	*	*
Liquid & Unspecified	1	1%	*	*	*	*	*	*	*	*	1	1	*
Gas & Liquid & Unspecified	*	*	*	2	*	*	*	*	*	*	*	*	*

\+ Data collection for 2017 is only partially complete. Italicized estimates may 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, 2007–2017.
Note: Reported annual estimates and estimated averages and percentages may not add to subtotals or totals due to rounding.

Engine-Driven Tools

Table 3 shows a breakdown of the fatality estimates for the 11-year period from 2007 through 2017 in the *Engine-Driven Tools* category. During 2017, engine-driven tools were associated with an estimated 104 carbon monoxide poisoning deaths (55% of the 190 total consumer product estimate). In the 3 most recent years, EDTs comprised 54 percent of all consumer-product-related CO fatalities (estimated annual average of 97 out of 180). Of these EDT fatalities, generators dominated, with an estimated annual average of 82 out of 97)

Lawnmowers were associated with slightly less than half of the deaths listed in the *Other Engine-Driven Tools* category for the 11-year period (52 of 107 total fatalities). There were six other deaths associated with a lawnmower and another product in this period. There was an estimated average of five lawnmower-related CO deaths per year from 2015 to 2017 (16 deaths, excluding multi-product deaths). There were multiple fatalities for three other sub-categories over the 2015 to 2017 period: welders (an estimated 4 fatalities), snow blowers (2) and power washers (2).

Table 3: Estimated Non-Fire Carbon Monoxide Poisoning Deaths Associated with Engine-Driven Tools, 2007–2017

Engine-Driven Tools	2015-*2017*+ Average Estimate	Average Percentage	Annual Estimate										
			2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	*2017*+
Total	**97**	**100%**	**85**	**93**	**78**	**61**	**78**	**66**	**73**	**64**	**97**	**91**	***104***
Generators	**82**	**85%**	**68**	**76**	**64**	**42**	**64**	**57**	**56**	**54**	**84**	**67**	***95***
Gasoline-fueled	78	80%	68	76	64	40	64	57	55	53	84	61	*89*
LP-fueled	2	2%	*	*	*	2	*	*	*	*	*	7	*
Unspecified Fuel	2	2%	*	*	*	*	*	*	1	1	*	*	*6*
Other Engine-Driven Tools (OEDTs)	**9**	**9%**	**11**	**6**	**12**	**14**	**10**	**6**	**13**	**8**	**8**	**11**	***8***
Lawn Mowers	**5**	**5%**	**5**	**2**	**6**	**7**	**3**	**4**	**7**	**2**	**4**	**7**	***5***
Riding Mowers	5	5%	4	2	6	5	3	2	6	1	3	7	*4*
Unspecified Mowers	1	1%	1	*	*	2	*	1	1	1	1	*	*1*
Paint Sprayer	*	*	*	*	*	*	1	*	*	*	*	*	*
Power Washer	1	1%	1	*	1	*	2	*	*	2	*	1	*1*
Snow Blower/Thrower	1	1%	2	*	3	1	1	*	2	1	1	1	*
ATV	< 1	< 1%	*	2	*	4	2	1	1	1	*	*	*1*
Water Pump	*	*	1	*	*	1	*	*	1	*	*	*	*
Welder	1	1%	1	1	*	*	*	*	*	*	3	1	*
Air Compressor	*	*	*	*	*	*	*	*	*	*	*	*	*
Concrete Saw	*	*	*	1	*	*	*	*	*	*	*	*	*
Tiller	*	*	*	*	1	*	*	*	*	*	*	*	*
Go-Cart	*	*	*	*	1	*	*	*	*	*	*	*	*
Small Engine	< 1	< 1%	*	*	*	*	*	*	*	*	*	1	*
Snowmobile	*	*	*	*	*	*	*	*	*	*	*	*	*
Stump Grinder	< 1	< 1%	*	*	*	*	*	*	1	*	*	*	*1*
Wood Splitter	*	*	*	*	*	*	*	1	*	1	*	*	*
Multiple Product: Engine-Driven Tools Involved	**6**	**5%**	**6**	**10**	**2**	**6**	**4**	**2**	**5**	**2**	**5**	**12**	*****
Generator + OEDT	< 1	< 1%	*	*	*	*	*	*	*	*	*	1	*
Generator + other Product	5	5%	6	8	2	6	3	2	3	2	4	10	*
Multiple OEDT	< 1	< 1%	*	2	*	*	1	*	*	*	*	1	*
OEDT + other product	< 1	< 1%	*	*	*	*	*	*	1	*	1	*	*

\+ Data collection for 2017 is only partially complete, and data are shown in italics. Italicized estimates may change in the future, if more reports of deaths are received.

* No reports received by CPSC staff.

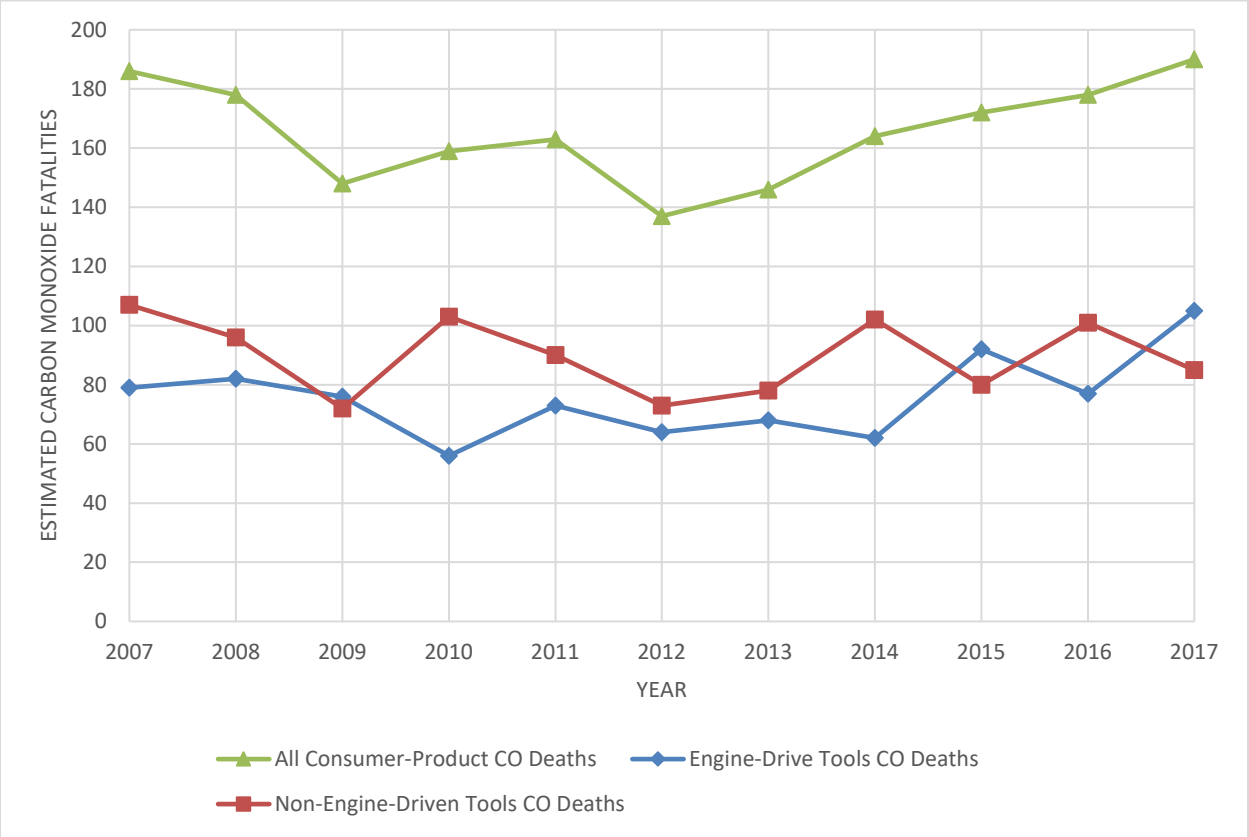
Source: U.S. Consumer Product Safety Commission/EPHA.
CPSC Death Certificate File, CPSC Injury or Potential Injury Incident File, CPSC In-Depth Investigation File, National Center for Health Statistics Mortality File, 2007–2017.

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 2007 to 2017 indicates no evidence of a statistically significant trend (p-value = 0.6601). However, if the trend is limited to the 9 most recent years (2009 to 2017), staff observes a statistically significant increasing trend (p-value = 0.0232). As can be seen in Figure 1 below, there has been a steady rise in the estimated CO fatalities from consumer products, increasing from an estimated 137 in 2012, up to 190 in 2017.

Figure 1: Comparison of Trends in Consumer Product-Related Carbon Monoxide Deaths, 2007 to 2017



Source: U.S. Consumer Product Safety Commission/EPHA.
CPSC Death Certificate File, CPSC Injury or Potential Injury Incident File, CPSC In-Depth Investigation File, 2007–2017.

Number of Deaths per Incident Reported to CPSC

Table 4 presents a summary of the incident data distributed 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. Table 4 shows that in 2017, 112 of the 131 fatal CO incidents (85% 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. Staff notes that these are counts of incidents reported in CPSC databases and do not represent the national estimates of deaths per CO incident. Therefore, the counts presented in Table 4 should not be expected to add up to the estimated deaths in other tables.

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 of these 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 death certificates, while others were identified from news articles contained in the CPSC Injury or Potential Injury Incident (IPII) database. Over the 11-year period covered by this report, CPSC records indicate that 18 percent of the incidents resulted in multiple deaths. Twenty incidents resulted in four or more CO deaths, including an incident in 2015, where eight people died, and another 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, 2007–2017

Number of Deaths Reported in Incident	2015–*2017*+		Annual Incidents										
	Annual Average	Average Percent	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	*2017*+
All Incidents	**122**	**100%**	**147**	**141**	**117**	**116**	**120**	**90**	**106**	**110**	**104**	**130**	***131***
1	102	84%	125	119	93	100	95	74	84	86	83	110	*112*
2	15	12%	13	15	19	14	22	14	21	21	15	16	*15*
3	2	2%	8	5	4	1	1	1	*	1	2	1	*3*
4	2	2%	1	2	1	1	1	*	1	1	3	2	*1*
5	*	*	*	*	*	*	1	1	*	1	*	*	*
6	< 1	< 1%	*	*	*	*	*	*	*	*	*	1	*
7	*	*	*	*	*	*	*	*	*	*	*	*	*
8	< 1	< 1%	*	*	*	*	*	*	*	*	1	*	*

\+ Data collection for 2017 is only partially complete, and data are shown in italics. Italicized counts may 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 Death

Table 5 shows that in 2017, an estimated 159 CO poisoning deaths occurred in home locations, including an estimated five deaths in detached structures at residential locations (*i.e.*, sheds, detached garages) and another 11 occurred in structures not intended originally as a permanent residence (*i.e.*, camper trailers, sea-land shipping containers). From 2015 to 2017, an annual average of 146 CO poisoning deaths (81% of the annual average estimate for all CO deaths) occurred at home locations. In 2017, an estimated 13 deaths took place in temporary shelters, such as campers, cabins, and trailers used for shelter. For 2015 to 2017, an annual average of 19 CO poisoning deaths (11%) took place in temporary shelters. Deaths due to CO poisoning in temporary shelters were most commonly associated with heating sources, generators, or lanterns.

A small percentage of the CO poisoning deaths occurred in vehicles (such as passenger vans, trucks, automobiles, or boats), where a consumer product was the CO-producing product in use. In 2017, there were an estimated 10 CO deaths in this category. For the 3-year period 2015 to 2017, an annual average of nine CO poisoning deaths (5%) took place in vehicles. All of the vehicle location incidents in this 3-year period involved a generator, LP heater, LP lantern, LP grill, or the burning of charcoal inside the vehicle.

Table 5: Estimated Non-Fire Carbon Monoxide Poisoning Deaths by Location of Death, 2007−2017

	2015−*2017*+		Annual Estimate										
Location of Death	**Average Estimate**	**Average Percent**	**2007**	***2008***	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	***2017***+
Total	**180**	**100%**	**186**	**178**	**148**	**159**	**163**	**137**	**146**	**164**	**172**	**178**	***190***
Home[1]	130	72%	138	124	109	125	122	107	104	100	113	135	*143*
Home – External Structure[2]	10	6%	11	13	7	5	10	5	13	15	14	11	*5*
Home – But Not House[3]	6	3%	4	6	1	5	5	1	3	12	4	3	*11*
Temporary Shelter	19	11%	22	20	18	17	15	21	16	21	24	19	*13*
Vehicles (including boats)	9	5%	8	9	12	6	9	*	7	6	12	4	*10*
Outdoors	< 1	< 1%	*	*	*	*	*	*	*	*	*	1	*
Other	4	2%	2	3	*	1	1	*	2	8	5	1	*7*
Unknown	< 1	< 1%	*	2	*	*	1	2	*	1	*	1	*

\+ Data collection for 2017 is only partially complete, and data are shown in italics. Italicized estimates may 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, 2007–2017.

By Time of Year

CPSC data indicate that there were more CO deaths attributable to incidents that occurred in the 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, 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 2017, an estimated 81 of the 190 estimated CO deaths (43%) were attributable to incidents that occurred during the four cold months of November, December, January, and February. Over the 11 years covered by this report, the average percentage occurring in the four colder months is somewhat higher at 55 percent. In 2017, an estimated 66 deaths (35%) are attributable to incidents that occurred during the transition months of March, April, September, and October. Conversely, this is somewhat higher than the 11-year average of 29 percent for the same four months. And in the warmer months of May, June, July, and August, an estimated 43 CO deaths (23%) occurred. Again, this is somewhat higher than the 11-year average of 16 percent for the same months.

Table 6: Estimated Non-Fire Carbon Monoxide Poisoning Deaths by Month and Year of the Fatality, 2007–2017

Month of Death	2015–*2017*+		Annual Estimate										
	Average Estimate	Average Percent	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	*2017*+
Total	**180**	**100%**	**186**	**178**	**148**	**159**	**163**	**137**	**146**	**164**	**172**	**178**	***190***
Cold Months	**91**	**51%**	**109**	**110**	**85**	**109**	**85**	**75**	**82**	**83**	**82**	**109**	***81***
November	20	11%	21	28	12	18	34	26	16	20	10	32	*17*
December	21	12%	25	25	20	38	20	25	28	20	23	19	*21*
January	26	14%	43	31	29	38	24	10	22	26	24	28	*27*
February	23	13%	20	26	24	15	8	14	16	17	24	29	*16*
Transition Months	**59**	**33%**	**49**	**34**	**41**	**33**	**55**	**46**	**43**	**44**	**62**	**49**	***66***
March	15	8%	19	7	12	22	9	6	12	10	19	12	*13*
April	19	11%	15	7	8	6	11	14	6	14	28	13	*15*
September	14	8%	1	7	4	2	13	6	5	6	11	7	*23*
October	12	7%	14	13	17	2	23	20	21	14	4	17	*15*
Warm Months	**31**	**17%**	**29**	**32**	**21**	**17**	**23**	**16**	**21**	**37**	**29**	**20**	***43***
May	6	3%	9	16	5	8	9	2	4	17	4	5	*9*
June	9	5%	4	8	10	5	2	5	6	4	9	3	*16*
July	9	5%	5	3	4	2	4	7	7	13	11	6	*10*
August	7	4%	11	5	2	1	8	1	5	4	5	6	*9*

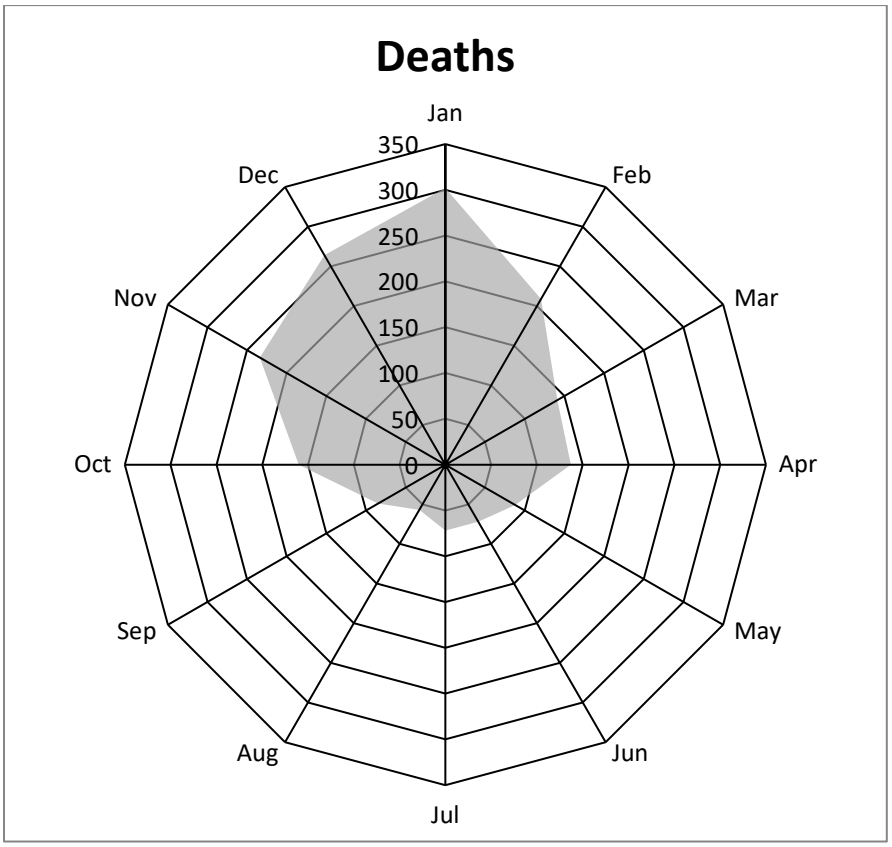
\+ Data collection for 2017 is only partially complete. Italicized estimates may change in the future, if more reports of deaths are received.

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, 2007– 2017

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 2007 through 2017. 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. Additionally, as time gets deeper into the colder season, the number of CO deaths increases. Conversely, as time get deeper into the warmer months, the number of deaths decreases.

Figure 2: Estimated Number of Consumer Product-Related Carbon Monoxide Deaths by Month of Death, 2007–2017



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, 2007– 2017.

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 (2007–2017). From the data, it appears that consumer product-related CO deaths are skewed toward older individuals. For the 3 most recent years (2015–2017), children younger than 15 years of age accounted for an annual average of 7 percent (an estimated 12 of 180) of the yearly CO poisoning deaths, while this age group represents an average of about 19 percent of the U.S. population. For the same time frame, deaths among adults 45 years and older was 58 percent (104 of 180), while they represented about 41 percent of the U.S. population. Statistical tests confirm the significance in the age-related differences in CO poisoning deaths.

Table 7: Estimated Non-Fire Carbon Monoxide Poisoning Deaths by Age of Victim, 2007–2017

Age	2015–*2017*+		Estimated Percentage of U.S. Population#	Annual Estimate										
	Average Estimate	Average Percent		2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	*2017*+
Total	**180**	**100%**	**100%**	**186**	**178**	**148**	**159**	**163**	**137**	**146**	**164**	**172**	**178**	***190***
Under 5	1	1%	6%	8	2	3	1	*	1	*	2	*	1	*2*
5 - 14	11	6%	13%	6	8	2	1	4	4	5	7	17	6	*9*
15 - 24	13	7%	13%	18	15	14	12	9	6	11	8	15	6	*17*
25 - 44	51	28%	26%	34	54	43	39	36	37	34	35	45	54	*55*
45 - 64	67	37%	26%	70	68	59	69	63	56	62	67	65	83	*55*
65 and over	37	21%	15%	49	30	27	36	52	32	36	44	31	29	*51*

\+ Data collection for 2017 is only partially complete. Italicized estimates may 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 (2015-2017). U.S. Census Bureau, 2019 Estimates.

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, 2007-2017.
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, 2019. June 2020.

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

Gender of Victim

Table 8 presents the distribution of estimated CO deaths categorized by gender. In 2017, 73 percent of CO poisoning victims were males, and 27 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 2015—2017, the average percentage of male CO victims was 75 percent, and the average percentage of female victims was 25 percent. By contrast, about 49 percent of the U.S. population is male, and 51 percent of the U.S. population is female.[6] The gender-related differences in CO poisoning deaths were confirmed to be statistically significant (p-value = < 0.0001).

[6] Three-year average, 2015 to 2017, from June 2020 U.S. Census estimates of the U.S. population.

Table 8: Estimated Non-Fire Carbon Monoxide Poisoning Deaths by Gender of Victim, 2007-2017

Gender	2015–*2017*+		Estimated Percentage of U.S. Population#	Annual Estimate										
	Average Estimate	Average Percent		2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	*2017*+
Total	**180**	**100%**	**100%**	**186**	**178**	**148**	**159**	**163**	**137**	**146**	**164**	**172**	**178**	***190***
Male	**135**	**75%**	49%	132	140	109	121	111	92	124	127	125	140	*139*
Female	**45**	**25%**	51%	53	36	39	38	52	45	22	37	48	38	*50*

\+ Data collection for 2017 is only partially complete. Italicized estimates may change in the future, if more reports of deaths are received.

\# Based on estimated U.S. population statistics for the 3-year average (2015-2017).

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, 2007–2017.
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, 2019. June 2020

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

Victim Race/Ethnicity

Table 9 provides a summary of CO fatality victims characterized by race/ethnicity for the years 2007 through 2017. Because of the growing proportion of people of Hispanic descent, Hispanic victims were categorized separately, irrespective of their race. Estimates of the percentage of the U.S. population categorized into the various race/ethnicity groupings were based on single-race characterizations, as represented in the U.S. Census Bureau reports. Non-Hispanic individuals reported as multi-race are included in the *Unknown/Other/Mixed* category.

The estimated percentages of the 2015–2017 annual average CO deaths demonstrated race/ethnicity-based differences in CO poisoning deaths that were statistically significant (p-value = 0.0016). When looked at as one race/ethnicity versus the rest, there was a statistically significant difference between the number of Black or African American victims of CO poisoning (approximately 19 percent of all CO poisoning deaths) and the resident Blacks or African American population (slightly more than 12 percent of the U.S. population). The p-value of this comparison was 0.0019. In contrast, the proportion of the CO poisoning fatality victims who were of Hispanic ethnicity (approximately 9%) was below the percentage of Hispanics in the U.S. population (slightly less than 18%) where the p-value was 0.0019. Among other race/ethnicities, no statistically significant differences were observed.

Table 9: Estimated Non-Fire Carbon Monoxide Poisoning Deaths by Race/Ethnicity, 2007−2017

Race/Ethnicity	2015–*2017*+		Estimated Percentage of U.S. Population#	Annual Estimate										
	Average Estimate	Average Percent		2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	*2017*+
Total	**180**	**100%**	**100%**	**186**	**178**	**148**	**159**	**163**	**137**	**146**	**164**	**172**	**178**	***190***
White (non-Hispanic)	**116**	**64%**	61%	122	122	93	82	106	82	86	108	109	118	*122*
Black or African American	**35**	**19%**	12%	35	30	20	43	38	31	35	26	47	32	*25*
Hispanic (All races)	**16**	**9%**	18%	23	14	11	18	9	11	13	18	14	13	*20*
Asian / Pacific[1]	**5**	**3%**	6%	3	1	3	4	3	5	7	6	*	7	*7*
American Indian[2]	**3**	**2%**	1%	1	5	1	5	1	*	1	1	*	1	*7*
Unknown / Other / Mixed[3]	**6**	**3%**	2%	2	4	19	8	6	7	5	5	3	6	*9*

\+ Data collection for 2017 is only partially complete. Italicized estimates may 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 (2015-2017).

1 Includes Asian, Pacific Islander, and Native Hawaiian

2 Includes American Indian, Native American, and Native Alaskan

3 Includes non-Hispanic Unknown races, Other races, and Multiple races

Source: U.S. Consumer Product Safety Commission / EPHA.
CPSC Death Certificate File, CPSC In-Depth Investigation File, CPSC Injury or Potential Injury Incident File,
National Center for Health Statistics Mortality File, 2007–2017.
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, 2019. June 2020

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

Population Density of Place of Death

Table 10 provides a breakout 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.[7] 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.[8] The new 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.

[7] 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.

[8] Version 3.10 of the ZIP code Rural-Urban Commuting Areas (RUCAs) geographic taxonomy, August 4, 2014. http://ruralhealth.und.edu/ruca/final310.csv.

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 ten years. The last update was for the year 2010. It is unlikely that there would be a significant change in the urban-rural population distribution between 2010 and the 3-year period average of 2015 through 2017.

Table 10 also includes the estimated percentage of the U.S. population, per population density designation category. As can be seen in the *All Locations* section, the estimated average percentage of CO deaths during the 3-year period 2015 through 2017, in urban locations (53%), 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 (19% versus 15% of the U.S. population), large rural town locations (9% versus 6%), and small town/rural isolated locations (17% versus 5%). Additionally, due to lack of detail in some of the death certificates that CPSC receives, the exact location of a small number of incidents (1%) could not be ascertained. Although the rate over the latest 3 years is somewhat higher than over the 11 years of this report (17% versus 14%), CO deaths that occurred in small town/rural isolated locations tend to be two to three times the percentage of the U.S. population living in these isolated locations.

However, looking at the *Non-Home Locations* category may help to identify some of the disparity for each of the non-urban location categories. An average of 31 percent of all non-home CO deaths occurred in small town/rural isolated locations, even though the U.S. population living in isolated locations is only 5 percent. In 2015 through 2017, an estimated average of 11 of 36 CO poisoning deaths in non-home locations occurred in small town/rural isolated locations. Two factors may help to explain the relatively high proportion of small town/isolated rural location CO deaths. Many non-home locations where CO deaths occurred were tents, camper trailers, or cabins in isolated locations, used during hunting or camping activities, where no local power utility is available. In these cases, individuals often resort to generators for power and use portable LP heaters, lanterns, and stoves. Though it is beyond the scope of this report to determine where victims were living if they were not at home locations, these people may not live in these small town/rural areas, instead may be coming to these areas from more densely populated regions, artificially inflating the small town/rural fatalities as compared to population. Removing incidents at temporary shelters (e.g., campers, trailers, cabins) would reduce the percentage in small town/rural isolated down to 6% of incidents, more in alignment with the percent of population that live in those areas. A second factor may be the often isolated nature of rural areas where first responders and emergency services are often very far away from a victim's location. The travel time involved to respond to an emergency at an isolated incident location by first responders and transport of a victim to treatment facility may be excessive, where time to intervention/treatment may be vital.

Table 10: Estimated Non-Fire Carbon Monoxide Poisoning Deaths by Population Density of Place of Death, 2007–2017

RUCA Population Density Designation	2015–*2017*+		Estimated Percentage of U.S. Population#	Annual Estimate										
	Average Estimate	Average Percent		2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	*2017*+
All Locations	**180**	**100%**	**100%**	**186**	**178**	**148**	**159**	**163**	**137**	**146**	**164**	**172**	**178**	***190***
Urban Core	96	53%	73%	114	105	78	94	95	79	84	73	77	108	*104*
Sub-Urban	35	19%	15%	31	32	42	33	33	25	27	34	41	25	*39*
Large Rural Town	16	9%	6%	12	23	10	25	14	9	12	19	14	20	*13*
Small Town/ Rural Isolated	31	17%	5%	28	17	18	7	18	19	23	32	39	22	*33*
Unknown Location	1	1%	-	*	*	*	*	2	6	1	6	1	2	*
Home Locations	**144**	**100%**	**100%**	**153**	**143**	**117**	**135**	**137**	**113**	**121**	**127**	**131**	**150**	***152***
Urban Core	79	55%	73%	96	89	66	88	78	71	73	63	62	92	*83*
Sub-Urban	31	22%	15%	22	27	30	24	28	20	24	29	39	21	*33*
Large Rural Town	13	9%	6%	11	16	10	19	14	6	7	14	11	18	*9*
Small Town/ Rural Isolated	21	15%	5%	24	11	11	4	15	11	15	21	18	18	*27*
Unknown Location	*	*	-	*	*	*	*	2	5	1	*	*	*	*
Non-Home Locations	**36**	**100%**	**100%**	**32**	**34**	**30**	**24**	**26**	**24**	**26**	**37**	**41**	**28**	***38***
Urban Core	17	47%	73%	18	16	11	6	18	7	11	11	14	16	*21*
Sub-Urban	3	8%	15%	9	5	12	8	5	5	2	5	1	3	*6*
Large Rural Town	3	8%	6%	1	7	*	6	*	2	5	5	3	2	*5*
Small Town/ Rural Isolated	11	31%	5%	4	6	7	4	3	7	8	11	22	4	*6*
Unknown Location	1	3%	-	*	*	*	*	*	1	*	6	1	2	*

\+ Data collection for 2017 is only partially complete. Italicized estimates may change in the future, if more reports of deaths are received.

* 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.

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, 2007–2017.
Center for Rural Health, University of North Dakota School of Medicine and Health Sciences, ZIP code RUCA Version 3.10

Geographical Region of Incident

Table 11 provides a breakout of the CO poisoning deaths characterized by geographic region where the incident occurred. As can be seen in the table, for the 3 most recent years (2015 to 2017), 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 would indicate that geographic location has an effect on the likelihood of fatal CO poisoning incidents. The regional differences in CO poisoning deaths were confirmed to be statistically significant (p-value = 0.0002). In particular, the average percentage of CO fatalities in the Midwest region (32%) was much higher than the percentage of people who live in this region (21%). Conversely, the average percentage of CO fatalities in the Northeast region (12%) was lower than the percentage of people who live in this region (17%).

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

Table 11: Estimated Non-Fire Carbon Monoxide Poisoning Deaths by Geographical Region of Incident, 2007–2017

Region‡	2015–*2017*+		Estimated Percentage of US Population#	Annual Estimates										
	Average Estimate	Average Percent		2007	2008	2009	2010	2011	2012	*2013*	2014	2015	2016	*2017*+
Total	**180**	**100%**	**100%**	**186**	**178**	**148**	**159**	**163**	**137**	**146**	**164**	**172**	**178**	***190***
Northeast	**21**	**12%**	**17%**	**44**	**28**	**14**	**23**	**43**	**25**	**34**	**37**	**30**	**21**	***11***
New England	8	4%	5%	10	12	5	5	16	1	14	8	13	8	*4*
Middle Atlantic	12	7%	13%	34	16	9	18	27	24	20	29	17	13	*7*
South	**62**	**34%**	**38%**	**61**	**51**	**55**	**55**	**55**	**55**	**43**	**42**	**62**	**55**	***68***
East South Central	10	6%	6%	9	10	19	12	13	7	3	9	11	10	*10*
South Atlantic	31	17%	20%	25	21	13	26	23	31	20	21	29	27	*37*
West South Central	20	11%	12%	27	21	23	17	19	17	20	12	22	18	*21*
Midwest	**58**	**32%**	**21%**	**47**	**58**	**48**	**49**	**33**	**31**	**48**	**40**	**44**	**69**	***61***
East North Central	37	21%	14%	25	39	28	40	27	26	27	22	27	44	*40*
West North Central	21	12%	7%	22	18	20	10	6	5	21	18	17	25	*21*
West	**40**	**22%**	**24%**	**33**	**40**	**31**	**31**	**32**	**25**	**22**	**44**	**37**	**33**	***50***
Mountain	15	8%	7%	17	25	16	11	9	13	8	26	14	18	*12*
Pacific	25	14%	16%	17	15	14	20	23	12	14	18	23	15	*38*

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

\+ Data collection for 2017 is only partially complete. Italicized estimates may change in the future, if more reports of deaths are received.

\# Based on estimated U.S. population statistics for the 3-year average (2015-2017).

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, 2007–2017.
U.S. Census Bureau, Population Division Annual Estimates of the Resident Population for the United States, Regions, States, and Puerto Rico:
April 1, 2010 to July 1, 2018 (NST-EST2018-01)

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

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

The first step in compiling the annual estimates is computing the total estimates of CO poisoning deaths associated with consumer products. The CPSC's Death Certificate (DTHS) File

and the CPSC's Abbreviated Death Certificate (ABDT) File were searched for cases associated with ICD-10 codes X47 and Y17.

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

The CPSC's ABDT File contains death certificates for CO poisonings (X47 and Y17) that involve motor vehicle exhaust, cases where the source of the CO is unknown, or where the death certificate does not mention a consumer product. Other examples of cases that may appear in the abbreviated file are cases associated with farm accidents, smoke inhalation from a structural fire, or other gas poisonings. Occasionally, newer information from CPSC IDIs may be matched with ABDT cases that were originally classified as having no known source, or did not mention a consumer product. If information from IDIs indicated that an ABDT case should be considered in scope, then it was included with the DTHS database files. For example in 2007, three cases were reclassified. For 2008, 2009, 2010, and 2011, no ABDT records were reclassified as in scope. For the four most recent years, nine cases were reclassified: three cases for 2012; one case for 2013; four cases for 2014; two cases in 2015; one case in 2016; and two cases in 2017.

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 (coincidentally, Texas in 2013). In 2016, CPSC received 56 Y17-coded death certificates from Texas, and 129 from the entire country. In 2017, death certificates with the Y17 code dropped to 34, but were still much higher than any state for any year. In 2016, Michigan, the second highest number of Y17 had 13. 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 certificate, more than the rest of the country put together. Clearly, some discrepancy exists with the way Texas codes Y17 death certificates compared to the rest of the states in the country.

To compensate for this apparent anomaly, this report substitutes 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.

Since the release of the previous annual report, additional records have been entered into the CPSC databases; therefore, the resulting initial categorization for 2016 through 2017 has been recalculated and is presented in Tables A.1.a through A.1.b.

Table A.1.a: Initial Categorization for 2016 Data

ICD-10 Code	NCHS Total	DTHS File & ABDT File				Number of Cases to be Imputed[1]
		In-Scope	Unknown Scope	Out-of-Scope	Total	
X47	921	154	27	668	849	99
Y17	94	4	6	68.6	78.6	21.4
Total	**1015**	**158**	**33**	**736.6**	**927.6**	**120.4**

Table A.1.b: Initial Categorization for 2017 Data

ICD-10 Code	NCHS Total	DTHS File & ABDT File				Number of Cases to be Imputed[1]
		In-Scope	Unknown Scope	Out-of-Scope	Total	
X47	936	150	39	614	803	172
Y17	85	5	5	66.6*	76.6	13.4
Total	**1015**	**158**	**33**	**680.6**	**879.6**	**185.4**

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

* Due to an apparent anomaly of reported ICD-10 Y17-coded death certificates from Texas in 2016 and 2017, the average number of Y17-coded Out-of-Scope death certificates of the previous 10 years from Texas was substituted for the Texas Out-of-Scope figures. See text for details.

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, 2016–2017.

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 ICD10 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 in the CPSC's Death Certificate File and the Abbreviated Death Certificate File coded under the specific ICD10 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 associated coded under the specific ICD10 code was counted (n_3).

4. The estimate of the number of non-fire CO poisoning deaths associated with consumer products under the specific ICD10 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 ICD10 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, a weighting factor was calculated to account for death certificates that are missing. The weighting factor allows the computation of national estimates of CO deaths by consumer products and by other characteristics collected by CPSC about each death.

Table A.2 contains the values for the variables used in the calculation, as well as the final computed 2016 and 2017 estimates of CO poisoning deaths.

Table A.2.a: Calculation Detail of the Final Computed 2016 Estimate of Non-Fire CO Poisoning Deaths Associated with Consumer Products

Variable	ICD-10 Code	
	X47	**Y17**
n_1	154	4
n_2	849 - 27 = 822	78.6 - 6 = 72.6
n_3	921	94
Weighting Factor *(n_3 / n_2)*	1.1204	1.2948
N	172.5474	5.1791
Total Estimate	{172.5474 + 5.1791 = 177. 7265 ~ 178}	

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 2016-2017.

Table A.2.b: Calculation Detail of the Final Computed 2017 Estimate of Non-Fire CO Poisoning Deaths Associated with Consumer Products

Variable	ICD-10 Code	
	X47	**Y17**
$\mathbf{n_1}$	150	5
$\mathbf{n_2}$	803 - 39 = 764	76.6 - 5 = 71.6
$\mathbf{n_3}$	936	85
Weighting Factor (n_3 / n_2)	1.2251	1.1872
N	183.7696	5.9358
Total Estimate	{183.7696 + 5.9358 = 189.7054 ~ 190}	

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 2016-2017.

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 has no way of correcting CPSC records to mesh with NCHS 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 made the assumption that, over time, the number of death certificates with ICD-10 codes changed by NCHS staff to the codes of interest (X47 and Y17), would equal approximately those changed to codes other than X47 or Y17, thereby having little long-term effect on the estimates.

Table A.3 shows the weighting factors used to calculate the estimates for the years 2007–2017, 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 2007–2017

Year	NCHS Total	Total in CPSC Databases*	In-Scope Cases+	Weighting Factor
2007				
X47	605	580	173	1.0431
Y17	89	68	4	1.3088
2008				
X47	677	660	166	1.0258
Y17	68	54	6	1.2593
2009				
X47	734	769	145	1.0000
Y17	72	52	2	1.3846
2010				
X47	675	567	125	1.1905
Y17	98	68	7	1.4412
2011				
X47	786	730	143	1.0767
Y17	89	76	8	1.1711
2012				
X47	736	591	109	1.2453
Y17	114	84	1	1.3571
2013				
X47	704	608	123	1.1579
Y17	76	60	3	1.2667
2014				
X47	803	679	137	1.1826
Y17	106	61	1	1.7377
2015				
X47	847	665	134	1.2737
Y17	91	53	1	1.7170
2016				
X47	921	822	154	1.1204
Y17	94	72.6	4	1.2948
2017				
X47	936	764	150	1.2251
Y17	85	71.6	5	1.1872

+ For some years, the number of in-scope cases has changed slightly from the previous report, due to either newly obtained information, or a recharacterization of a few cases.

* 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, 2007–2017.

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 were 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 those 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 actually, 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. Further information on the CO deaths was obtained from review of the CPSC's IDI File.

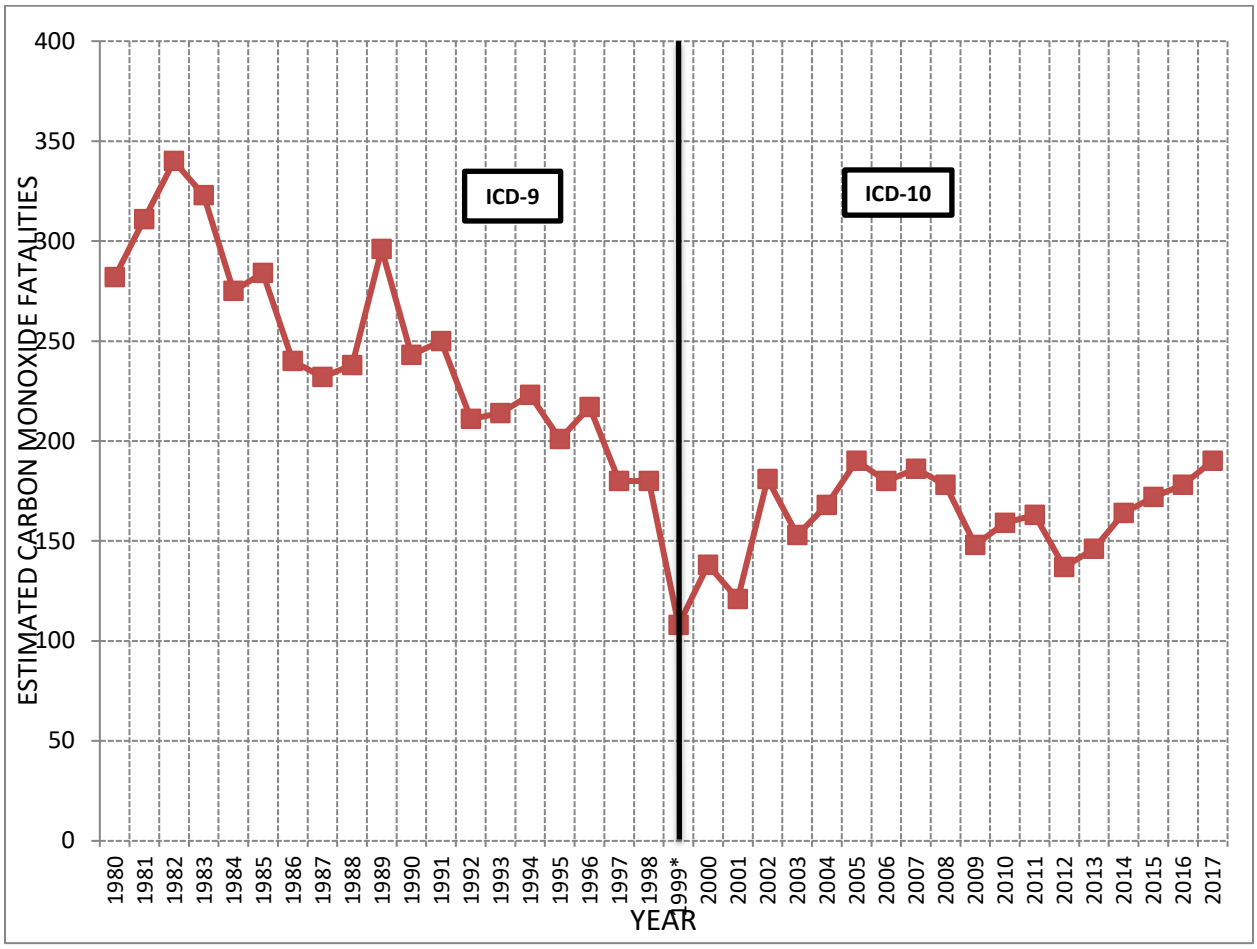
Reports of non-fire CO poisoning deaths were retrieved from the DTHS and ABDT files based on the following criteria: date of death between 1/1/2007 and 12/31/2017, and ICD-10 code of X47 or Y17. Death certificates entered into the CPSC's database before August 24, 2020, were included in this analysis. Whenever possible, each CO death was reviewed and coded by the author, according to the consumer product and type of fuel involved, incident location, and whether multiple deaths were associated with the same incident. If information about the product's condition, venting system, or installation environment was provided in the IDI report, then this information was coded for informational purposes.

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 being 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 usually was 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 outside the jurisdiction of the CPSC.

Appendix B: National Estimates and Mortality Rates of Consumer Product-Related CO Poisoning Deaths, 1980 to 2017

Figure B.1 below graphically suggests a trend of the estimated CO deaths from 1980 to 2017. Before the implementation of the ICD-10 coding in 1999, the estimated number of non-fire, consumer product-related CO poisoning deaths decreased from the early 1980s to the late 1990s, from a high of 340 in 1982, to a low of 180 in both 1997 and 1998. In 1999, there were an estimated 108 consumer product-related CO deaths, well below the estimated 180 deaths in each of the two previous years. The difference may be due, in part, to the change from ICD-9 coding to ICD-10 coding, where product identification could be assessed more accurately.

Figure B.1: Estimated Non-Fire CO Poisoning Deaths Associated with Consumer Products: 1980–2017



* 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, 2007–2017.

Estimated CO Mortality 3-Year Trends

Table B.1 presents the annual estimates from 1980 to 2017, and the 3-year average mortality rates associated with each year, where 3 years of data were available. The 3-year average mortality rate is presented in the table for the mid-point year. The estimated 3-year average mortality rate decreased from the 1982 high of 14.02 per 10 million population, to a 3-year average rate of 4.34 per 10 million in 2000, a reduction of 69 percent. Subsequently, the 3-year average rate increased annually through 2006, to a rate of 6.21. Since 2006, the rate has been slowly dropping to the 2013 estimate of 4.71, before rising in the 2014 estimate to a rate of 5.05. The 2016 rate increased again to 5.57, the highest rate since the 2008 estimate.

Table B.1: Estimated Non-Fire Carbon Monoxide Poisoning Deaths Associated with Consumer Products, 1980−2017

Year	Estimate	U.S. Population Estimates (thousands)	3-Year 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	309,338	5.06
2011	163	311,644	4.91
2012	137	313,993	4.74
2013	146	316,235	4.71
2014	164	318,857	5.05
2015	172	321,419	5.34
2016	178	323,128	5.57
2017	190	325,719	

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

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

Source: U.S. Consumer Product Safety Commission/EPHA.
U.S. Census Bureau, Population Division. Annual Estimates of the Resident Population by Sex, Age, Race, and Hispanic Origin for the United States and States: April 1, 2010 to July 1, 2019. June 2020

Before implementation of ICD-10 in 1999, generating estimates for an important category of products—generators and other engine-driven tools—was not possible.[9] With the advent of ICD-10 coding, generation of estimates of deaths associated with generators and other engine-driven tools is now possible. Table B.2 presents a summary of the mortality rates associated with generators, which steadily increased from 1999 through 2006, but have retracted somewhat from the 2006 high point. However, the 3-year average mortality rate from 2015 to 2017 reached the second highest level (same rate as in 2007), just short of the 2.69 rate in 2006 that included the Hurricane Katrina impact of 2005. This 3-year average mortality rate range for generators alone is nearly five times greater than the 3-year average rate in 2000.

Table B.2: Estimated Non-Fire Carbon Monoxide Poisoning Deaths Associated with Generators, 1999−2017*

Year	Estimate+	U.S. Population (thousands)	3-Year 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	309,338	1.83
2011	64	311,644	1.74
2012	57	313,993	1.88
2013	56	316,235	1.76
2014	54	318,857	2.03
2015	84	321,419	2.12
2016	66	323,128	2.53
2017	95	325,719	

* 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 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.

[9] See Appendix B of Mah (2001) for details.

Table B.3 shows the CO poisoning mortality rates associated with all consumer products, excluding generators. The data indicate that, when generators are excluded, there does not appear to be a trend in the mortality rate for consumer products related CO deaths. The 2000, 3-year annual average mortality rate was 3.60. The 2016, 3-year average mortality rate was 2.69, a decrease of 25 percent. However, the 3-year averages did not change much from 2008 through 2016, hovering in the 2.66 to 2.88 range after dropping from a 2003 high of 3.93.

Table B.3: Estimated Non-Fire Carbon Monoxide Poisoning Deaths Associated with Consumer Products (Excluding Generator-Related Deaths),* 1999-2017

Year	Estimate+	U.S. Population (thousands)	3-Year 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	309,338	2.87
2011	91	311,644	2.87
2012	75	313,993	2.66
2013	85	316,235	2.77
2014	103	318,857	2.79
2015	79	321,419	2.86
2016	93	323,128	2.69
2017	89	325,719	

* 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 average mortality rate is reported at 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 average mortality rates of all engine-driven tools, including generators, through 2016. Although the average mortality rates for 2007 through 2011 have dropped slightly since the 2006 high (3.18), in 2016, the rate (2.83) increased to the highest rate since the 2007 rate of 2.93. The table shows that the 3-year average mortality rate has nearly quadrupled from the rate in 2000 (0.72), to 2016 (2.83).

Table B.4: Estimated Non-Fire Carbon Monoxide Poisoning Deaths Associated with Generators and Other Engine-Driven Tools, 1999–2017*

Year	Estimate+	U.S. Population (thousands)	3-Year Average Mortality Rate per 10 Million Population
1999	13	279,040	
2000	26	282,172	0.72
2001	22	285,082	1.17
2002	52	287,804	1.51
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	309,338	2.21
2011	73	311,644	2.06
2012	64	313,993	2.18
2013	68	316,235	2.05
2014	62	318,857	2.32
2015	92	321,419	2.40
2016	77	323,128	2.83
2017	105	325,719	

* 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 average mortality rate is reported at 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 annual average, 3-year mortality rate decreased by 31 percent for non-engine-driven tool consumer products (*i.e.*, excluding generator and other engine-driven tools), from the 2000 rate of 3.44 to the 2016 rate of 2.39. In the 10 years between 2006 and the current estimate for 2016, the non-EDT CO fatality rates has been relatively consistent, fluctuating in a narrow band between 2.37 and 2.64 per 10 million population.

Table B.5: Estimated Non-Fire Carbon Monoxide Poisoning Deaths Associated with Consumer Products (Excluding Generator- and Other Engine-Driven Tool-Related Deaths)*, 1999−2017

Year	Estimate+	U.S. Population (thousands)	3-Year Average Mortality Rate per 10 Million Population
1999	89	279,040	
2000	110	282,172	3.44
2001	92	285,082	3.72
2002	116	287,804	3.44
2003	89	290,326	3.56
2004	105	293,046	3.07
2005	76	295,753	2.81
2006	68	298,593	2.58
2007	87	301,580	2.64
2008	84	304,375	2.54
2009	61	307,007	2.53
2010	88	309,338	2.49
2011	82	311,644	2.55
2012	68	313,993	2.37
2013	73	316,235	2.49
2014	95	318,857	2.50
2015	71	321,419	2.58
2016	82	323,128	2.39
2017	79	325,719	

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

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

Note 1: The 3-year average mortality rate is reported at 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 28 percent increase in the CO mortality rate from a 3-year average mortality rate of 4.34 in 2000, to 5.57 in 2016, as shown in Table B.1. Engine-driven tools and generators, in particular, have had a substantial impact on the increase in CO poisoning mortality rate involving consumer products.

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 (2007–2017). For the Chi-Square statistical analysis, the two younger groups ("Under 5" and "5−14") were combined, due to their small estimated averages. Chi-Square goodness-of-fit test results indicate a statistically significant difference (p-value = < 0.0001) between the proportion of CO victims in each age group from that of the general U.S. population. Each age group was analyzed separately, versus the expected proportion of the respective age group, based on U.S. population figures (assuming there was no age group effect on the CO poisoning fatality rate), to determine which age group proportions were significantly different from expectation. Binomial tests indicate that three of 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[10] was significantly lower (< 0.0001);
2. The "15–24" group was significantly lower (0.0072); and
3. The "45–64" group was significantly higher (0.0036).

Gender Group Test Result

Table 8 presents the distribution of estimated CO deaths categorized by gender. For 2015–2017, the average percentage of male CO victims was also 75 percent, and the average percentage of female victims was 25 percent. By contrast, about 49 percent of the U.S. population is male, and 51 percent of the U.S. population is female.[11] The gender-related differences in CO Poisoning deaths were confirmed to be statistically significant (p-value = < 0.0001).

Ethnicity/Race Group Test Result

Table 9 provides a summary of CO fatality victims characterized by race/ethnicity for the years 2007 through 2017. Estimates of the percentage of the U.S. population categorized into the various race/ethnicity groupings were based on single-race characterizations, as represented in the U.S. Census Bureau reports. Individuals reported as multi-race are included in the *Unknown/Other/Mixed* category.

Chi-square goodness-of-fit test results indicate a significant statistical difference (p-value = 0.0016) between the proportion of CO victims categorized by race/ethnicity from that of the general U.S. population. Each race/ethnicity group was analyzed separately, versus the expected proportion of the respective race/ethnicity group based on U.S. population figures, assuming there was no race/ethnicity group effect on the CO poisoning fatality rate. A Chi-Square statistical analysis was performed to determine which race/ethnicity group proportions were significantly greater than or less than the expectation. For the Chi-Square analysis, the three smaller groups ("Asian/Pacific," "American Indian," and "Unknown/Other/Mixed") were combined, due to their relative small proportion of the U.S. population. Binomial tests indicate that two race/ethnicity groups were statistically significantly different from the expected proportion based on the U.S. population. The observed proportion of Hispanic CO deaths was significantly lower (p-value of 0.0019) than the proportion of Hispanics in the U.S. population. Additionally, the observed proportion of Black or African American CO deaths was significantly higher (p-value = 0.0019) than the proportion of Black or African Americans in the U.S. population.

[10] "Under 5" and "5–14" groups were combined due to small sample sizes.
[11] Three-year average, 2015 to 2017, from July 2020 U.S. Census estimates of the U.S. population.

Geographic Region Test Result

Table 11 shows the estimated number of CO poisoning deaths categorized by geographical region of occurrence for the 11 most recent years of data (2007–2017). For the Chi-Square statistical analysis, the four major regions ("Northeast", "South", "Midwest", and "West") were used for this analysis due to the small estimated averages for some of the sub-regions. For the three most recent years (2015 through 2017), the Chi-Square goodness-of-fit test results indicate a statistically significant difference (p-value = 0. 0021) between the proportion of CO victims from each region to that of the general U.S. population. Each region group was analyzed separately, versus the expected proportion of the respective region group, based on U.S. population figures (assuming there was no regional group effect on the CO poisoning fatality rate), to determine which region group proportions were significantly different from expectation. Binomial tests indicate that two of individual groups were found to be significantly different from what would be expected if there was no population group effect. In the Midwest region, CO poisoning fatalities were shown to be significantly greater than expectations based U.S. population figure (p-value = 0.0002). And, in the Northeast region, CO poisoning fatalities were significantly lower than expectations based U.S. population figure (p-value = 0.0358).

Appendix D: Regional Definitions

1) Northeast 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) Midwest 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) South 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) West 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
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