



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

1999 and 2000 Annual Estimates

Susan A. Vagts
U.S. Consumer Product Safety Commission
Directorate for Epidemiology
Division of Hazard Analysis
4330 East West Highway
Bethesda, MD 20814
July 31, 2003

Executive Summary

This report provides information about the number of unintentional non-fire deaths attributed to carbon monoxide (CO) poisoning that were associated with the use of consumer products in 1999 and 2000.

From 1999-2000, there were an average yearly estimated 124 unintentional non-fire CO poisoning deaths associated with consumer products under the jurisdiction of the U.S. Consumer Product Safety Commission (CPSC). This average estimate is based on an estimated 109 and 138 non-fire CO poisoning deaths associated with the use of consumer products, excluding motor vehicles, in 1999 and 2000 respectively. An average of 52 percent of the yearly deaths in 1999-2000 were associated with the use of heating systems (45% in 1999 and 59% in 2000). In 1999-2000, natural gas heating accounted for an average of 42 percent and liquefied petroleum (LP) gas heating accounted for an average of 40 percent of yearly heating deaths. From 1999-2000, an average of 16 percent of annual CO poisoning deaths were associated with engine-powered tools, 11 percent were associated with charcoal grills, seven percent were associated with gas ranges and ovens, five percent were associated with camp stoves and lanterns, two percent were associated with gas water heaters, and eight percent were associated with other or multiple appliances.

According to 1999-2000 data, some form of venting problem was noted in an average of 26 percent of the annual fatal CO deaths. Adults 45 years of age and older represented over half of the CO poisoning deaths. An average of 64 percent of CO deaths occurred in the home, while deaths in tents and other temporary shelters accounted for an average of 29 percent of deaths. Deaths in these temporary types of shelters were mostly associated with LP gas portable heaters. From 1999-2000, a large percentage (an average of 82%) of the yearly fatal CO incidents involved a single fatality. Although it was not uncommon for non-fatal injuries to accompany fatalities in the fatal CO incidents, they were not quantified for analysis in this report.

Prior to 1999, the Ninth Revision of the International Statistical Classification of Diseases and Related Health Problems (ICD-9) was used to categorize the cause-of-death. In 1999, the Tenth Revision of the International Statistical Classification of Diseases and Related Health Problems (ICD-10) was implemented. Part of the decrease from the 1994-1998 average annual estimate of 200 consumer product related CO poisoning deaths to an average of 124 in 1999-2000 may be the result of the changes introduced with the new ICD revision along with a new methodology applied to generate the estimates (which was necessitated by changes in the classification system). Also, the previous years' estimation process relied on the assumption that specific ICD-9 codes were non-fire CO poisonings associated with consumer products. This assumption may have resulted in an overestimate as cases within these ICD-9 codes may have been outside the scope of the report (e.g. raw gas poisonings, work-related exposures, and fire-related incidents). The methodology applied to generate the estimates using the ICD-10 revision eliminated the need for this assumption. Because of these changes no trend analysis was performed in this report.

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, oil, wood, coal, and other fuels. The health effects related to CO depend upon its concentration in blood, which in turn depends on its concentration in air, the duration of exposure, and each individual's general health. Carbon monoxide combines with hemoglobin (Hb) with an affinity about 250 times that of oxygen, forming carboxyhemoglobin (COHb) and interfering with oxygen transport, delivery, and utilization. Generally, there are no perceptible health effects or symptoms in healthy individuals 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. At around three percent COHb, a decrease in time to onset of angina in exercising individuals with ischemic heart disease, electrocardiographic changes, and neurobehavioral effects in healthy individuals have been recorded (Long & Saltzman, 1995; Burton, 1996).

Some symptoms of CO poisoning may mimic common illnesses, such as influenza or colds; thus, there likely is a high incidence of initial misdiagnosis by physicians and victims (Long & Saltzman, 1995). Patients are frequently unaware of exposures, and health care providers may not always consider CO poisoning as a cause of such non-specific symptoms. COHb formation is reversible, as are some clinical symptoms of CO poisoning. However, some delayed neurological effects that develop following 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, gasoline, coal, and wood can produce large amounts of CO when there is insufficient oxygen available for combustion. Consumer products that burn kerosene, oil, gasoline, coal or wood (such as wood stoves, oil boilers, and kerosene heaters) produce an irritating smoke that can alert the victim to a potentially hazardous situation. Other products, such as charcoal briquettes and pressed wood-chip logs, produce relatively smokeless fires, even at times of inefficient combustion. Victims receive no obvious sensory warning that high CO levels are present. A different hazard scenario is present when gas appliances are not vented properly or are malfunctioning. Natural and LP gas burn more efficiently and cleanly compared with other forms of fuel. In circumstances of poor maintenance, inadequate ventilation, or defective 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.

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

From 1999-2000, there were an average yearly estimated 124 carbon monoxide (CO) poisoning deaths associated with the use of a consumer product, excluding motor vehicles. This average estimate is based on an estimated 109 and 138 non-fire CO poisoning deaths associated with the use of consumer products, excluding motor vehicles, in 1999 and 2000 respectively. Carbon monoxide poisonings referred to in this report do not include those where the CO gas resulted from a fire.

Due to changes in the International Statistical Classification of Diseases and Related Health Problems (ICD) with the implementation of the Tenth Revision, there are discontinuities in comparing the estimate of CO deaths associated with consumer products in 1999 to prior years' estimates. Also, the methodology implemented in calculating the annual estimates of CO poisoning deaths associated with consumer products was revised in order to account for the changes in the cause of death classification system. Differences in ICD-9 and ICD-10 classification and the methodology used to generate the estimates are further explained in Appendix B. Due to these differences, when comparing 1999 and 2000 data with previous years, this report will provide comparisons of relative distributions for given categories or product types rather than comparisons of numbers of estimated fatalities.

Table 1 presents the consumer product distribution of CO poisoning deaths. The estimate for Heating Systems, historically a large majority of the consumer product estimate, is further distributed among the various fuel types. The consumer product estimate and product distributions were derived using the methodology described in Appendix A. Beginning in 1999, a new consumer product category entitled 'engine-powered tools' was added to Table 1. Previously it was not possible for the CPSC to calculate estimates for deaths associated with engine-powered tools but with the ICD-10 this is possible. This is explained further in Appendix B.

From 1999-2000, of the average yearly estimated 124 deaths, heating systems were associated with 66 deaths (a yearly average of 52% of the total consumer product estimate, 62% of the total estimate excluding engine-powered tools). In 1999, of the estimated 109 deaths, heating systems were associated with 49 fatalities (45% of the total consumer product estimate, 51% of the total estimate excluding engine-powered tools). In 2000, of the estimated 138 deaths, heating systems were associated with 82 fatalities (59% of the total consumer product estimate, 74% of the total estimate excluding engine-powered tools).

Among heating systems, from 1999-2000, natural gas heating was associated with an average yearly estimated 28 deaths (a yearly average of 42% of heating deaths) and LP gas heating was associated with a yearly estimated 26 deaths (a yearly average of 40% of heating deaths).

In 1999, natural gas heating was associated with an estimated 19 deaths (39% of heating deaths) and LP gas heating was associated with an estimated 22 deaths (45% of heating deaths). Gas heating systems where the type of gas could not be determined were associated with an estimated three deaths (6% of heating deaths). Kerosene/oil heating systems and heating systems where the fuel used could not be determined were each associated with an estimated two deaths

(each accounted for 4% of heating deaths).

In 2000, natural gas heating was associated with an estimated 37 deaths (45% of heating deaths) and LP gas heating was associated with an estimated 29 deaths (35% of heating deaths). Gas heating systems where the type of gas could not be determined were associated with an estimated seven deaths (9% of heating deaths), kerosene/oil-heating systems were associated with an estimated six deaths (7% of heating deaths), and coal/wood heating were associated with an estimated two deaths (2% of heating deaths). A heating system where the fuel used could not be determined was associated with an estimated one death (1% of heating deaths).

Beginning with 1997 data, the CPSC staff increased the percentage of follow-up investigations performed on fatal CO poisonings. Additional information collected from these follow-ups resulted in smaller estimates associated with the general categories of Unspecified Gas Heating Systems and Heating Systems, Not Specified. Conversely, the percentage of deaths associated with Natural Gas Heating Systems increased compared with previous years. The degree to which staff obtain fuel type information about each CO death varies from year-to-year; therefore, caution should be used when comparing fuel-specific estimates over time.

From 1999-2000, charcoal grills were associated with an average annual estimated 13 CO deaths (an average of 11% of the total consumer product estimate, 12% of the total estimate excluding engine-powered tools). Charcoal grills were associated with an estimated 17 deaths in 1999 and eight deaths in 2000. From 1999-2000, gas water heaters were associated with an average yearly estimated two deaths (an average of 2% of the total consumer product estimate, 2% of the total estimate excluding engine-powered tools). Gas water heaters were associated with an estimated one death in 1999 and three deaths in 2000. From 1999-2000, camp stoves and lanterns were associated with an average yearly estimated six deaths (an average of 5% of the total consumer product estimate, 6% of the total estimate excluding engine-powered tools). Camp stoves and lanterns were associated with an estimated nine deaths in 1999 and three deaths in 2000. From 1999-2000, gas ranges and ovens were associated with an average annual estimated nine deaths (an average of 7% of the total consumer product estimate, 8% of the total estimate excluding engine-powered tools). Gas ranges and ovens were associated with an estimated six deaths in 1999 and 11 in 2000. From 1999 to 2000, an average annual estimated nine deaths were associated with other or multiple appliances (an average of 8% of the total consumer product estimate, 9% of the total estimate excluding engine-powered tools). Other or multiple appliances were associated with an estimated 14 deaths in 1999 and three in 2000. Other or multiple appliances include: LP gas refrigerator, LP gas grill, LP fish cooker, and a gas pool heater, as well as multiple fuel-burning products used simultaneously, such that a single source of the CO could not be determined. Products that were simultaneously used and associated with CO poisoning deaths were: a propane cook stove and lantern, a propane heater and lantern, a gas water heater and gas heating system, a gasoline tiller and a propane heater, a kerosene heater and a generator. An average yearly estimated 20 CO poisoning deaths (16% of the total consumer estimate) were associated with engine-powered tools, which include generators, snowblowers, and power lawn mowers. Engine-powered tools were associated with an estimated 13 deaths in 1999 and 27 in 2000.

Table 1
Estimated Non-Fire Carbon Monoxide Poisoning Deaths
By Associated Fuel-Burning Consumer Product, 1994-1998 vs. 1999-2000.

Consumer Product	Average Estimate 1994-1998	Average Percent 1994-1998	Average Estimate 1999-2000	Average Percent 1999-2000¹	1999 Estimate²	2000 Estimate
Total Deaths	200	100%	124	100% (100)	109	138
Heating Systems	152	76%	66	52% (62)	49	82
Unspecified Gas Heating	25	12%	5	4% (5)	3	7
LP Gas Heating	46	23%	26	21% (25)	22	29
Natural Gas Heating	35	18%	28	22% (27)	19	37
Coal/Wood Heating	6	3%	1	1% (1)	0	2
Kerosene/Oil Heating	9	4%	4	3% (4)	2	6
Heating Systems, Not Specified	32	15%	2	1% (1)	2	1
Charcoal Grills, Charcoal	17	9%	13	11% (12)	17	8
Gas Water Heaters	7	4%	2	2% (2)	1	3
Camp Stoves, Lanterns	9	5%	6	5% (6)	9	3
Gas Ranges/ Ovens	7	4%	9	7% (8)	6	11
Other/Multiple Appliances	6	3%	9	8% (9)	14	3
Engine-Powered Tools	*	*	20	16% (*)	13	27

¹ Numbers in parenthesis represent percent of total excluding Engine-Powered Tools.

² The Tenth Revision of the International Statistical Classification of Diseases and Related Health Problems (ICD-10) was implemented.

* Prior to 1999, estimates could not be calculated for this category. See Appendix B for further explanation.

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, 1994 - 2000.

Note: Detail may not add to total due to rounding.

Detailed information regarding the conditions of products associated with fatalities could not be routinely collected, and the availability of such information in the CPSC's files varied widely. From 1999-2000, conditions that compromised vent systems, flue passageways, or chimneys for furnaces, boilers, vented natural and LP gas heaters, pool heaters, and water heaters were mentioned as contributing to an average of 26 percent (23% in 1999 and 28% in 2000) of annual fatal CO incidents and an average of 43 percent (43% in 1999 and 44% in 2000) of fatal CO incidents associated with heating systems. Vent systems include the portion of piping that connects the flue outlet of the appliance and exhausts air to the outside through the ceiling or sidewall, or connects to the chimney. Some vented products had vents that became detached or were improperly installed or maintained. Deteriorating or collapsing chimneys or outdoor debris, birds' nests, or small animals in the chimney or flue pipe created a blockage for the venting of the exhaust gases in some incidents. 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. Some vented products

had exhaust fans, which did not function properly thus inhibiting the venting of the exhaust gases.

Less frequently, other conditions related to furnaces included compromised heat exchangers, filter door or covers that were removed or not sealed, and dirty filters. Cooking stoves and ovens used as heating devices were involved in the majority of deaths associated with these products. A few products were over 20 years old and apparently were poorly maintained such that there were several factors involved in generating and exacerbating the amount of CO produced. Isolated incidents mentioned a backdraft condition, use of a natural gas heater with an LP gas supply, and the use of a product despite its being red-tagged by the utility company.

From 1999-2000, engine-powered tools were associated with an annual estimate of 20 carbon monoxide poisoning deaths (a yearly average of 16% of the total consumer product estimate). In 1999, an estimated 13 deaths were associated with engine-powered tools (12% of the total consumer product estimate). An estimated seven of these 13 CO poisoning deaths (54%) were associated with engine-powered generators and six deaths (46%) were associated with garden tractors or power lawn mowers. In 2000, an estimated 27 deaths were associated with engine-powered tools (20% of the total consumer product estimate). An estimated 19 of these 27 CO deaths (70%) were associated with engine-powered generators, seven deaths (26%) were associated with garden tractors or power lawn mowers, and one death (4%) was associated with a snowblower. Deaths associated with power lawn mowers, garden tractors, and snowblowers often occurred in the shed or garage of a home, while a consumer was performing maintenance on the product. Generators were most often used to provide power to a home during a power interruption.

Table 1 also lists the average annual percentage of CO poisoning deaths associated with each group of consumer products over the years 1994-1998 and 1999-2000. From 1999-2000, the annual average percentage (excluding engine-powered tools) was 62 percent for heating systems and 12 percent for charcoal grills. From 1994-1998, an average of 76 percent of annual deaths involved heating systems and nine percent involved charcoal grills. The remaining product categories each involved less than 10 percent of the annual average percentage for both 1999-2000 and 1994-1998. From 1999-2000, an average of eight percent of annual CO poisoning deaths (excluding engine-powered tools) involved gas ranges and ovens, six percent involved camp stoves and lanterns, and two percent involved gas water heaters. From 1994-1998, an average of four percent of annual deaths involved gas ranges and ovens, five percent involved camp stoves and lanterns, and four percent involved gas water heaters. From 1999-2000, an average of nine percent of the annual deaths were associated with other or multiple appliances. From 1994-1998, an average of three percent of annual deaths were associated with other or multiple appliances. Part of this increase may be due to a change in methodology in 1998, which expanded the 'other' category to include incidents associated with multiple fuel-burning products used simultaneously.

Table 2 shows that in 1999-2000 children less than 15 years of age accounted for an annual average of five percent of yearly CO poisoning deaths. Similarly from 1994-1998, children in this age group accounted for an average of eight percent of yearly CO poisoning deaths. From 1999-2000 adults aged 25 years and older accounted for an annual average of 87 percent of yearly CO poisoning deaths and in 1994-1998 adults in this age group accounted for an average of 77 percent of the CO poisoning deaths. Between 1999-2000, the annual average percentage of deaths represented by adults 45 years and older was 56 percent, similar to the annual average percentage in 1994-1998 for this age group. In 1999-2000, adults aged 65 years and older accounted for an average annual percentage of 15 percent of CO poisoning deaths and in 1994-1998 this percentage was 25.

Table 2
Estimated Non-Fire Carbon Monoxide Poisoning Deaths by Age of Victim,
1994-1998 vs. 1999-2000.

Age	Average Estimate 1994-1998	Average Percent 1994-1998	Average Estimate 1999-2000	Average Percent 1999-2000	1999 Estimate¹	2000 Estimate
Total	200	100%	124	100%	109	138
Under 5	7	3%	2	1%	0	3
5 – 14	9	4%	5	4%	7	3
15 – 24	30	15%	9	7%	8	10
25 – 44	54	27%	38	31%	32	44
45 – 64	48	24%	50	41%	45	55
65 and over	51	25%	19	15%	16	22
Unknown	1	1%	0	0%	0	0

¹ 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.

CPSC Death Certificate File, CPSC In-Depth Investigation File, CPSC Injury or Potential Injury Incident File, National Center for Health Statistics Mortality File, 1994 - 2000.

Note: Detail may not add to total due to rounding.

Adults in the older age groups were more frequently reported to have pre-existing health conditions affecting the heart, lungs, and circulatory system. The presence of one or more of these conditions lowers a victim's tolerance of COHb in the bloodstream, increasing the risk of a fatal CO exposure. From 1999-2000, an annual average of 21 percent of the CO victims were noted as having a pre-existing health condition not related to the CO poisoning. In 1999, 21 percent (23) of the estimated 109 CO victims were noted as having secondary health conditions not related to CO poisoning at the time of death. Ninety percent of these 23 deaths were individuals who were 45 years of age or older. In 2000, 21 percent (29) of the estimated 138 CO victims were noted as having secondary health conditions not related to CO poisoning at the time of death. Eighty-one percent of these 29 deaths were individuals who were 45 years of age or older. Consumers in the older age groups also tend to own older products, especially installed appliances, which are not affected by recent improvements in voluntary standards. Lack of routine product maintenance, especially in older products, may further increase the potential for a fatal scenario.

Alcohol and recreational drug use can act as a central depressant causing dulled reactions, which could likely impair a person’s ability to react appropriately to a CO hazard, thus potentially prolonging exposure and increasing the chance of a fatal outcome. From 1999-2000, an annual average of 18 percent (14% in 1999 and 22% in 2000) of the CO victims were noted as having used alcohol or recreational drugs during the time period surrounding the incident. This information was obtained from the Medical Examiner or Coroner and it should be noted that this information was not provided for every CO poisoning fatality.

In 1999, 80 percent of CO victims were males and 20 percent were females. In 2000, 76 percent of CO poisoning fatalities were male and 24 percent were female. This is slightly different than the gender distribution in 1998 when 69 percent of CO victims were males and 31 percent were females. In 1999, fifty percent of the deaths occurred during the winter months of January, February, and December. In 2000, forty-two percent of the deaths occurred during the winter months of January, February, and December.

Table 3 shows that in 1999-2000, an average of 82 percent of fatal CO incidents reported yearly to the CPSC involved a single death. The average yearly percent of fatal CO incidents that involved a single death from 1994-1998 was 77 percent. It should be noted that Table 3 accounts for only the fatally injured victims in each CO poisoning incident. It is not uncommon for CO incidents involving one or more fatalities to also result in one or more non-fatal CO poisoning injuries but they were not quantified for analysis in this report.

Table 3
Number of Carbon Monoxide Poisoning Incidents reported to CPSC
By Number of Deaths Per Incident, 1994-1998 vs. 1999-2000.

Number of Deaths Reported in Incident	Average 1994-1998	Average Percent 1994-1998	Average 1999-2000	Average Percent 1994-1998	1999 Number	2000 Number
Total Incidents	106	100%	90	100%	79	100
1	82	77%	74	82%	66	81
2	19	19%	14	16%	12	16
3	3	3%	1	1%	0	2
4	1	1%	1	1%	1	1
5 or more	1	1%	0	0%	0	0

Source: U.S. Consumer Product Safety Commission / EPHA.
 CPSC Death Certificate File, CPSC In-Depth Investigation File, CPSC Injury or Potential Injury Incident File, 1994 - 2000.

Note 1: Detail may not add to total due to rounding.

Note 2: Data in Table 3 do not add to totals presented in Table 1. Data presented in Table 3 are not national estimates derived from the NCHS totals, but reported deaths contained in the CPSC files. NCHS data do not contain enough detail to identify multiple victims of the same CO poisoning incident.

Table 4 shows that from 1999-2000, 64 percent of annual CO poisoning deaths occurred in homes, including manufactured and mobile homes, and this percentage was similar in 1994-1998. In 1999-2000, an annual average of 29 percent of CO poisoning deaths took place in temporary shelters, such as tents, recreational vehicles, seasonal cabins, and trailers. An annual average of 18 percent of deaths took place in temporary shelters, from 1994-1998. LP gas heaters were the products most frequently associated with these deaths. Charcoal grills, LP gas lanterns, LP and natural gas fixed heating systems, LP gas cook stoves, generators, and a kerosene portable heater were also associated with these scenarios. A consistently small percentage of deaths occurred in vans, trucks, or automobiles in which victims were spending the night. The products used in these settings were charcoal grills, LP gas portable heaters, and kerosene heaters. 'Other' locations include a boat, a fishing lodge, motel, storage-shed separate from the home, and an underground shelter. Products used within these locations include charcoal grill, LP stove, LP heater, wall heater, and generator.

Table 4
Estimated Non-Fire Carbon Monoxide Poisoning Deaths by Location of Death,
1994-1998 vs. 1999-2000.

Location of Death	Average Estimate 1994-1998	Average Percent 1994-1998	Average Estimate 1999-2000	Average Percent 1999-2000	1999 Estimate¹	2000 Estimate
Total	200	100%	124	100%	109	138
Home	136	68%	80	64%	67	93
Temporary Shelter	35	18%	35	29%	35	35
Auto	11	5%	5	4%	7	2
Other	11	6%	4	3%	0	8
Unknown	6	3%	0	0%	0	0

¹ 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.

CPSC Death Certificate File, CPSC In-Depth Investigation File, CPSC Injury or Potential Injury Incident File, National Center for Health Statistics Mortality File, 1994 - 2000.

Note: Detail may not add to total due to rounding.

Appendix A: Methodology

This appendix describes the data sources and methodology used to compute the national estimate of non-fire 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 U.S. 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 was implemented in 1999. Although the NCHS data contain cause of death codes that are helpful in identifying deaths due to CO poisoning, the data do not contain any narrative information that might indicate the involvement of a consumer product.

To complement the NCHS mortality data, the CPSC purchases death certificates from the 50 states, the District of Columbia, and New York City. Specifically, the CPSC purchases death certificates for certain cause of death codes for which there is a high probability that consumer products are involved. In addition to the cause of death codes and demographic and geographic information, the death certificate contains information on the incident location and a brief narrative describing the incident. Any references to consumer products are usually found in these narratives. The CPSC staff conducts follow-up in-depth investigations on selected deaths to confirm and expand upon the involvement of consumer products as resources allow.

The Tenth Revision of the International Statistical Classification of Diseases and Related Health Problems (ICD-10) classifies deaths associated with carbon monoxide with the codes listed below. The focus of this report is unintentional carbon monoxide poisoning deaths and concentrates on those deaths coded as X47 and Y17.

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 both searched for cases associated with ICD-10 codes X47 and Y17.

Each death found in the CPSC’s Death Certificate File and coded as X47 and Y17 was manually reviewed and categorized as in-scope, out-of-scope, or whether the source of the CO was 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 (including motor vehicle exhaust cases), 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 if it could not be ruled out whether a consumer product was associated with the incident but the exact source of CO was unknown. If the death certificate categorized the death as work-related even if the exact source of the CO is unknown, the incident was categorized as out-of-scope.

Deaths found in the CPSC’s Abbreviated Death Certificate (ABDT) File were categorized as out-of-scope cases, with a small number of exceptions. The ABDT File contains death certificates that did not mention a consumer product, motor vehicle exhaust, or unknown source of CO. 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. Therefore almost all cases found in the abbreviated file were considered out-of-scope for this report.

There were a small number (three deaths in 1999 and two deaths in 2000) of in-scope CO poisoning deaths that were identified in the Abbreviated Death Certificate (ABDT) File. If a CO poisoning death was identified in CPSC’s Injury or Potential Injury Incident (IPII) File or CPSC’s In-Depth Investigation (INDP) File but had no duplicate death certificate in the Death Certificate (DTHS) File, the Abbreviated Death Certificate (ABDT) File was searched. The search was based on the variables provided in the ABDT File (i.e. ICD-10 code, state, and date of death). The NCHS Mortality File was also searched to determine if there was a match in the NCHS file for the given variables. If a given death was matched to an NCHS record and an ABDT record, then the death certificate originally placed in the ABDT File was assumed to have been misclassified as an ABDT file and was counted as an in-scope death certificate and added to the DTHS file total.

The results of the initial categorization are found in the table below.

ICD-10 Code	NCHS Total	DTHS File			Total in ABDT File	Total in CPSC Database (ABDT + DTHS)
		In-scope	Unknown Source	Total		
1999						
X47	542	93	8	338	137	475
Y17	80	1	3	42	23	65
Total	622	94	11	380	160	540
2000						
X47	600	122	19	414	141	555
Y17	76	1	2	48	18	66
Total	676	123	21	462	159	621

Source: U.S. Consumer Product Safety Commission / EPA. CPSC Death Certificate File, CPSC In-Depth Investigation File, Abbreviated Death Certificate File, National Center for Health Statistics Mortality File, 1999-2000.

The proportion of death certificates found in the CPSC database associated with non-fire accidental X47 or Y17 deaths and associated with consumer products were applied to the NCHS totals to calculate the total estimated number of non-fire CO poisoning deaths associated with consumer products. This was done in the following way and was done for ICD-10 codes X47 and Y17 separately.

1. The number of in-scope deaths in the CPSC's Death Certificate File coded as X47 and Y17 separately 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 as X47 and Y17 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 with X47 and Y17 was counted (n_3).
4. The estimate of the number of non-fire CO poisoning deaths associated with consumer products in code X47 and Y17 was calculated separately 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 in code X47 and Y17 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 those death certificates that are missing. The weighting factor allows the computation of national estimates of CO deaths by consumer product and by other characteristics collected by CPSC about each death.

The following table contains the values for the variables used in the calculation as well as the final computed estimate of non-fire CO poisoning deaths associated with consumer products.

Variable	ICD-10 Code	
	X47	Y17
1999		
n ₁	93	1
n ₂	475-8 = 467	65-3 = 62
n ₃	542	80
<i>Weighting Factor (n₃/n₂)</i>	<i>1.1606</i>	<i>1.2903</i>
N	107.9356	1.2903
Total Estimate-1999	109.2259 ~ 109	
2000		
n ₁	122	1
n ₂	555-19 = 536	66-2 = 64
n ₃	600	76
<i>Weighting Factor (n₃/n₂)</i>	<i>1.1194</i>	<i>1.1875</i>
N	136.5672	1.1875
Total Estimate-2000	137.7547 ~ 138	

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, 1999-2000.

Incidents with unknown or highly questionable CO sources were excluded from the denominator of the weighting factor. The group of cases with unknown or highly questionable sources was assumed to contain the same proportion of cases associated with a consumer product as the group of cases within the CPSC database with known CO sources (this is the same assumption that is made for 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 when actually their scope status is unknown. Therefore they are really more similar to cases where the death certificate is missing and for weighting purposes, cases where the source was unknown or highly questionable were treated in the same way cases which are missing were treated.

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

Reports of non-fire CO poisoning deaths were retrieved from the DTHS and ADBT files based on the following criteria: date of death between 1/1/99 and 12/31/99 for 1999 and 1/1/00 and 12/31/00 for 2000; and ICD-10 code of X47 or Y17. 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 the result of the same incident, whenever possible. If information about the product's condition, venting system, or installation environment or the victim's health or drug or alcohol use was provided on the death certificate or the in-depth investigation report, this information was coded for anecdotal purposes.

In Table 1, the heating systems category combined furnaces, boilers, vented floor and wall heaters, unvented space heaters, camping heaters, and other miscellaneous heating systems.

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 grills, even though this practice was usually done for heating purposes. Portable stoves, meant for cooking, were presented under camp stoves. 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 other/multiple appliances. Engine-powered tools included generators and power gardening equipment, such as power lawn mowers, garden tractors, and snowblowers. Generators that were original equipment installed on a recreational vehicle (RV), trailer, camper, or boat were considered out-of-scope, as they are outside the jurisdiction of the CPSC.

Appendix B: Differences in Methodology in 1999

Beginning in 1999 the Tenth Revision of the International Statistical Classification of Diseases and Related Health Problems (ICD-10) was implemented. Prior to 1999 the Ninth Revision (ICD-9) was used. ICD-10 differs substantially from ICD-9 in several respects. There have been changes in the classification system and changes in the rules for classifying deaths. These changes may be responsible for certain discontinuities in cause-of-death trends from 1998 to 1999. For some leading causes of death (e.g. Influenza and Pneumonia, Septicemia, Alzheimer's Disease) the discontinuity in trend is substantial (Anderson, et al, 2001). In the area of deaths related to carbon monoxide the classification system has also changed. The exact method of interpreting changes between 1998 and 1999 for deaths associated with CO poisoning is unknown at this time, but the introduction of ICD-10 may account for some of the decrease in the non-fire CO poisoning death estimate from 1998 to 1999.

In addition to the changes resulting solely from changing the ICD-9 system to the ICD-10 classification system, the changing of the ICD codes has made it necessary that the CPSC staff's methodology for estimating CO deaths associated with consumer products be modified.

In the Ninth Revision, ICD-9 codes pertaining to unintentional carbon monoxide poisonings were grouped into the following categories:

ICD-9 Code	Shorthand Definition
867.0	Accidental poisoning by gas distributed by pipeline
868.0	Accidental poisoning by liquefied petroleum distributed in mobile containers
868.1	Accidental poisoning by other and unspecified utility gas
868.3	CO from incomplete combustion of other domestic fuels
868.2	<i>Accidental poisoning by motor vehicle exhaust gas</i>
868.8	CO from other sources
868.9	Unspecified CO

The first step in compiling the annual estimates is to compute the total estimate of CO deaths associated with consumer products. In 1998, this step relied only on the use of NCHS (National Center for Health Statistics) Mortality File totals for each of the relevant ICD-9 codes. ICD-9 codes 867, 868.0, 868.1, and 868.3 were assumed to be non-fire CO poisonings associated with consumer products. ICD-9 codes 868.8 and 868.9 were considered to contain CO deaths where the source of CO is unknown. Deaths in these 'unknown' ICD-9 codes were allocated between the consumer product category (ICD-9 codes 867, 868.0, 868.1, and 868.3) and the motor vehicle exhaust category (ICD-9 code 868.2) based upon each category's proportion of the total. The total estimate of the number of CO deaths associated with consumer products was calculated by summing those deaths within ICD-9 codes 867, 868.0, 868.1, and 868.3 and a proportion of those deaths within ICD-9 codes 868.8 and 868.9. This total represented the national estimate of non-fire CO poisonings associated with the use of a consumer product. In 1998, this total was 180.

The second step in the process was to search the CPSC's Death Certificate File for death certificates where the cause of death was non-fire CO poisoning and a consumer product was

mentioned in the narrative. Since 1979, CPSC has purchased all death certificates in ICD-9 codes 867.0, 868.0, 868.1, 868.3, 868.8, and 868.9 since they are assumed to involve, or potentially involve, consumer products. Since ICD-9 code 868.2 is generally used to classify CO deaths from products that are outside the jurisdiction of CPSC, death certificates with this ICD-9 code were not purchased. Although the majority of CO deaths reported to the CPSC were found in the DTHS file, a small number of additional CO deaths associated with consumer products were identified from the CPSC's Injury or Potential Injury Incident (IPII) File. The IPII File contains voluntarily submitted incident reports, and includes newsclips, medical examiner's reports, and coroner's reports. Any follow-up reports found in the CPSC's In-Depth Investigation (INDP) File that were based on a CO death were also reviewed to obtain more detailed product, fuel type, location, and victim information. Each CO death found in the CPSC files was then manually reviewed to exclude out-of-scope and highly questionable cases and to remove duplicates.

The resulting number of CO deaths from the CPSC files was used with the consumer product CO estimate derived from NCHS mortality data to compute a weighting factor for each CPSC death. The 1998 weighting factor was computed by dividing the national estimate of consumer product CO deaths (180) by the number of CO deaths culled from the CPSC files (111). The weighting factor for 1998 was 1.62. Since each CO death reported to CPSC (in most cases) is coded to reflect the consumer product(s) involved, the weighting factor allows the computation of national estimates of CO deaths by consumer product and by other characteristics collected by CPSC about each death.

In 1999, the Tenth Revision of the International Classification of Deaths was implemented. This revision groups all CO deaths by their intent and there is no further sub-classification of unintentional CO poisonings as there was in the Ninth Revision.

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

Similar to the methodology used with the ICD-9 codes, the first step in compiling the annual estimates was to compute the total estimate of CO deaths associated with consumer products. Due to the changes in the ICD coding system, it was not possible with data coded using the ICD-10 system to compute the total estimate of CO deaths associated with consumer products based solely upon NCHS data since all CO deaths are placed within one of the three codes listed above and the categorization is based upon intent alone. Therefore the CPSC's Death Certificate File together with the NCHS Mortality File was used to compute the total estimate of CO deaths associated with consumer products (as explained in Appendix A).

This first step in calculating the total estimate of non-fire CO poisonings associated with consumer products is where the major difference in methodology between utilizing the ICD-10 versus the ICD-9 codes occurs. Prior to 1999, by making the assumption that specific ICD-9 codes captured CO poisoning deaths associated with consumer products, NCHS data alone was used to compute the total estimate of CO deaths associated with consumer products. From 1999 and forward, it is necessary to utilize the CPSC's Death Certificate File together with the NCHS Mortality File in order to compute the total estimates of CO deaths associated with consumer products. The second step in calculating the estimates, where deaths are allocated into product categories and other variables of interest are extracted, is relatively similar in generating 1999 annual estimates as it was in generating pre-1999 annual estimates.

With the new revision of ICD codes being implemented, a thorough review of the methodology applied to estimating the number of non-fire related CO deaths was performed and a possible issue with previous estimates was noted. Prior to 1999, the estimation process relied on the assumption that ICD-9 codes 867, 868.0, 868.1, and 868.3 were non-fire CO poisonings associated with consumer products. When exploring these e-codes further, this assumption may have resulted in an overestimate as cases within these ICD-9 codes may have been associated with raw gas inhalation, fire, or may have been associated with a product not under the jurisdiction of the CPSC (examples: deaths associated with installed equipment on a boat or a work related exposure). The new methodology implemented with the introduction of the ICD-10 codes does not present this difficulty, as there is no assumption made about the NCHS data.

There are a few additional differences in the methodology used with the post-1999 annual estimates. Cases in CPSC's Death Certificate (DTHS) File and the Abbreviated Death Certificate (ABDT) File were utilized in the report. Previously, a small number of additional CO deaths associated with consumer products were identified from CPSC's Injury or Potential Injury Incident (IPII) File. The IPII File contains voluntarily submitted incident reports, which includes news clippings, medical examiner's reports, and coroner's reports. The CPSC routinely collects death certificates and there is no reason to believe that they differ substantially from the total number of death certificates collected nationally. The incidents in the IPII file, however, are likely to be a biased sample. IPII cases are voluntarily submitted and they may not be representative of the entire sample of deaths that occur nationally. Therefore only those cases that appear in the CPSC's Death Certificate File were weighted to calculate annual estimates.

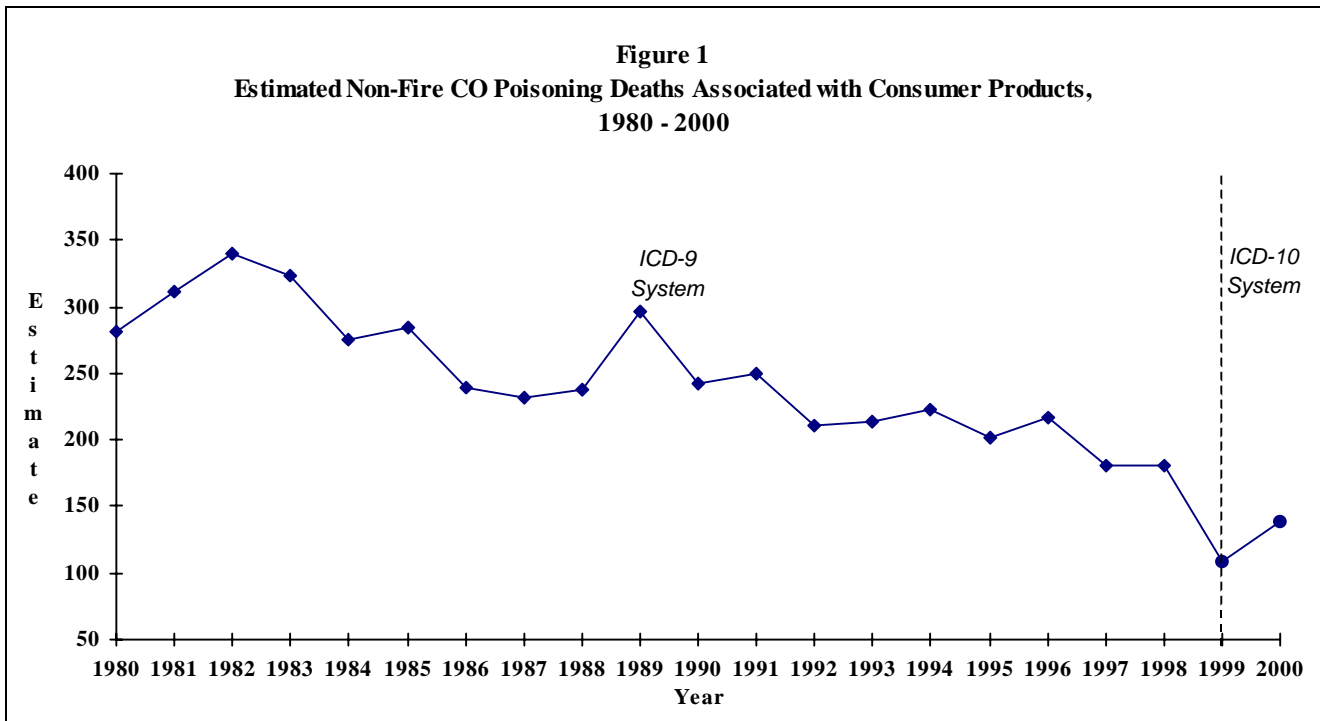
Previously, estimates could not be calculated for those incidents associated with engine-powered tools. The CPSC did not collect death certificates for deaths coded as ICD-9 code 868.2. Although the complete definition for ICD-9 code 868.2 encompassed gas engines and motors, which can be found in consumer products such as generators and power mowers and tools, this ICD-9 code was generally used to classify CO deaths from auto exhaust and other motor vehicles (products outside the jurisdiction of the CPSC). With the new revision of the ICD codes, the CPSC is collecting the death certificates for these products and generating annual estimates of deaths associated with engine-powered tools.

Appendix C: National Estimates of Consumer Product CO Poisoning Deaths, 1980 - 2000

**Estimated Non-Fire Carbon Monoxide Poisoning Deaths
Associated with Consumer Products, 1980-2000**

Year	Estimate
1980	282
1981	311
1982	340
1983	323
1984	275
1985	284
1986	240
1987	232
1988	238
1989	296
1990	243
1991	250
1992	211
1993	214
1994	223
1995	201
1996	217
1997	180
1998	180
1999*	109
2000	138

* 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.



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

References

Anderson R, Miniño A, Hoyert D, Rosenberg H. Comparability of Cause of Death Between ICD-9 and ICD-10: Preliminary Estimates. National Vital Statistics Report; Vol. 49, no. 2. Hyattsville, MD: National Center for Health Statistics. 2001.

Ault K. Non-fire Carbon Monoxide Death and Injury Estimates. Washington, D.C.: U.S. Consumer Product Safety Commission. 1997.

Ault K. A Description and an Evaluation of the Death Certificate Project. Washington, D.C.: U.S. Consumer Product Safety Commission. 2001.

Burton L.E. Toxicity from Low Level Human Exposure to Carbon Monoxide, Washington, D.C.: U.S. Consumer Product Safety Commission. 1996.

Long K, Saltzman L. Non-fire Carbon Monoxide Incidents: Morbidity and Mortality Related to the Use of Household Appliances. Washington, D.C. U.S.: Consumer Product Safety Commission. 1995.

Mah J. Non-fire Carbon Monoxide Deaths Associated with the Use of Consumer Products: 1998 Annual Estimates. Washington, D.C.: U.S. Consumer Product Safety Commission. 2001.