Non-Fire Carbon Monoxide Deaths Associated with the Use of Consumer Products
2001 Annual Estimates

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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 2001.

In 2001, there were an estimated 130 unintentional non-fire CO poisoning deaths associated with consumer products under the jurisdiction of the U.S. Consumer Product Safety Commission (CPSC). From 1999-2001, there were an average yearly estimated 126 unintentional non-fire CO poisoning deaths associated with consumer products.

Fifty-eight percent of the estimated deaths in 2001 were associated with the use of heating systems. Natural gas heating accounted for 37 percent and liquefied petroleum (LP) gas heating accounted for 35 percent of the estimated heating deaths. An estimated 18 percent of the 2001 annual CO poisoning deaths were associated with engine-powered tools, nine percent were associated with charcoal grills, eight percent were associated with gas ranges and ovens, one percent were associated with camp stoves and lanterns, and seven percent were associated with other or multiple appliances.

According to 2001 data, some form of problem with a product's venting system was noted in 17 percent of the annual fatal CO deaths. Adults 45 years of age and older represented 60 percent of the CO poisoning deaths. Almost 70 percent of CO deaths occurred in the home, while deaths in tents and other temporary shelters accounted for an estimated 21 percent of deaths. Deaths in these temporary types of shelters were mostly associated with generators and LP gas heaters. In 2001, a large percentage (81%) of the 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 126 in 1999-2001 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

During 2001, the most recent year for which complete data are available, there were an estimated 130 carbon monoxide (CO) poisoning deaths associated with the use of a consumer product under the jurisdiction of the U.S. Consumer Product Safety Commission (CPSC). Carbon monoxide poisonings referred to in this report do not include those where the CO gas resulted from a fire or a motor vehicle.

Although there can be multiple factors contributing to a CO poisoning fatality, the source of CO is virtually always a fuel-burning product. As mentioned earlier, poor product maintenance by professionals or consumers, inadequate ventilation, defective exhaust pathways, and user judgment in operating these products can result in fatal scenarios, even in incidents where the fuel-burning products are not inherently defective. It should be noted that CPSC staff produces the CO estimates by associated consumer products in order to identify product groups involved in fatal CO scenarios and to monitor this distribution over time. It is within the individual, product-specific CPSC projects that further analysis is done to consider whether improvements are warranted in the areas of product design, ventilation safeguards, or user information and education.

Due to changes in the International Statistical Classification of Diseases and Related Health Problems (ICD) with the implementation of the Tenth Revision in 1999, there are discontinuities in comparing the estimate of CO deaths associated with consumer products in 1999-2001 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 of the 1999 and 2000 Annual Estimate Report (Vagts, 2003). Due to these differences, when comparing 1999 and later 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 percentage 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 system this is possible. This is explained further in Appendix B of the 1999 and 2000 Annual Estimate Report (Vagts, 2003).

In 2001, of the estimated 130 CO poisoning deaths associated with a consumer product, heating systems were associated with 75 deaths (58% of the total consumer product estimate). Gas heating systems were associated with an estimated 60 deaths (80% of heating deaths). Among gas heating systems, natural gas heating was associated with an estimated 28 deaths (37% of heating deaths), LP gas heating was associated with an estimated 26 deaths (35% of heating deaths), and unspecified gas heating was associated with an estimated 6 deaths (8% of heating deaths). Coal/wood heating systems and kerosene oil heating each were associated with an estimated 6 deaths (8% of heating deaths), respectively. An estimated one death was associated with a heating system, not specified.

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. The degree to which staff obtains fuel type information about each CO death varies from year-to-year; therefore, caution should be used when comparing fuel-specific estimates over time.

In 2001, an estimated 12 CO deaths (9% of the total consumer product estimate) were associated with charcoal grills; no deaths were associated with gas water heaters; camp stoves and lanterns were associated with an estimated one death (1% of the total consumer product estimate); gas ranges and ovens were associated with an estimated 10 deaths (8% of the total consumer product estimate); and an estimated nine deaths were associated with other or multiple appliances (7% of the total consumer product estimate). In 2001, the other or multiple appliances category included all 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 a CO poisoning death were: a propane cook stove and lantern, a propane heater and generator, a gas water heater and a gas dryer, a lawn tractor and a generator, and a gas stove, a water heater, and a generator. An estimated 23 CO poisoning deaths (18% of the total consumer estimate) were associated with engine-powered tools, which include generators and power lawn mowers.

Table 1 shows the estimated number of deaths associated with a consumer product for 1999-2001. The average yearly total of CO deaths for this three-year period was 126 (with a standard error of approximately 8.6). The 95 percent confidence interval[+] for this estimated average ranged from 88 to 163 deaths. Due to the limited number of years for which estimates have been calculated using the new methodology implemented for 1999 and later data, a linear regression analysis will not be presented. 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 2001.

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 1999-2001. From 1999-2001, the annual average percentage (excluding engine-powered tools) was 65 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 1999-2001 and 1994-1998. From 1999-2001, an average of nine percent of annual CO poisoning deaths (excluding engine-powered tools) involved gas ranges and ovens, four percent involved camp stoves and lanterns, and one 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 1999-2001, 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.

[+] Confidence interval based on a t-distribution with two degrees of freedom.

Table 1
Estimated Non-Fire Carbon Monoxide Poisoning Deaths
By Associated Fuel-Burning Consumer Product, 1994-1998 vs. 1999-2001.

	1994-1998		1999-2001		Annual Estimate		
Consumer Product	**Average Estimate**	**Average Percent**	**Average Estimate**	**Average Percent[1]**	**1999[2]**	**2000**	**2001**
Total Deaths	**200**	**100%**	**126**	**100% (100)**	**109**	**138**	**130**
Heating Systems	**152**	**76%**	**69**	**65% (54)**	**49**	**82**	**75**
Unspecified Gas Heating	25	12%	5	**5%** (4)	3	7	6
LP Gas Heating	46	23%	26	**24%** (20)	22	29	26
Natural Gas Heating	35	18%	28	**26%** (22)	19	37	28
Coal/Wood Heating	6	3%	3	**2%** (2)	0	2	6
Kerosene/Oil Heating	9	4%	5	**4%** (4)	2	6	6
Heating Systems, Not Specified	32	15%	1	**1%** (1)	2	1	1
Charcoal Grills, Charcoal	**17**	**9%**	**12**	**12% (10)**	**17**	**8**	**12**
Gas Water Heaters	**7**	**4%**	**1**	**1% (1)**	**1**	**3**	**0**
Camp Stoves, Lanterns	**9**	**5%**	**4**	**4% (4)**	**9**	**3**	**1**
Gas Ranges/ Ovens	**7**	**4%**	**9**	**9% (7)**	**6**	**11**	**10**
Other/Multiple Appliances	**6**	**3%**	**9**	**9% (7)**	**14**	**3**	**9**
Engine-Powered Tools	*	*	**21**	**+ (16)**	**13**	**27**	**23**

[1] Two percentages are provided. The first numbers represent the percent of the total excluding Engine-Powered Tools and the numbers in parenthesis represent the percent of the total including 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.

\+ Engine-Powered Tools are excluded from the total estimate.

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 - 2001.

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. In 2001, conditions that compromised vent systems, flue passageways, or chimneys for furnaces, boilers, vented natural and LP gas heaters were mentioned as contributing to 17 percent of the CO deaths and 29 percent of CO deaths 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. 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.

In some incidents, gas heaters intended to be vented to the outside or heaters meant for outdoor use were used in an enclosed space without ventilation. Less frequently, other conditions related to furnaces included compromised heat exchangers or filter door or covers that were removed or not sealed. 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. Other incidents mentioned a backdraft condition, use of a heater with a different gas supply than it was intended for, and the use of a product that was later red-tagged by the utility company. Cooking stoves and ovens used as heating devices were involved in the majority of deaths associated with these products.

In 2001, engine-powered tools were associated with an annual estimate of 23 carbon monoxide poisoning deaths (18% of the total consumer product estimate). Twenty two of these CO poisoning deaths were associated with a generator and 1 death was associated with a power lawn mower. In 2000, an estimated 27 deaths were associated with engine-powered tools (19 of these deaths were associated with engine-powered generators, seven deaths were associated with garden tractors or power lawn mowers, and one death was associated with a snowblower). In 1999, an estimated 13 deaths were associated with engine-powered tools (seven of these deaths were associated with engine-powered generators and six deaths were associated with garden tractors or power lawn mowers). From 1999-2001, a yearly estimated average of 16 deaths were associated with engine-powered generators.

Table 2 shows that for the three most recent years of data (1999-2001), children less than 15 years of age accounted for an annual average of six 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. In 1999-2001 and 1994-1998, adults aged 25 years and older accounted for an average of approximately 80 percent of yearly CO poisoning deaths. The annual average percentage of deaths represented by adults 45 years and older was 57 percent in 1999-2001, and 50 percent in 1994-1998. In 1999-2001, adults aged 65 years and older accounted for an average annual percentage of 19 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. 1999-2001.

	1994-1998		1999-2001		Annual Estimate		
Age	Average Estimate	Average Percent	Average Estimate	Average Percent	1999[1]	2000	2001
Total	**200**	**100%**	**126**	100%	**109**	**138**	**130**
Under 5	7	3%	2	2%	0	3	4
5 – 14	9	4%	5	4%	7	3	6
15 – 24	30	15%	12	9%	8	10	18
25 – 44	54	27%	33	26%	32	44	23
45 – 64	48	24%	48	39%	45	55	45
65 and over	51	25%	24	19%	16	22	33
Unknown	1	1%	0	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 - 2001.

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. In 2001, an estimated 21 percent of the CO victims were noted as having a pre-existing health condition not related to the CO poisoning. Eighty-one percent of these 27 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 nervous system 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. In 2001, an estimated 18 percent 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 2001, 66 percent of CO victims were males and 34 percent were females. This is slightly different than the gender distribution in 2000 when 76 percent of CO victims were males and 24 percent were females. In 2001, 62 percent of the deaths occurred during the winter months of January, February, and December.

Table 3 shows that in 2001, 81 percent of fatal CO incidents reported to the CPSC involved a single death. In 1999-2001, a yearly average of 82 percent of fatal CO incidents reported to the CPSC involved a single death and in 1994-1998, 77 percent of the reported incidents involved a single death. 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. 1999-2001.

Number of Deaths Reported in Incident	1994-1998		1999-2001		Annual Estimate		
	Average Estimate	Average Percent	Average Estimate	Average Percent	1999[1]	2000	2001
Total Incidents	**106**	**100%**	**88**	**100%**	**79**	**100**	**84**
1	82	77%	72	**82%**	66	81	68
2	19	19%	14	**16%**	12	16	15
3	3	3%	1	**1%**	0	2	1
4	1	1%	1	**1%**	1	1	0
5 or more	1	1%	0	**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, 1994 - 2001.

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 in 2001, an estimated 90 CO poisoning deaths (69%) occurred in homes, including manufactured and mobile homes. From 1999-2001, an annual average of 66 percent of annual CO poisoning deaths occurred in homes, including manufactured and mobile homes, and this percentage was similar in 1994-1998. In 2001, an estimated 27 (21%) deaths took place in temporary shelters, such as tents, recreational vehicles, cube vans, seasonal cabins, and trailers (including horse trailers). In 1999-2001, an annual average of 26 percent of CO poisoning deaths took place in temporary shelters and in 1994-1998, an annual average of 18 percent of deaths took place in temporary shelters. In 2001, deaths in these temporary types of shelters were most commonly associated with generators and LP gas heaters. Charcoal grills, an LP gas camp stove, an LP gas lantern, and an LP gas cook stove were also associated with these scenarios. A consistently small percentage of deaths occurred in passenger vans, trucks, or automobiles in which victims were spending the night. In 2001, the products used in these settings were charcoal grills and LP gas portable heaters. In 2001, the 'other' location category included a resort and a detached workshop on a farm. Products used within these locations include a charcoal grill and an LP gas heater.

Table 4
Estimated Non-Fire Carbon Monoxide Poisoning Deaths by Location of Death, 1994-1998 vs. 1999-2001.

	1994-1998		1999-2001		Annual Estimate		
Location of Death	**Average Estimate**	**Average Percent**	**Average Estimate**	**Average Percent**	**1999[1]**	**2000**	**2001**
Total	**200**	**100%**	**126**	**100%**	**109**	**138**	**130**
Home	136	68%	83	**66%**	67	93	90
Temporary Shelter	35	18%	32	**26%**	35	35	27
Auto	11	5%	6	**5%**	7	2	10
Other	11	6%	4	**3%**	0	8	3
Unknown	6	3%	0	**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 - 2001.

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.

Deaths found in the CPSC's Abbreviated Death Certificate (ABDT) File were categorized as out-of-scope cases. 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 cases found in the abbreviated file were considered out-of-scope for this report. In previous years a small number of cases (three deaths in 1999 and two deaths in 2000) in the ABDT File were identified as in-scope. The method used to identify those 1999 and 2000 cases is found in Appendix A of the 1999 and 2000 Annual Estimate Report (Vagts, 2001). For 2001 data, no in-scope cases were identified in the ABDT File.

The results of the initial categorization for 2001 data 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		
X47	596	98	14	350	127	477
Y17	79	3	0	50	10	60
Total	**675**	**101**	**14**	**400**	**137**	**537**

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, 2001.

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 2001 estimate of non-fire CO poisoning deaths associated with consumer products.

	ICD-10 Code	
Variable	**X47**	**Y17**
$\mathbf{n_1}$	98	3
$\mathbf{n_2}$	477-14 = 463	60-0 = 60
$\mathbf{n_3}$	596	79
Weighting Factor *(n_3 / n_2)*	*1.2873*	*1.3167*
N	126.1512	3.95
Total Estimate	**130.1012 ~ 130**	

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, 2001.

The table below shows the weighting factors used to calculate the estimates for the years 1999-2001.

Year	NCHS Total	Total in CPSC Databases*	In-Scope Cases	Weighting Factor
1999				
X47	542	467	93	1.1606
Y17	80	62	1	1.2903
2000				
X47	600	536	122	1.1194
Y17	76	64	1	1.1875
2001				
X47	596	463	98	1.2873
Y17	79	60	3	1.3167

* 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, 1999-2001.

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 ABDT files based on the following criteria: date of death between 1/1/01 and 12/31/01 and ICD-10 code of X47 or Y17. Death certificates entered into CPSC's database prior to April 30, 2004 were included in this analysis. 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. Examples of products historically included in the 'other' category include: LP gas refrigerator, LP gas grill, LP fish cooker, and gas pool heater. 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.

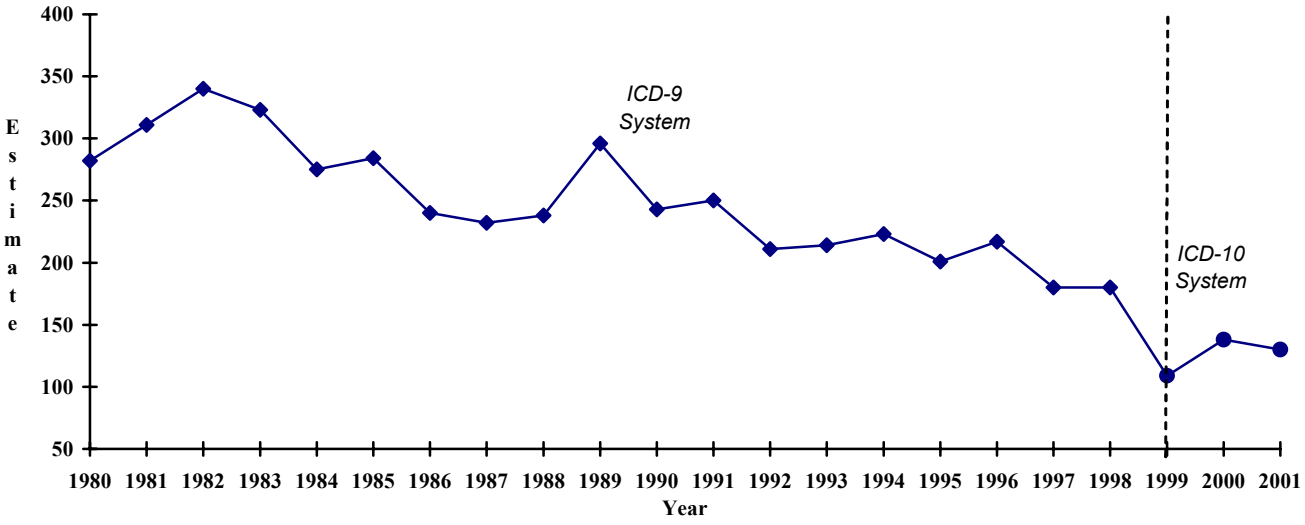
Appendix B: National Estimates of Consumer Product CO Poisoning Deaths, 1980 - 2001

Estimated Non-Fire Carbon Monoxide Poisoning Deaths Associated with Consumer Products, 1980-2001

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
2001	130

* 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.

Figure 1
Estimated Non-Fire CO Poisoning Deaths Associated with Consumer Products, 1980 - 2001



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.

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.

Vagts S. Non-fire Carbon Monoxide Deaths Associated with the Use of Consumer Products: 1999 and 2000 Annual Estimates. Washington, D.C.: U.S. Consumer Product Safety Commission. 2003.