



**Non-Fire Carbon Monoxide Deaths and Injuries
Associated with the Use of Consumer Products
Annual Estimates**

October 2000

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Executive Summary

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

Between 1993 and 1997, the total number of unintentional non-fire CO poisoning deaths, including both deaths associated with consumer products under the jurisdiction of the U.S. Consumer Product Safety Commission (CPSC) and deaths associated with motor vehicle exhaust, averaged 534 annually. During this time, the annual average number of CO poisoning deaths attributed to motor vehicle exhaust was 327 or about 61 percent of all unintentional non-fire CO poisoning deaths. The remaining 207 (39%) deaths were associated with consumer products. Most of the non-fire, consumer product-related CO poisoning deaths were associated with the use of heating systems. Other consumer products associated with these poisoning deaths included charcoal grills, gas water heaters, gas ranges and ovens, and fuel-burning camping equipment.

Between 1995 and 1999, an estimated average of 10,200 people reported to hospital emergency rooms each year for non-fire, non-fatal CO poisoning injuries associated with consumer products. This estimate excludes incidents involving auto exhaust. As with deaths, most injuries were associated with heating systems.

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 air, the duration of exposure, and its concentration in blood, as well as 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 of 10 percent. Symptoms at blood levels 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 3 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 are not always aware of the symptoms of CO poisoning. 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 liquid petroleum (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.

Non-fire Carbon Monoxide Poisoning Deaths

During 1997, the most recent year for which complete death certificate data are available, there were an estimated 180 non-fire CO poisoning deaths associated with the use of consumer products, excluding motor vehicles. Table 1 relates the distribution of estimated non-fire CO poisoning deaths attributed to consumer products and the various fuel types involved. These distributions were derived using the methodology described in Appendix 1. Of the 180 deaths, heating systems were involved in 135. These 135 deaths associated with heating systems are 75 percent of all consumer product-related CO poisoning deaths reported in 1997. Among the specified heating system fuel types, natural gas heating was associated with 46 deaths, LP gas heating was associated with 41 deaths, and unspecified gas heating systems were associated with 12 deaths. Other heating system fuel types reported included coal and wood (5) and kerosene and oil (10). Unspecified fuel type heating systems were reported in 20 of the fatalities. A higher than average percentage of CPSC follow-up investigations performed on fatal incidents occurring in 1997 most likely caused fewer deaths to appear under the catch-all categories of Heating Systems, Unspecified Gas and Heating Systems, Not Specified. This also contributed to the larger estimated number of deaths associated with Heating Systems, Natural Gas, compared with previous years. The degree to which staff can 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.

Table 1
Estimated Non-Fire Carbon Monoxide Poisoning Deaths
by Type of Consumer Product Reported, 1993 - 1997

Consumer Product	Average Percent	Average Estimate	1993	1994	1995	1996	1997
Total Deaths	100%	207	214	223	201	217	180
Heating Systems	76%	157	152	177	159	163	135
Unspecified Gas Heating	16%	33	44	59	26	22	12
LP Gas Heating	20%	42	27	35	51	54	41
Natural Gas Heating	13%	27	14	24	31	19	46
Coal/Wood Heating	3%	6	7	6	6	7	5
Kerosene/Oil Heating	5%	10	10	9	5	15	10
Heating Systems, Not Specified	19%	40	50	44	40	47	20
Charcoal Grills, Charcoal	10%	20	27	15	14	19	23
Gas Water Heaters	4%	8	11	7	5	8	8
Camp Stoves, Lanterns	4%	9	10	12	15	3	5
Gas Ranges/ Ovens	4%	8	6	9	5	15	5
Other Appliances	2%	5	7	3	3	8	3

Source: U.S. Consumer Product Safety Commission / EPA.
 CPSC Death Certificate File, CPSC Injury or Potential Injury Incident File, National Center for Health Statistics Mortality File, 1993 - 1997.

Note1: Detail may not add to total due to rounding.

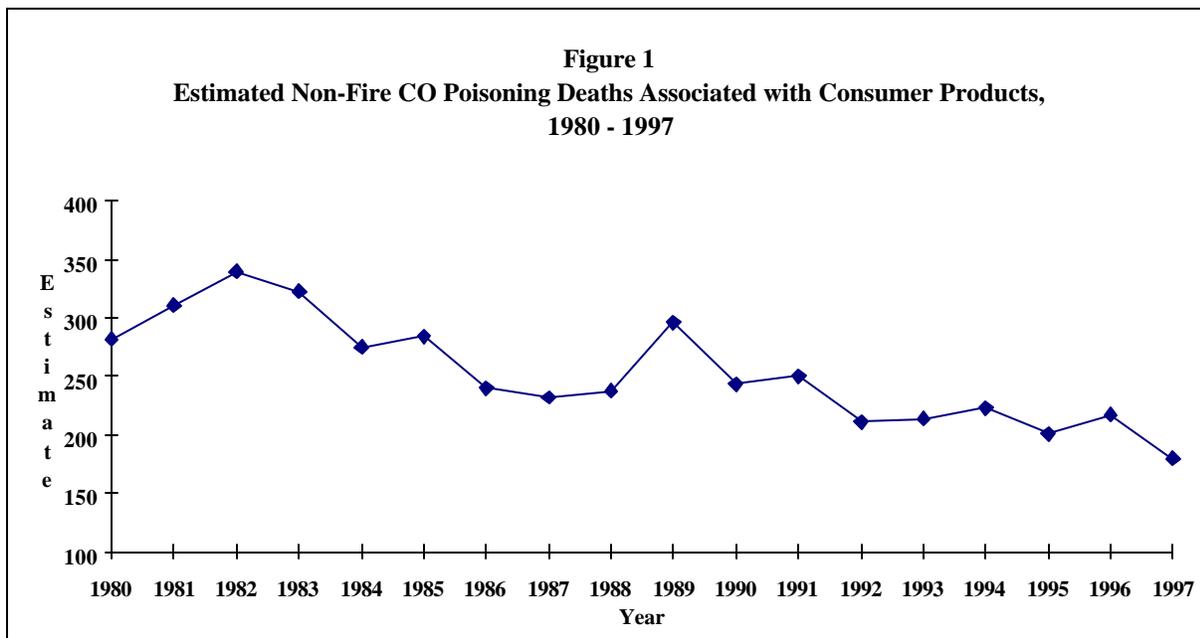
Note 2: The p-value for the regression analysis F-test statistic was 0.203. A significant p-value is a value less than 0.05 for a 95% confidence test.

Other consumer products reported to have been involved in CO poisoning deaths were charcoal grills and charcoal burned not as part of an appliance (23), gas water heaters (8), camp stoves and lanterns (5), and gas ranges and ovens (5). Other appliances, such as propane refrigerators and LP gas tanks and fittings, were associated with 3 deaths. Although information regarding vent conditions of vented products was not systematically provided with each reported death, problems with chimneys, flues, or vents in connection with fuel-burning products were often mentioned in the fatal scenarios.

Deaths associated with fuel-powered, “motor/engine” type appliances, such as portable generators, lawn mowers, and power washers were reported to CPSC; however, comparable death estimates for these products are not available due to the way in which CO deaths are categorized by the National Center for Health Statistics. (See Appendix 2.)

Additionally, Table 1 shows the estimated number of deaths for the period 1993 to 1997. On average, the annual number of non-fire CO poisoning deaths for this period was 207 (with a standard error of approximately 7.6). The 95 percent confidence interval for the five-year average ranged from 192 to 222 deaths. A regression analysis did not show a significant increase or decrease in the estimated total number of non-fire CO poisoning deaths during this period.

However, a regression analysis did show a significant decrease in the estimated CO deaths during the 18-year period beginning in 1980. Estimated deaths have been significantly lower relative to 1980 since at least as early as 1994, with the highest estimate occurring in 1982 (340) and the lowest occurring in 1997 (180). Figure 1 below illustrates the annual estimated CO poisoning deaths for 1980 through 1997. (See Appendix 3 for the data point values and p-value.)



Source: U.S. Consumer Product Safety Commission / EPHA.
CPSC Death Certificate File, CPSC Injury or Potential Injury Incident File, National Center for Health Statistics Mortality File, 1980 - 1997.

Table 1 also shows the average percentage of deaths associated with the various reported products. On average, about 76 percent of the deaths involved heating systems and 10 percent involved charcoal grills. The remaining deaths were associated with other consumer products including gas water heaters, camp stoves and lanterns, gas ranges/ovens, and other fuel-powered appliances. Each of these products was associated with less than 5% of the five-year average estimate for deaths.

Table 2 shows that, from 1993 to 1997, on average, adults age 25 years and older accounted for over 75 percent of non-fire CO poisoning deaths. Adults age 65 years and over accounted for 24 percent of total deaths. Children under 15 years of age accounted for about 9 percent of all CO deaths. On average about 68 percent of the victims were males and 32 percent were females. Most of the deaths (65%) occurred from November through February, the primary months when heating appliances are used.

Table 2
Estimated Non-Fire Carbon Monoxide Poisoning Deaths by Age of Victim, 1993 - 1997

Age	Average	1993	1994	1995	1996	1997
Total	100%	214	223	201	217	180
Under 5	4%	7	10	7	8	5
5 - 14	5%	12	7	15	12	4
15 - 24	17%	40	50	40	23	20
25 - 44	28%	64	55	51	66	49
45 - 64	24%	52	50	51	45	45
65 and over	24%	39	51	37	62	54
Unknown	0%	0	0	0	0	1

Source: U.S. Consumer Product Safety Commission / EPHA.
CPSC Death Certificate File, CPSC Injury or Potential Injury Incident File, National Center for Health Statistics Mortality File, 1993 - 1997.

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

Table 3 shows that over the same five year period, an average of almost 80 percent of reported fatal incidents involved a single death. About 20 percent of these reported incidents involved two or more CO poisoning deaths.

Table 3
Number of Reported Carbon Monoxide Poisoning Incidents
By the Number of Deaths Reported in Each Incident, 1993 - 1997

Number of Deaths Reported in Incident	Average Percent	1993	1994	1995	1996	1997
Total Incidents	100%	120	123	104	122	104
1	79%	96	102	84	93	80
2	17%	18	17	17	24	20
3	3%	6	2	1	3	4
4	1%	0	1	1	2	0
5 or more	0%	0	1	1	0	0

Source: U.S. Consumer Product Safety Commission / EPHA.
CPSC Death Certificate File, CPSC Injury or Potential Injury Incident File, 1993 - 1997.

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 estimated deaths but reported deaths contained in the CPSC Death Certificate or Injury or Potential Injury Incident Files. NCHS data do not contain enough detail to identify multiple-victim fatal CO poisoning incidents.

It should be noted that Table 3 counts only victims who suffered fatal injuries in each CO poisoning incident. The table does not count victims who may have suffered non-fatal injuries in these same incidents. It is not unusual for CO incidents with one or more fatality to involve additional victims who suffer non-fatal CO poisoning injuries.

Table 4
Estimated Non-Fire Carbon Monoxide Poisoning Deaths by Location of Death 1993 - 1997

Location of Death	Average Percent	1993	1994	1995	1996	1997
Total	100%	214	223	201	217	180
Home	68%	147	161	119	159	118
Temporary Shelter	14%	11	22	40	38	30
Auto	6%	17	15	11	7	16
Other	6%	10	12	23	11	8
Unknown	6%	29	13	8	1	7

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

CPSC Death Certificate File, CPSC Injury or Potential Injury Incident File, National Center for Health Statistics Mortality File, 1993 - 1997.

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

Table 4 shows that over two-thirds of deaths occurred in homes, including mobile homes and garages. Almost 15 percent of deaths were in temporary shelters, such as cabins, recreational vehicles or campers, tents, or trailers. A small percentage of CO poisoning deaths occurred in vans, trucks, or automobiles in which victims were spending the night. Although these deaths occurred in vehicles, the fatalities were reportedly associated with fuel-burning consumer products (e.g., portable heaters) or charcoal, and not motor vehicle exhaust. "Other" locations included a restaurant, motel, and an office building.

Non-Fire Carbon Monoxide Poisoning Injuries Reported in Emergency Rooms

The CO poisoning injury estimates in this report are based on a national sample of emergency room (ER) cases where CO exposure was indicated in the diagnosis or as the reason for the ER visit. The sample and estimation methodology are described in Appendix 1.

Non-fatal poisonings from CO exposure are difficult to estimate. Many victims do not recognize the symptoms of CO exposure or do not seek medical attention. If victims do seek medical attention, their symptoms may be misdiagnosed, since symptoms can be similar to those associated with colds and the flu. Carbon monoxide victims who report to ERs typically complain of fatigue, headache, nausea, dizziness, shortness of breath, chest pain, diarrhea, and other symptoms. In the ideal case, the physician quickly recognizes the possibility of CO poisoning, and the victim's COHb is measured as soon as possible after suspected CO exposure. However, in many cases the victim is misdiagnosed and recognition of CO poisoning is delayed or does not occur.

More recently, as safety and health organizations and utility companies educate consumers of the causes, symptoms, and health effects of CO poisoning, some consumers may report to emergency rooms as a precaution if they are alerted by a CO alarm or suspect CO exposure. There is also greater awareness within the medical community, which may lead to more accurate CO poisoning diagnoses. Currently, the number of CO poisoning injuries that go undiagnosed, as well as the number of reported injuries that are not actually poisonings, is not known. The injury estimates in this report are national estimates of CO injuries reported in emergency rooms.

In 1999, the latest year for which emergency room data are available, an estimated 7,900 people reported to hospital emergency rooms for non-fire CO poisoning related to consumer products. Table 5 shows a distribution of these reported injuries by the type of product reportedly involved. In 1999, heating systems, primarily furnaces, contributed to an estimated 4,300 injuries (54%). The types of heating systems associated with these injuries included natural gas or LP gas heating systems (2,700), kerosene or oil heating systems (100), coal or wood heating systems (200), and heating systems with an unspecified fuel type (1,300). Other products reported as being involved in CO poisoning injuries included gas ranges and ovens (400), grills and portable stoves (100), gas water heaters, portable generators, and fuel-powered tools and appliances (1,600). There were more CO poisoning injuries associated with water heaters (800) in 1999 than in any of the four preceding years.

Often, gas ranges and ovens were inappropriately used for heating purposes. In 1999, fuel-powered tools and appliances included power saws, refrigerators, sprayers, and air-conditioners. The remaining 1,400 poisoning injuries categorized in Table 5 as "No Product Specified" were based on reports where either pipes were the only reported product involved, CO alarms were the only reported product involved, or the source of CO was reported as unknown. Note that some of the CO injuries in this category may not necessarily be consumer product-related (e.g., motor vehicle exhaust).

Table 5
Estimated Injuries Reported in Emergency Rooms
for Non-Fire Carbon Monoxide Poisoning by
Type of Consumer Products Reported, 1995 – 1999

Type of Product	Average Percent	Average Estimate	1995	1996	1997	1998	1999
Total Non-Fatal Poisonings	100%	10,200	9,200	15,100	11,000	7,700	7,900
Sample Size			235	334	273	210	260
Coefficient of Variation			.16	.18	.15	.19	.20
Heating Systems	56%	5,700	7,000	9,100	4,600	3,700	4,300
Natural Gas / LP Heating	22%	2,200	2,600	3,200	2,300	400*	2,700
Kerosene / Oil Heating	4%	400	1,200*	600*	200*	100*	100*
Coal / Wood Heating	4%	400	800*	400*	100*	400*	200*
Other Heating	2%	200	0	0	100*	700*	0
Heating Systems, Not Specified	24%	2,500	2,500	4,900	1,900	2,100	1,300
Gas Ranges / Ovens	6%	600	900	900	500	500*	400*
Grills / Stoves	3%	400	100*	600*	700	300*	100*
Other Products	12%	1,200	500*	1,700*	1,300*	700*	1,600
Gas Water Heaters	4%	400	300*	100*	400*	200*	800
Portable Generators and Pumps							
Fuel-Powered Tools / Appliances							
Gas Clothes Dryers							
No Product Specified	22%	2,200	800	2,800	3,700	2,500	1,400

Source: U.S. Consumer Product Safety Commission / EPHA.
National Electronic Injury Surveillance System, 1995 - 1999.

Note 1: Estimates rounded to the nearest 100.

Note 2: Detail may not add to total due to rounding.

Note 3: Estimates noted by an asterisk are based on sample sizes less than 20 and may have large variances. A more detailed product-specific table is included in Appendix 4.

Note 4: Due to the NEISS sample change in 1997, prior year estimates have been adjusted to account for the sample change. Appendix 1 lists the adjustment factors used.

Table 5 also shows the estimated number of reported CO poisoning injuries for 1995 to 1998. The estimated annual average for non-fire CO poisoning injuries for this period was 10,200. The average year-to-year change in the annual estimates from 1995 – 1999 was around two percent, but ranged from a 64 percent increase (1995-96) to a 30 percent decrease (1997-98). Table 5 also shows the annual average percentage of reported injuries by type of consumer product involved in the injury. Heating systems contributed to 56 percent of all reported poisoning injuries. Natural gas and LP gas heating systems accounted for 22 percent, unspecified gas heating systems accounted for 24 percent, and kerosene, oil, coal, and wood heating systems collectively accounted for 10 percent. On average, gas ranges and ovens contributed to 6 percent of the injuries, grills and portable stoves contributed to 3 percent, and other products combined contributed to 12 percent. (For a more detailed breakdown of the *Other Products* category, see Appendix 4.) Reported injuries fitting the criteria for the “No Product Specified” category contributed an average of 22 percent of the CO poisoning injuries.

Table 6 shows that, from 1995 to 1999, on average adults between 25 and 44 years old reported the greatest percentage of CO poisoning injuries (31%) and children between 5 and 14 years old reported the next highest percentage (24%). Children younger than 5 years of age accounted for 16 percent of CO poisoning injuries. Adults 45 years old and older account for only 15 percent of CO poisoning injuries; however, as Table 2 (p.5) shows, the same age group accounts for 48 percent of non-fire CO poisoning fatalities.

Table 6
Estimated Injuries Reported in Emergency Rooms
for Non-Fire Carbon Monoxide Poisoning by
Age of Victim, 1995 - 1999

Age	Average Percent	1995	1996	1997	1998	1999
Total	100%	9,200	15,100	11,000	7,700	7,900
Under 5	16%	1,500	2,200	1,400	1,300	1,500
5 – 14	24%	2,000	3,900	1,900	2,300	1,900
15 – 24	14%	1,400	2,000	1,600	1,000	1,100
25 – 44	31%	3,200	4,300	4,400	1,700	2,200
45 – 64	11%	800	2,000	1,500	900	800*
65 and over	4%	400*	800*	200*	500*	300*

Source: U.S. Consumer Product Safety Commission / EPHA.
National Electronic Injury Surveillance System, 1995 - 1999.

Note 1: Estimates rounded to the nearest 100.

Note 2: Detail may not add to total due to rounding.

Note 3: Estimates noted by an asterisk are based on sample sizes less than 20 and may have large variances.

Note 4: Due to the NEISS sample change in 1997, prior year estimates have been adjusted to account for the sample change. Appendix 1 lists the adjustment factors used.

Table 7 shows that, from 1995 to 1999, on average 97% of the victims of non-fatal CO poisonings were examined and/or treated in the hospital emergency room and released. Three percent of the poisonings required admission for hospitalization.

Table 7
Estimated Injuries Reported in Emergency Rooms
for Non-Fire Carbon Monoxide Poisoning by
Disposition of Victim, 1995 - 1999

Disposition	Average Percent	1995	1996	1997	1998	1999
Total	100%	9,200	15,100	11,100	7,700	7,900
Treated & Released	97%	9,000	14,800	10,700	7,400	7,700
Hospitalized	3%	200*	300*	300*	400	100*
Unknown	0%	**	100*	0	0	0

Source: U.S. Consumer Product Safety Commission / EPHA.
National Electronic Injury Surveillance System, 1995 -1999.

Note 1: Estimates rounded to the nearest 100.

Note 2: Detail may not add to total due to rounding.

Note 3: The double asterisk denotes that the estimate is less than 50.

Note 4: Estimates noted by an asterisk are based on sample sizes less than 20 and may have large variances.

Note 5: Due to the NEISS sample change in 1997, prior year estimates have been adjusted to account for the sample change. Appendix 1 lists the adjustment factors used.

Table 8 shows that an average of fifty-nine percent of the reported ER incidents involved only 1

injury, while the remaining 41 percent involved at least 2 injuries.

Table 8
Number of Reported Carbon Monoxide Incidents
By the Number of Injuries Reported in Each Incident, 1995 - 1999

Number of Injuries Reported in Incident	Average Percent	1995	1996	1997	1998	1999
Total Incidents	100%	122	168	204	126	128
1	59%	67	86	134	87	72
2	18%	21	38	37	17	23
3	10%	17	24	11	9	15
4	7%	12	9	9	9	10
5 or more	5%	5	11	13	4	8

Source: U.S. Consumer Product Safety Commission / EPHA.
National Electronic Injury Surveillance System, 1995 - 1999.

Note: Data in Table 8 are based on unweighted, actual injuries reported in the National Electronic Injury Surveillance System, 1995 – 1999. Therefore injury totals add to the sample size totals, and not the estimated totals, in Table 5.

Summary

In 1997, the estimated number of deaths associated with non-fire, consumer product-related carbon monoxide poisoning was 180. Heating systems continue to be involved in around 75 percent of these deaths. Although venting systems for these and other appliances are not broken out as separate products, blocked or leaky vents were sometimes reported in these fatal incidents. Although the 1997 CO death estimate was the lowest of the five years presented, because of typical variation in the annual estimates, it was not found to be a significant decrease (using a 95% confidence test) within the five-year period. However, considering the longer, 18-year time period beginning with 1980, a significant decrease in estimated CO deaths was detected through 1997.

According to 1999 injury data, the estimated number of emergency room reported CO injuries was 7,900, virtually unchanged from the 1998 estimate (7,700). The average year-to-year change in the annual estimates from 1995 – 1999 was around two percent, however the yearly changes fluctuated substantially. Heating systems continued to account for about 55 percent of reported CO injuries, and in 1999 1,600 CO injuries were associated with water heaters (800), generators and pumps, and fuel-powered tools/appliances.

Appendix 1 - Methodology

Non-fire Carbon Monoxide Deaths

All death certificates filed in the U.S. are compiled by the National Center for Health Statistics (NCHS) into multiple cause of mortality data files. The mortality data files contain demographic and geographic information as well as the International Classification of Diseases codes for the underlying cause of death and up to 20 contributing conditions. The 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, Injuries, and Causes of Death. The International Classification of Diseases, Ninth Revision was implemented in 1979 and was in effect through 1997, the latest year of data presented in this report.

The following methodology was used to determine non-fire CO poisoning deaths associated with the use of consumer products. The first step in the estimation process is searching the NCHS data for the following external cause of death codes (Ecodes):

Ecodes Assumed to Contain CO Poisoning Deaths Associated with Consumer Products

- 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)

Death counts for the above Ecodes were combined to obtain the total number of known non-fire, consumer product-related CO poisoning deaths (n_1). The balance of the known non-fire CO poisoning deaths is found in Ecode 868.2 - Motor vehicle / engine exhaust (n_3). Although Ecode 868.2 may contain deaths that involve consumer products such as small-engined tools, the Ecode is generally used to classify CO deaths from auto exhaust and other motor vehicles, which are outside the jurisdiction of CPSC.

Non-fire CO poisoning deaths of unknown origin are found in Ecodes 868.8 - CO from other sources and 868.9 - Unspecified CO. The CO deaths in these Ecodes (n_2) are proportionally allocated between the consumer product-related CO deaths and the CO deaths due to motor vehicle / engine exhaust. To do this, proportions were computed using only deaths where the cause of CO poisoning was known. The proportion of known consumer product-related deaths was computed as:

$$\frac{n_1}{n_1 + n_3}$$

Where:

n_1 = number of known consumer product-related deaths

n_3 = number of known motor vehicle / engine exhaust deaths

$n_1 + n_3$ = total known non-fire CO poisoning deaths

This proportion was then applied to the quantity of unknown CO poisoning deaths (n_2) to arrive at the estimated number of unknown CO poisoning deaths that were actually related to consumer products. The estimated number of unknown CO poisoning deaths actually related to motor vehicle / engine exhaust was similarly computed, with n_3 replacing n_1 in the numerator of the proportion.

The estimated total for non-fire, consumer product-related CO poisoning deaths was finally computed as the sum of the known consumer product-related CO poisoning deaths plus the estimated number of unknown CO poisoning deaths actually related to consumer products.

*Estimated Total of Non-Fire
Consumer Product-Related
CO Poisoning Deaths*

$$N = n_1 + \frac{n_1}{n_1 + n_3} \times n_2$$

The table below shows the estimated totals, after the allocation of unknown CO deaths, for both consumer product-related CO deaths and motor vehicle / engine exhaust CO deaths for the most recent five years of NCHS data.

Estimated Totals of Unintentional Non-Fire Carbon Monoxide Poisoning Deaths

Estimated Totals	1993	1994	1995	1996	1997
Consumer Products	214	223	201	217	180
Auto / Engine Exhaust	335	359	333	316	294
Total Unintentional Non-Fire CO Deaths	549	582	533	531	474

Source: National Center for Health Statistics Mortality File, 1993 - 1997.

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

The next step in the process was to search CPSC's Death Certificate File (DCRT) for death certificates having Ecodes associated with consumer product-related or potentially consumer product-related CO poisonings (867.0, 868.0, 868.1, 868.3, 868.8, and 868.9). Since Ecode 868.2 is generally used to classify CO deaths from products that are outside the jurisdiction of CPSC, death certificates with this Ecode were not available. Although virtually all CO deaths reported to CPSC were found in the above Ecodes, a small number were found in different Ecodes and selected for inclusion based on the death certificate narratives. A small number of CO deaths not documented in the DCRT but identified from CPSC's Injury or Potential Injury Incident File (IPII) were also included in the set of reported CO deaths.

The number of CO deaths retrieved from the CPSC data files was used in combination with the estimated number of consumer product-related CO deaths from the NCHS mortality data to compute a weighting factor for each CO death reported to CPSC. Since each CO death reported to CPSC (in most cases) is coded to reflect the consumer product(s) involved, the weighting factor enables us to compute annual CO death estimates associated with various consumer products. The weighting factor is computed by dividing the estimated number of non-fire, consumer product-related CO deaths (N) by the number of unique CO deaths reported in the DCRT and IPII files. The table below shows the weighting factors used for the 1993 - 1997 estimates.

1993 – 1997 Weighting Factors for Non-Fire Carbon Monoxide Deaths Reported to CPSC

Year	Estimated NCHS Consumer Product Total	Deaths Reported to CPSC (DCRT, IPII)	Weighting Factor
1993	214	150	1.43
1994	223	151	1.48
1995	201	130	1.55
1996	217	158	1.37
1997	180	132	1.36

Source: U.S. Consumer Product Safety Commission / EPHA.
National Center for Health Statistics Mortality File, CPSC Death Certificate File, Injury or Potential Injury Incident File, 1993 - 1997.

The non-fire, consumer product-related CO poisoning deaths were retrieved from the DCRT system based on the following criteria: date of death between 1/1/97 and 12/31/97 and Ecode - 867.0, 868.0, 868.1, 868.3, 868.8, or 868.9, or narrative contained reference to carbon monoxide or CO. Carbon monoxide deaths were retrieved from the IPII system based on the following criteria: date of incident between 1/1/97 and 12/31/97; disposition – death (8); hazard type – poisoning (6) or suffocation (8); and narrative contained reference to carbon monoxide, poisoning, or exposure. After the initial queries of DCRT and IPII, cases were manually reviewed to exclude out-of-scope cases and to remove duplicates.

Each CO death reported to CPSC was reviewed and coded by the author based on the product and type of fuel involved, as well as the incident location, whenever possible. The heating systems category combined wall heaters and furnaces, floor furnaces, boilers, space 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) were presented with charcoal grills, even though this practice was usually done for heating purposes. Portable stoves, whether meant for heating or cooking, were presented under camp stoves.

Non-fire Carbon Monoxide Poisoning Injuries Reported in Hospital Emergency Rooms

The estimated number of non-fatal CO poisonings reported in hospital emergency rooms is based on the National Electronic Injury Surveillance System (NEISS). The NEISS is a probability sample of hospitals selected from the population of all hospitals with emergency rooms (ERs) in the U.S. and its territories. The hospitals in the sampling frame are stratified by size (number of emergency room visits) into four strata. An additional stratum is comprised of children's hospitals. Within each stratum, hospitals are sorted by a serpentine ordering of states by ZIP code. A systematic sample of hospitals is then selected from each stratum. Injuries associated with consumer products and recreational activities are collected on a daily basis via a computer from each participating hospital. Data relating to each injury, including the consumer product(s) involved, location of injury, and a brief narrative, are collected.

Because of the properties of a probability sample such as the NEISS sample, each reported injury in a sampled hospital is weighted to represent similar injuries in the U.S. and its territories. In this way, national estimates associated with different types of injuries, and associated with various consumer products, may be derived using the injury reports collected in the NEISS sample. Probability samples also permit the computation of variances, a measure of the variation in a sample, associated with each estimate. The variances are derived from the statistical variability associated with the sample or the sampling error. For the injury estimates presented in this report, the respective coefficients of variation are given along with the sample sizes for the estimates. The coefficient of variation is equal to the square root of the variance (also known as the standard error) divided by the value of the estimate. (Kessler, Schroeder, 1998)

In 1999, the data collection period for the most recent national injury estimates, there were 101 hospitals included in the NEISS sample (Marker, 1996). Estimates provided in a previous memorandum (Ault, 1997) have been revised to account for the NEISS sample change in 1997. The prior year adjustment factors are listed below.

1996 Adjustment Factor = 0.983236

1995 Adjustment Factor = 0.983236

The non-fire, consumer product-related CO poisoning injuries were retrieved from the NEISS system based on the following criteria: treatment date between 1/1/99 and 12/31/99; diagnosis code – anoxia (65) or poisonings (68); type of injury – not work-related; and narrative contained reference to carbon monoxide, CO, or variations thereof. After the initial query of NEISS, cases were manually reviewed to exclude out-of-scope cases.

Appendix 2

In the NCHS data, the Ecode 868.2 is used for reporting non-fire CO deaths associated with motor vehicle (not in transit) exhaust and CO deaths associated with the use of farm tractors, gas engines, motor pumps, and any other type of combustion engine not in watercraft. CPSC does not routinely collect death certificates for Ecode 868.2, since most motor vehicles are not within the jurisdiction of CPSC. Thus appropriate weighting factors (as discussed in Appendix 1) are not available for computing annual death estimates associated with these products.

Based on the methodology and the table of weighting factors presented in Appendix 1, the five year average percentage of non-fire CO poisoning deaths reported to CPSC, relative to the NCHS national totals, is about 70 percent. Inversely, this translates into a five year average weighting factor of 1.44 for each CPSC reported death in that time period. If this average weighting factor is applied to the counts below, then the five year average estimate of non-fire CO poisoning deaths associated with generators and other engine-driven products is 22 deaths. The table below shows the number of reported non-fire CO poisoning deaths associated with generators and other engine-driven appliances used by consumers, such as pumps, lawn mowers, power washers, and snow blowers.

Reported Non-Fire CO Poisoning Deaths Associated with Generators and Engine-Driven Appliances

Appliance	1993	1994	1995	1996	1997
Total	13	11	13	20	20
Generators	10	7	12	17	18
Other Products	3	4	1	3	2

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

CPSC Death Certificate File, CPSC Injury or Potential Injury Incident File, 1993 - 1997.

Appendix 3

Estimated Non-Fire Carbon Monoxide Poisoning Deaths Associated with Consumer Products, 1980-1997

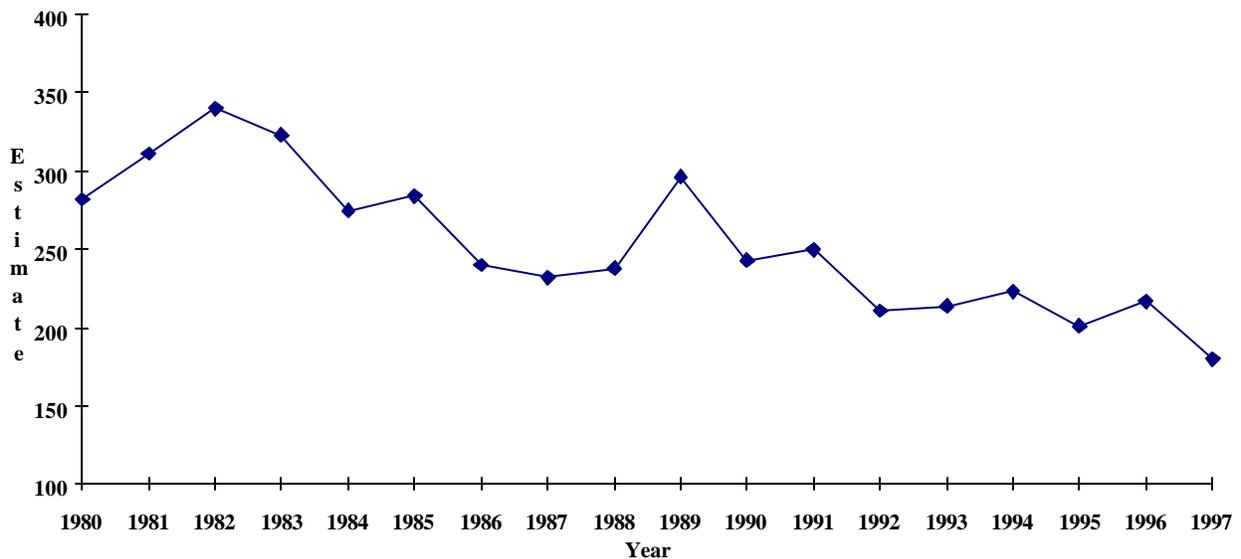
Year	Estimate
1980	282
1981	311
1982	340
1983	323
1984	275
1985	284
1986	240
1987	232
1988	238
1989	296
1990	243
1991	250
1992	211
1993	214
1994	223
1995	201
1996	217
1997	180

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

CPSC Death Certificate File, CPSC Injury or Potential Injury Incident File, National Center for Health Statistics Mortality File, 1980 - 1997.

Note: The p-value for the regression analysis F-test statistic was less than 0.01. A significant p-value is a value less than 0.05 for a 95% confidence test.

Figure 1
Estimated Non-Fire CO Poisoning Deaths Associated with Consumer Products,
1980 - 1997



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

CPSC Death Certificate File, CPSC Injury or Potential Injury Incident File, National Center for Health Statistics Mortality File, 1980 - 1997.

Appendix 4

The table below contains a more detailed breakdown of Table 5. The estimates denoted by an asterisk in the table are based on small samples and may have large variances. Caution must be used when citing these estimates.

**Estimated Injuries Reported in Emergency Rooms
for Non-Fire Carbon Monoxide Poisoning by
Type of Consumer Products Reported (Detail), 1995 – 1999**

Type of Product	Average Percent	1995	1996	1997	1998	1999
Total Non-Fatal Poisonings	100%	9,200	15,100	11,000	7,700	7,900
Heating Systems	56%	7,000	9,100	4,600	3,700	4,300
Gas / LP Heating	22%	2,600	3,200	2,300	400*	2,700
Kerosene / Oil Heating	4%	1,200*	600*	200*	100*	100*
Coal / Wood Heating	4%	800*	400*	100*	400*	200*
Other Heating	2%	0	0	100*	700*	0
Heating Systems, Not Specified	24%	2,500	4,900	1,900	2,100	1,300
Gas Ranges / Ovens	6%	900	900	500	500*	400*
Grills	3%	100*	600*	700	300*	100*
Charcoal Grills	1%	0	300*	200	100*	**
Other Grills	2%	100*	300*	500	200*	100*
Gas Water Heaters	4%	300*	100*	400*	200*	800
Portable Generators and Pumps	3%	100*	700*	400*	200*	300*
Fuel-Powered Tools	4%	200*	500*	400*	300*	500*
Gas Clothes Dryers	1%	0	400*	0	0	0
No Product Specified	22%	800	2,800	3,700	2,500	1,400

Source: U.S. Consumer Product Safety Commission / EPHA.
National Electronic Injury Surveillance System, 1995 - 1999.

Note 1: Estimates rounded to the nearest 100.

Note 2: Detail may not add to total due to rounding.

Note 3: Estimates noted by an asterisk are based on sample sizes less than 20 and may have large variances.

Note 4: The double asterisk denotes that the estimate is less than 50.

Note 5: Due to the NEISS sample change in 1997, prior year estimates have been adjusted to account for the sample change. Appendix 1 lists the adjustment factors used.

References

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

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