Review of Severe Carbon Monoxide Poisoning Mortality and Morbidity in Florida 1999-2006

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Introduction

Carbon monoxide (CO) is a colorless, odorless, toxic gas that results from incomplete combustion of fossil fuels like natural or liquefied petroleum gas, oil, wood, and coal. Toxic effects of CO exposure are nonspecific symptoms like headache, dizziness, nausea and disorientation with unconsciousness and death at higher levels. An increase in CO poisoning was detected in Florida during the 2004-2005 hurricane season prompting a review of available records over a longer time frame. An initial review of the mortality and morbidity data in Florida was conducted. The most severe cases of CO poisoning were examined, those case which resulted in hospitalization and/or death.

Methods

Morbidity cases were identified using the *International Classification of Disease 9th Revision* (ICD-9-CM) codes and mortality cases were identified using *International Classification of Disease 10th Revision* (ICD-10) codes (Table 1). Morbidity data was obtained from the Florida Agency for Health Care Administration (AHCA) which collects data on all patients hospitalized in Florida. A record was defined as a case if one the ICD-9-CM code was found within the primary or secondary diagnosis fields. Specific information about location of injury and/or source of poisoning was extracted using ICD-9-CM external cause of injury codes (ecodes). Death Certificate data was obtained from the Florida Vital Statistics database. Records were defined as a case if the ICD-10 code T58 was listed as the cause or contributing cause of death. Specific information about location of death and source of exposure was obtained from variables on the death certificate. Rates were calculated using annual demographic population estimates from the Florida Legislature's Office of Economic and Demographic Research. Case fatality rates were calculated as the number of CO deaths divided by the sum of CO deaths and CO hospitalizations multiplied by 100.

Table 1. CSTE definition for confirmed and probable cases of CO poisoning using hospitalization discharge data

	ICD-9-CM	Definition
Confirmed	986	Toxic effect of CO
	E868.3	Accidental CO poisoning from incomplete combustion of other domestic fuels
	E868.8	Accidental CO poisoning from other sources
	E868.9	Unspecified CO
	E952.1	Suicide and self-inflicted poisoning by CO
	E982.1	Poisoning by CO, undetermined whether accidental or purposely inflicted
Probable	E868.2	Accidental poisoning from motor vehicle exhaust
	E952.0	Suicide and self-inflicted poisoning by motor vehicle exhaust
	E982.0	Poisoning by motor vehicle exhaust, undetermined whether accidental or purposely inflicted
	ICD-10	Definition
Confirmed	T58	Toxic effect of CO

Mortality and morbidity data were obtained for the years 1999 to 2006. Extracted records for CO poisoning were identified as intentional (suicide or homicide), unintentional (fire related or non-fire related), or of undetermined intent based on ICD-9-CM or ICD-10 coding categories. Within these categories the following demographic information was summarized: age group (0-14, 15-24 … 65-74, 75-84, 85 plus), sex, and race (white, black, other, unknown).

Results

Between 1999 and 2006, 1,266 Florida residents were hospitalized with carbon monoxide poisoning. Of these hospitalizations 39.0 percent (494) were categorized as suicide and less than 1 percent (10) as homicide. The remaining 60.2 percent (762) of hospitalizations were due to either unintentional poisoning (Table 2 and 3) or poisoning of undetermined intent (Table 4). During the same time period 1,239 Florida residents died with CO listed as a contributing cause of death. Of these deaths 61.0 percent (756) were due to suicide attempts and 1.9 percent (23) were due to homicide. The other 37.1 percent (460) of deaths were due to either unintentional poisoning or poisoning of undetermined intent.

Table 2. Estimated annual number, percentage, and rate with 95 percent confidence interval of persons with nonfatal and fatal unintentional fire *related* carbon monoxide (CO) exposures, by selected characteristics (Florida, 1999 -2006)

	Nonfatal (n = 111)				Fatal (n = 205)				
Characteristic	average no. of hospitalizations per year	(%)	Rate (per 100,000)	(95% CI)	average no. of deaths per year	(%)	Rate (per 100,000)	(95% CI)	CFR*
Age group (yrs)									
0-14	1.8	12.6	0.06	(0.03 - 0.08)	4.8	18.5	0.15	(0.1 - 0.2)	73.1
15-24	0.9	6.3	0.04	(0.01 - 0.07)	2.8	10.7	0.13	(0.07 - 0.18)	75.9
25-34	2.5	18.0	0.12	(0.07 - 0.17)	2.4	9.3	0.11	(0.06 - 0.16)	49.7
35-44	2.4	17.1	0.09	(0.05 - 0.14)	3.9	15.1	0.15	(0.1 - 0.21)	62.0
45-54	2.5	18.0	0.11	(0.06 - 0.16)	4.3	16.6	0.18	(0.12 - 0.25)	63.0
55-64	1.4	9.9	0.08	(0.03 - 0.12)	2.6	10.2	0.15	(0.08 - 0.21)	65.6
65-74	1.0	7.2	0.07	(0.02 - 0.11)	2.0	7.8	0.13	(0.07 - 0.2)	66.7
75-84	1.0	7.2	0.09	(0.03 - 0.15)	2.1	8.3	0.19	(0.1 - 0.29)	68.0
85 plus	0.5	3.6	0.13	(0 - 0.26)	0.9	3.4	0.23	(0.06 - 0.4)	63.6
Sex									
Male	8.0	57.7	0.10	(0.07 - 0.12)	16.3	63.4	0.20	(0.16 - 0.23)	67.0
Female	5.9	42.3	0.07	(0.05 - 0.09)	9.4	36.6	0.11	(0.08 - 0.13)	61.5
Race									
White	8.5	61.3	0.06	(0.05 - 0.08)	18.4	71.7	0.13	(0.11 - 0.15)	68.4
Black	4.3	30.6	0.16	(0.1 - 0.21)	6.8	26.3	0.25	(0.18 - 0.32)	61.4
Other	0.6	4.5	0.15	(0.02 - 0.27)	0.5	2.0	0.12	(0 - 0.23)	44.4
Unknown	0.5	3.6	---	---	0.0	0.0	---	---	0.0
Total	13.9	100.0	0.08	(0.07 - 0.1)	25.6	100.0	0.15	(0.13 - 0.17)	64.9

*Number of fatalities divided by the sum of hospitalizations and fatalities multiplied by 100

Table 3. Estimated annual number, percentage, and rate with 95 percent confidence interval of persons with nonfatal and fatal unintentional *non-fire related* carbon monoxide (CO) exposures, by selected characteristics (Florida, 1999 -2006)

	Nonfatal (n = 436)				Fatal (n = 230)				
Characteristic	average no. of hospitalizations per year	(%)	Rate (per 100,000)	(95% CI)	average no. of deaths per year	(%)	Rate (per 100,000)	(95% CI)	CFR*
Age group (yrs)									
0-14	6.8	12.4	0.21	(0.16 - 0.27)	2.0	7.3	0.06	(0.03 - 0.09)	22.9
15-24	5.8	10.6	0.27	(0.19 - 0.36)	2.6	9.5	0.12	(0.07 - 0.18)	31.3
25-34	4.0	7.4	0.19	(0.12 - 0.25)	2.8	10.0	0.13	(0.08 - 0.18)	40.7
35-44	9.1	16.8	0.36	(0.28 - 0.45)	4.0	14.5	0.16	(0.1 - 0.21)	30.5
45-54	9.5	17.5	0.41	(0.32 - 0.51)	4.1	15.0	0.18	(0.12 - 0.24)	30.3
55-64	7.0	12.9	0.39	(0.29 - 0.49)	2.8	10.0	0.15	(0.09 - 0.22)	28.2
65-74	4.8	8.7	0.32	(0.22 - 0.42)	3.3	11.8	0.22	(0.13 - 0.3)	40.6
75-84	6.0	11.0	0.55	(0.39 - 0.7)	3.5	12.7	0.32	(0.2 - 0.44)	36.8
85 plus	1.5	2.8	0.40	(0.17 - 0.62)	2.5	9.1	0.66	(0.37 - 0.95)	62.5
Sex									
Male	31.3	57.4	0.38	(0.33 - 0.42)	17.8	64.5	0.21	(0.18 - 0.25)	36.2
Female	23.1	42.5	0.27	(0.23 - 0.3)	9.8	35.5	0.11	(0.09 - 0.14)	29.7
Race									
White	40.0	73.5	0.29	(0.26 - 0.32)	23.9	86.8	0.17	(0.15 - 0.2)	37.4
Black	12.4	22.7	0.46	(0.37 - 0.55)	2.9	10.5	0.11	(0.06 - 0.15)	18.9
Other	1.3	2.3	0.29	(0.11 - 0.47)	0.8	2.7	0.17	(0.03 - 0.31)	37.5
Unknown	0.8	1.4	---	---	0.0	0.0	---	---	0.0
Total	54.4	100.0	0.32	(0.29 - 0.35)	27.5	100.0	0.16	(0.14 - 0.18)	33.6

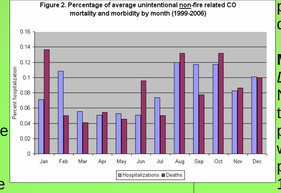
*Number of fatalities divided by the sum of hospitalizations and fatalities multiplied by 100

Unintentional CO poisoning is almost entirely preventable. The remainder of this of this poster will focus on characterizing the mortality and morbidity of CO poisoning of unintentional or undetermined intent.

Morbidity (non-intentional poisoning)

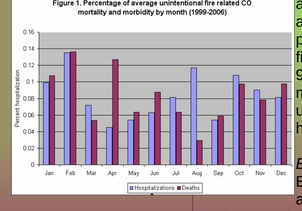
Demographics

CO poisoning of undetermined intent was attributed to 28.3 percent (216) of cases, 14.6 percent (111) of cases were fire related, and 57.1 percent (435) of cases were non-fire related. The demographics of the three groups were somewhat different. Blacks, who comprise 16 percent of the Florida population, were disproportionably affected by CO poisoning for all three categories with the largest difference found in fire related CO poisonings. Minorities of other races comprise 3 percent of all Floridians and were also disproportionably affected by CO poisoning due to non-fire related and fire related poisonings.



Place of Exposure

Place associated with CO poisoning exposure (defined by the ICD-9-CM ecode E849) was not uniformly recorded; 45.9 percent (51) of fire related cases contained place information, while 30.1 percent (131) of non-fire related cases and 6.9 percent (15) of CO poisoning of undetermined intent contained any place information. Of those fire related cases which contained place information, 96.1 percent (49) occurred within the home. For non-fire related cases, 69.5 percent (91) occurred within the home, while 9.2 percent (12) occurred at an industrial place or premise. The majority (60.0%) of CO poisoning of undetermined intent also occurred at home.



Exposure situation and cause

Ecode with information about the cause and situation of CO exposure was included in the hospitalization data for 88.3 percent (384) of all non-fire related CO poisonings. Of these 384 records, 29.9 percent (115) were from motor vehicle exhaust fumes, while 32.6 percent (125) of cases were from a source other than motor vehicle, utility gas, liquid petroleum, or combustion of domestic fuels.

Year and month chronology

Average number of hospitalizations by month looks similar between the three categories (fire related, non-fire related, and undetermined intent), however, the peaks are different (Figure 1-3). The number of hospitalizations for fire related poisonings and poisonings of undetermined intent do not appear to be affected by natural disasters. Non-fire related CO poisoning, on the other hand, was higher during active hurricane years (Figure 4).

Table 4. Estimated annual number, percentage, and rate with 95 percent confidence interval of persons with nonfatal and fatal carbon monoxide (CO) exposures of undetermined intent, by selected characteristics (Florida, 1999 -2006)**

	Nonfatal (n = 216)				Fatal (n = 30)				
Characteristic	average no. of hospitalizations per year	(%)	Rate (per 100,000)	(95% CI)	average no. of deaths per year	(%)	Rate (per 100,000)	(95% CI)	CFR*
Age group (yrs)									
0-14	2.0	2.1	0.06	(0.03 - 0.09)	0.1	0.2	---	---	5.9
15-24	1.5	1.6	0.07	(0.03 - 0.11)	0.1	0.2	---	---	7.7
25-34	2.8	2.9	0.13	(0.08 - 0.18)	0.4	0.7	---	---	12.0
35-44	4.6	4.9	0.18	(0.12 - 0.24)	0.8	1.3	0.03	(0.01 - 0.05)	14.0
45-54	5.3	5.5	0.23	(0.16 - 0.3)	0.6	1.1	0.03	(0 - 0.05)	10.6
55-64	2.9	3.0	0.16	(0.09 - 0.22)	0.8	1.3	0.04	(0.01 - 0.07)	20.7
65-74	3.3	3.4	0.22	(0.13 - 0.3)	0.1	0.2	---	---	3.7
75-84	3.4	3.5	0.31	(0.19 - 0.42)	0.5	0.9	0.05	(0 - 0.09)	12.9
85 plus	1.4	1.4	0.36	(0.15 - 0.56)	0.4	0.7	---	---	21.4
Sex									
Male	14.0	14.7	0.17	(0.14 - 0.2)	2.5	4.3	0.03	(0.02 - 0.04)	15.2
Female	13.0	13.6	0.15	(0.12 - 0.18)	1.3	2.2	0.01	(0.01 - 0.02)	8.8
Race									
White	21.6	22.7	0.16	(0.13 - 0.18)	3.4	5.9	0.02	(0.02 - 0.03)	13.5
Black	4.6	4.9	0.17	(0.12 - 0.23)	0.3	0.4	---	---	5.1
Other	0.4	0.4	0.09	(-0.01 - 0.19)	0.1	0.2	---	---	26.0
Unknown	0.4	0.4	---	---	0.0	0	---	---	0.0
Total	27.0	28.3	0.16	(0.14 - 0.18)	3.8	6.5	0.02	(0.01 - 0.03)	12.2

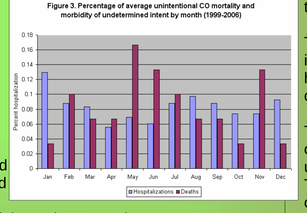
*Number of fatalities divided by the sum of hospitalizations and fatalities multiplied by 100

**Rates and confidence intervals were not calculated where the total number of cases was less than 4

Mortality (non-intentional poisoning)

Demographics

Nearly half of all CO poisoning deaths (47.8 percent, 460) were attributed to fire. For all deaths, 44.6 percent (205) were non-fire related while 6.5 percent (30) were of undetermined intent. Blacks had 1.9 times the rate of whites for fire related CO poisoning. However, among non-fire related CO poisoning deaths, whites had a rate 1.6 times the rate of blacks. In addition, whites had a higher case fatality rate (CFR) than blacks among all categories.



Place of Exposure

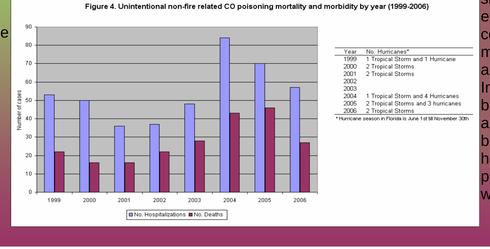
CO poisoning exposure that resulted in death occurred most frequently in the home; 94.6 percent (194) for fire related exposure, 71.0 percent (154) for non-fire related exposure, and 96.7 percent (29) for exposure of undetermined intent. The other main exposure location for non-fire related deaths was the street and/or highway (11.1%, 24).

Exposure cause and situation

Notes related to cause and situation of death for CO exposure were included in the death certificate for 35.1 percent (72) of all unintentional non-fire related CO poisoning deaths. Vehicle exhaust fumes were listed in 37.5 percent (27) of death certificates with notes, while generator related exposure accounted for 20.8 percent (15) of deaths. For CO poisoning deaths of undetermined intent, 16.7 percent (5) contained notes on exposure. The majority (3) of which were exposed to toxic levels of CO within an enclosed space.

Year and Month Chronology

Average number of fatalities by month appears quite different among the three categories (Figure 1-3). Non-fire related poisonings appear to be higher in years with an active hurricane season (Figure 4), while poisoning of undetermined intent and fire related poisoning do not seem to be affected.



Conclusion

The disease burden of CO poisoning in Florida is mostly unexplored, except for a few studies examining CO exposure during specific hurricane seasons. In the past Florida has focused its prevention message on generator usage during hurricane related power outages. Surprisingly, this descriptive analysis noted a large number of poisonings which occur during the winter months (not during hurricane season). This is not to downplay the effect of hurricane related poisonings. The frequency for non-fire related poisonings was highest in 2004 and 2005 when 5 hurricanes per year hit the state.

While this study shows a number of cases related to motor vehicle exhaust fumes and deaths related to generator exposure, information on exposure source was very limited. For instance, it is difficult to determine from this analysis if boat related CO poisoning is a problem in Florida and if prevention funds should be concentrated in this area.

The analysis was limited to severe CO poisoning. Acute CO poisoning cases were not include – those individuals who were seen only in the emergency department but not hospitalized or those cases seen in an outpatient setting. Individuals who did not seek care were also not included.

There are differences between CO poisoning morbidity versus mortality among each of the three categories (unintentional fire related, non-fire related, and poisoning of undetermined intent) for the characteristics examined (age groups, sex and race). There are also differences in characteristics between the three categories regardless of mortality and morbidity. Since this is the case for severe poisoning, an analysis examining acute CO poisoning using the emergency department data and poison control call center data would be beneficial in characterizing Floridians affected by CO poisoning. However, to obtain a complete picture, more information on the cause and situations involving CO exposure is needed. This could be done through medical record abstraction and/or patient interviews. In addition, an ethnicity breakdown of cases should also be completed as it has been shown that Hispanics have a higher rate of CO poisoning treatment than white non-Hispanics.

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