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# Incidence of Severe Unintentional Carbon Monoxide Poisoning Differs Across Racial/Ethnic Categories

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**SYNOPSIS**

**Objective.** This study was conducted to test the hypothesis that the incidence of severe, acute, unintentional carbon monoxide (CO) poisoning differs across racial/ethnic categories.

**Methods.** The authors retrospectively reviewed medical records of all Washington State residents treated with hyperbaric oxygen for severe, acute, unintentional CO poisoning from December 1, 1987, through February 28, 1997.

**Results.** Among 586 Washington State residents treated with hyperbaric oxygen for severe, acute, unintentional CO poisoning, racial/ethnic designations could be determined from record review for 530 (90%). The black and Hispanic white populations of Washington State had higher relative risks for severe, acute, unintentional CO poisoning than the non-Hispanic white population. The most common sources of CO poisoning differed by racial/ethnic category.

**Conclusions.** Members of certain groups in Washington State are at higher risk for severe, unintentional CO poisoning. Public education programs regarding CO exposure should be targeted to populations at risk.

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Carbon monoxide (CO) poisoning is a significant health problem in the United States. It is the most common cause of poisoning death in the country, accounting for approximately 1100 accidental and 2500 intentional deaths annually.[1] Morbidity from CO poisoning is also significant, with an estimated 40,000 emergency department visits for the condition each year.[2]

A number of reports have suggested that some types of CO poisoning may be more common among members of minority "racial"/ethnic groups than among the non-Hispanic white US population.[1,3–7] Some of these studies, however, have had methodological limitations preventing calculation of the relative risk for poisoning for specific minority groups. The present study was designed to carefully examine the relationship of racial/ethnic categories and risk for severe unintentional CO poisoning. In a 1991 article, Cobb and Etzel proposed that accidental CO poisoning can be prevented through public education programs.[1] In order to target disease prevention programs effectively, it is necessary to accurately define the population at risk and the specific practices that put people at risk.

## METHODS

We retrospectively reviewed medical records of Washington State residents of all ages treated with hyperbaric oxygen ($HBO_2$) for acute unintentional CO poisoning from December 1, 1987, through February 28, 1997. We defined a case as the appearance of any symptom consistent with poisoning and an elevated carboxyhemoglobin (COHb) level (>2.0% for nonsmokers and >9.0% for smokers[8]) in a patient referred for $HBO_2$ therapy who had a history of unintentional CO exposure. Symptoms consistent with CO poisoning are headache, nausea, vomiting, dizziness, and loss of consciousness. Only the most severely poisoned patients are typically referred for $HBO_2$ treatment.[9]

During the approximately nine-year period reviewed, 586 Washington State residents were treated with $HBO_2$ for unintentional CO poisoning. We collected data from all three hyperbaric treatment facilities operational in the state during those years. The largest number of cases (526) were from Virginia Mason Medical Center in Seattle, 44 were from Fairchild Air Force Base in Spokane, and two were from Kadlec Medical Center in Richland. We also included data on 14 Washington State residents who were referred across the state border for hyperbaric treatment at Providence Medical Center in Portland, Oregon.

We obtained information on individual cases by reviewing emergency and hyperbaric department records. Data abstracted about each case included the documented patient age, gender, smoking status, racial/ethnic category, county of residence, and source of exposure. We used US Census racial/ethnic categories[10] to classify patients as Asian, black, American Indian, Hispanic white, non-Hispanic white, or "other race." "Other race" is the US Census category for individuals who are not Asian/Pacific Islander, black, American Indian, Eskimo, Aleut, or white.

For analyses involving racial categorization, we included only those cases in which the patient's racial/ethnic category was clearly identified in the medical record. In the majority of cases, the racial/ethnic category was identified on the emergency department admitting demographic sheet. Otherwise, we used the racial/ethnic category documented in a physician or nursing note. A racial/ethnic category was determined from medical record review for 530 (90%) of the 586 patients referred for hyperbaric treatment.

We categorized sources of carbon monoxide as charcoal briquettes, motor vehicle exhaust, fire, gasoline-powered electrical generator, forklift, boat, furnace, other gasoline-powered engine, space heater, or "other/unknown."

We obtained population counts by racial/ethnic category and county population totals for Washington State from the 1990 US Census.[11] We used 1990 data because 1990 fell within the time encompassed by the study and these data are the most accurate available with regard to "race"/ethnicity for the period studied.

We calculated mortality rates as the number of cases observed during the 9.25-year interval divided by 9.25 times the population. We calculated the relative risks of severe, acute, unintentional CO poisoning for racial/ethnic categories using logistic regression and used Wald tests to assess the differences in risk between the non-Hispanic white population and each of the other groups. We then used Fisher's exact test to analyze the racial/ethnic distribution of poisoned patients by source of CO and used chi-square tests to analyze the gender and age distributions of poisoned patients by source of CO.

## RESULTS

A total of 586 Washington State residents were treated with $HBO_2$ for severe, acute, unintentional CO poisoning from December 1987 through February 1997. In an earlier study, present author NBH found that approximately

10% of people seen in emergency departments for CO poisoning in Washington State were treated with $HBO_2$ in 1994.[2] In the present investigation, we found that the number of individuals per county treated for severe, acute, unintentional poisoning was linearly related to the 1990 county population ($r = 0.980$).[11] This suggests that referral bias on the basis of distance from a hyperbaric treatment facility was unlikely and that geographic differences in "racial"/ethnic population distributions were unlikely to have influenced the present findings.

The mean COHb level in the study population was 21.4% (standard deviation 11.1%).

Table 1 shows the breakdown of the CO-poisoned group into racial/ethnic categories in comparison to the breakdown in the general state population. Also shown is the relative risk for CO poisoning by racial/ethnic category, with non-Hispanic white patients as the reference group.

Certain groups had higher incidences of severe, acute, unintentional CO poisoning. Using the non-Hispanic white population of Washington State as the reference group, the Hispanic white population had a relative risk of 3.96 ($P < 0.001$) and the black population had a relative risk of 2.91 ($P < 0.001$).

Age and gender distributions by racial/ethnic categories are shown in Table 2. Hispanic white patients had the lowest mean age (23 ± 16 years), while Asian Americans had the highest mean age (41 ± 21 years). The gender distribution differed by racial/ethnic category ($P = 0.002$, Fisher's exact test). Non-Hispanic white males outnumbered non-Hispanic white females by a 2:1 ratio (252:126). Among Hispanic white patients, there were more males than females, while among black patients there were more females than males.

Sources of CO poisoning are shown in Table 3 by racial/ethnic category, not adjusted for age and gender. Charcoal briquettes were the most common source of poisoning for the 530 patients for whom a racial/ethnic designation was identified. However, Asian, black, and Hispanic white patients accounted for 81/93 (87%) of the charcoal exposures, while representing only 12% of Washington State's population in 1990.[11] Within each of these three racial/ethnic groups, charcoal briquettes were by far the most common source of CO; they were the source for 66.7% of Asian patients, 39.5% of black patients, and 65.8% of Hispanic white patients. All 39 of the boat-associated CO poisonings were among non-Hispanic white patients.

**Table 1. People treated with $HBO_2$ for severe, acute, unintentional CO poisoning, by racial/ethnic category, Washington State, 12/1/87–2/28/97**

| | *Washington state population* n = 4,866,692 | | *Patients treated with $HBO_2$ for severe CO poisoning* n = 530 | | | | | |
|---|---|---|---|---|---|---|---|---|
| *Racial/ethnic category* | *Number* | *Percent* | *Number* | *Percent* | *Incidence rate per 100,000 person-years* | *Relative risk* | *95% CI* | *P-value* |
| Non-Hispanic white | 4,221,622 | 86.7 | 378 | 71.3 | 0.97 | 1.00 | — | — |
| Hispanic white | 214,570 | 4.4 | 76 | 14.3 | 3.83 | 3.96 | 3.09, 5.06 | <0.0001 |
| Asian | 203,668 | 4.2 | 24 | 4.5 | 1.28 | 1.32 | 0.87, 1.99 | 0.1920 |
| Black | 146,000 | 3.0 | 38 | 7.2 | 2.81 | 2.91 | 2.08, 4.06 | <0.0001 |
| American Indian | 76,397 | 1.6 | 5 | 0.9 | 0.70 | 0.73 | 0.30, 1.77 | 0.4863 |
| "Other race"[a] | 4,435 | 0.1 | 9 | 1.7 | 21.94 | 22.7 | 11.7, 44.0 | <0.0001 |

NOTE: Percentages may not add to 100% due to rounding errors. Severe CO poisoning was defined as any symptoms consistent with CO poisoning and an elevated carboxyhemoglobin level (>2.0% for nonsmokers and >9.0% for smokers) in a patient referred for $HBO_2$ treatment with a history of unintentional CO exposure.

[a]"Other race" is the US Census category for individuals who are not Asian/Pacific Islander, black, American Indian, Eskimo, Aleut, or white.[10]

$HBO_2$ = hyperbaric oxygen

CO = carbon monoxide

**Table 2. Age and gender distribution of people treated with $HBO_2$ for severe, acute, unintentional CO poisoning, by racial/ethnic categories, Washington State, 12/1/87–2/28/97**

| *Racial/ethnic category* | *Number* | *Mean age (years)* | *Standard deviation* | *Male/female ratio* |
|---|---|---|---|---|
| Non-Hispanic white | 378 | 34 | ±20 | 252/126 |
| Hispanic white | 76 | 23 | ±16 | 43/33 |
| Asian | 24 | 41 | ±21 | 12/12 |
| Black | 38 | 26 | ±20 | 15/23 |
| American Indian | 5 | 17 | ±18 | 5/0 |
| "Other race"[a] | 9 | 29 | ±14 | 4/5 |

NOTE: Percentages may not add to 100% due to rounding errors. Severe CO poisoning was defined as any symptoms consistent with CO poisoning and an elevated carboxyhemoglobin level (>2.0% for nonsmokers and >9.0% for smokers) in a patient referred for $HBO_2$ treatment with a history of unintentional CO exposure.

[a]"Other race" is the US Census category for individuals who are not Asian/Pacific Islander, black, American Indian, Eskimo, Aleut, or white.[10]

$HBO_2$ = hyperbaric oxygen

CO = carbon monoxide

**Table 3. Source of severe, acute, unintentional CO poisoning, by racial/ethnic category, Washington State, 2/1/87–2/28/97**

| | | *Racial/ethnic category* | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | *Non-Hispanic white* | | *Hispanic white* | | *Asian* | | *Black* | | *American Indian* | | *"Other race"[a]* | | |
| *Source* | *Number* | *Number* | *Percent* | *Number* | *Percent* | *Number* | *Percent* | *Number* | *Percent* | *Number* | *Percent* | *Number* | *Percent* | *P-value[b]* |
| Charcoal briquettes | 93 | 11 | 2.91 | 50 | 65.8 | 16 | 66.7 | 15 | 39.5 | 0 | 0 | 1 | 11.1 | <0.0001 |
| Motor vehicles | 88 | 70 | 18.5 | 10 | 13.2 | 1 | 4.2 | 5 | 13.3 | 2 | 40.0 | 0 | 0 | 0.1410 |
| Fire | 62 | 53 | 14.0 | 1 | 1.3 | 0 | 0 | 7 | 18.4 | 1 | 20.0 | 0 | 0 | 0.0011 |
| Generator | 48 | 39 | 10.3 | 4 | 5.3 | 1 | 4.2 | 2 | 5.3 | 2 | 40.0 | 0 | 0 | 0.1470 |
| Forklift | 40 | 35 | 9.3 | 4 | 5.3 | 1 | 4.2 | 0 | 0 | 0 | 0 | 0 | 0 | 0.3070 |
| Boat | 39 | 39 | 10.3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0023 |
| Furnace | 39 | 35 | 9.3 | 0 | 0 | 1 | 4.2 | 3 | 7.9 | 0 | 0 | 0 | 0 | 0.0420 |
| Other gas engines | 33 | 26 | 6.9 | 4 | 5.3 | 1 | 4.2 | 1 | 2.6 | 0 | 0 | 1 | 11.1 | 0.8210 |
| Space heaters | 20 | 20 | 5.3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.1880 |
| Other/unknown | 68 | 50 | 13.2 | 3 | 4.0 | 3 | 12.5 | 5 | 13.2 | 0 | 0 | 7 | 77.8 | <0.0001 |
| Total | 530 | 378 | 100.0 | 76 | 100.0 | 24 | 100.0 | 38 | 100.0 | 5 | 100.0 | 9 | 100.0 | |

NOTE: Percentages may not add to 100% due to rounding errors.

[a]"Other race" is the US Census category for individuals who are not Asian/Pacific Islander, black, American Indian, Eskimo, Aleut, or white.[10]

[b]Fisher's Exact Test

**Table 4. Gender distribution of people treated with $HBO_2$ for severe, acute, unintentional CO poisoning, by source of CO poisoning, Washington State, 12/1/87–2/28/97**

| | | Gender | | | | |
|---|---|---|---|---|---|---|
| | | Male | | Female | | |
| Source | Number | Number | Percent | Number | Percent | P-value |
| Charcoal briquettes | 95 | 41 | 43.2 | 54 | 56.8 | <0.001 |
| Motor vehicles | 103 | 81 | 78.6 | 22 | 21.4 | <0.001 |
| Fire | 70 | 46 | 65.7 | 24 | 34.3 | 0.612 |
| Generator | 51 | 23 | 45.1 | 28 | 54.9 | 0.006 |
| Forklift | 40 | 36 | 90.0 | 4 | 10.0 | <0.001 |
| Boat | 50 | 29 | 58.0 | 21 | 42.0 | 0.447 |
| Furnace | 44 | 15 | 34.1 | 29 | 65.9 | <0.001 |
| Other gas engines | 34 | 30 | 88.2 | 4 | 11.8 | 0.002 |
| Space heaters | 20 | 17 | 85.0 | 3 | 15.0 | 0.638 |
| Other/unknown | 79 | 51 | 64.6 | 28 | 35.4 | 0.753 |
| Total | 586 | 369 | 63.0 | 217 | 37.0 | |

Table 4 shows the gender distribution of patients by CO source, and Table 5 shows the age distribution by CO source. Females predominated in charcoal and furnace poisonings, while most CO exposures related to motor vehicles and forklifts occurred among males. More than 40% of poisonings from charcoal briquettes and motor vehicles occurred among the youngest quartile of patients (<19 years old).

## DISCUSSION

This study shows a heightened risk for severe, acute, unintentional CO poisoning among certain "racial"/ethnic groups in Washington State and a difference across groups in typical sources of CO.

Socioeconomic differences may have played a role in the distribution of CO sources; however,

**Table 5. Age distribution of people treated with $HBO_2$ for severe, acute, unintentional CO poisoning, by source of CO poisoning, Washington State, 2/1/87–2/28/97**

| | | Age category | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | <19 | | 19–31 | | 32–43 | | >43 | | |
| Source | Number | Number | Percent | Number | Percent | Number | Percent | Number | Percent | P-value |
| Charcoal briquettes | 95 | 40 | 42.1 | 31 | 32.6 | 15 | 15.8 | 9 | 9.5 | <0.001 |
| Motor vehicles | 103 | 44 | 42.7 | 18 | 17.5 | 17 | 16.5 | 24 | 23.3 | <0.001 |
| Fire | 70 | 16 | 22.9 | 17 | 24.3 | 16 | 22.9 | 21 | 30.0 | 0.856 |
| Generator | 51 | 10 | 19.6 | 8 | 15.7 | 13 | 25.5 | 20 | 39.2 | 0.081 |
| Forklift | 40 | 0 | 0 | 17 | 42.5 | 16 | 40.0 | 7 | 17.5 | <0.001 |
| Boat | 50 | 8 | 16.0 | 10 | 20.0 | 8 | 16.0 | 24 | 48.0 | 0.003 |
| Furnace | 44 | 14 | 31.8 | 12 | 27.3 | 8 | 18.2 | 10 | 22.7 | 0.682 |
| Other gas engines | 34 | 3 | 8.8 | 6 | 17.6 | 14 | 41.2 | 11 | 32.4 | 0.016 |
| Space heaters | 20 | 1 | 5.0 | 3 | 15.0 | 8 | 40.0 | 8 | 40.0 | 0.039 |
| Other/unknown | 79 | 14 | 17.7 | 26 | 32.9 | 21 | 26.6 | 18 | 22.8 | 0.163 |
| Total | 586 | 150 | | 148 | | 136 | | 152 | | |

NOTE: Percentages may not add to 100% due to rounding errors.

socioeconomic data were not available for the study population.

If members of minority groups have poorer access to health care than the non-Hispanic white population, they may have less access to HBO2 treatment. However, we found higher rates of treatment for CO poisoning for black and Hispanic white residents of Washington State; thus, preferential referral of non-Hispanic white, Asian, or American Indian patients for medical treatment does not appear to explain the differences in treatment rates.

Cultural practices may explain the variation in typical sources of CO poisoning. About two-thirds of CO poisonings among both Asian and Hispanic white patients were due to indoor burning of charcoal briquettes. In an earlier study, present author NBH found that charcoal was a common source of poisoning among Asian and Hispanic white Americans,[12] perhaps due at least in part to a continuation by recent immigrants of practices common in their homelands.[13]

Most cases of CO poisoning related to forklifts occurred among non-Hispanic white patients. Forklift cases are typically occupational exposures. All poisonings onboard boats were among non-Hispanic white patients, as were all poisonings by space heater.

In summary, this study demonstrates a significantly elevated risk for CO poisoning for members of certain minority groups in the state of Washington. In addition, the sources of CO differed across groups. Public awareness programs regarding CO exposure should take these findings into account in order to target education to populations at greatest risk and to educate people about relevant sources of CO.

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