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Original Contributions

EMERGENCY DEPARTMENT VISITS FOR CARBON MONOXIDE POISONING IN THE PACIFIC NORTHWEST

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□ **Abstract—This study was conducted to determine the annual number of emergency department (ED) visits and rate of hyperbaric oxygen (HBO_2) treatment for carbon monoxide (CO) poisoning in Washington, Idaho, and Montana. All hospital emergency departments and hyperbaric treatment facilities in the region were surveyed by mail and telephone regarding their patient treatment experience for calendar year 1994. Results demonstrated that there were approximately 2.51 million total ED visits in 1994 in the three states studied. Among these, an estimated 1,325 individuals were seen with carbon monoxide poisoning (52.9 CO cases per 100,000 ED visits; 18.1 CO cases per 100,000 population). A total of 91 patients were treated with HBO_2, yielding an HBO_2 treatment rate of 6.9% of those evaluated in EDs. Extrapolating these figures to the US population suggests that the number of individuals seeking emergency medical care for CO poisoning is much greater than is commonly quoted. Even after correcting for the known increased rate of CO poisoning in the Pacific Northwest, the incidence of nonfatal poisoning appears to be significantly higher than may be appreciated from previous reports.**

□ **Keywords—carbon monoxide; poisoning; emergency department; hyperbaric oxygen**

INTRODUCTION

Accidental carbon monoxide (CO) poisoning is extremely common in the United States. The significance of this form of poisoning as a cause of death is repeatedly emphasized in the medical literature (1,2). Approximately 1,000 deaths occurred annually from accidental CO poisoning in the United States from 1979 to 1988 (1).

Data on nonfatal CO poisoning are more difficult to obtain. The National Electronic Injury Surveillance System (NEISS) of the United States Consumer Product Safety Commission (CPSC) tracks emergency department (ED) visits for injuries associated with consumer products or recreational activities in a probability sample of 91 hospitals. This tracking system includes injuries from CO poisoning. The NEISS estimates that 5,900 individuals were treated in hospital EDs in 1995 for non-fire-related CO poisoning associated with the use of household appliances (3). This estimate, however, does not include cases due to occupational exposure or those associated with motor vehicles. The significance of such sources of CO poisoning cannot be underestimated, as they may be responsible for a significant proportion of CO-related injuries. In the case of motor vehicles, for example, it has been reported that automobiles are responsible for a majority of accidental CO poisoning deaths in the United States (1).

It is commonly reported in the medical literature that there are 10,000 cases of CO poisoning annually in the United States sufficiently severe to cause afflicted individuals to seek medical attention or to lose one or more days of normal activity. This estimate, however, was originally published in the medical literature in 1974 and

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Table 1. 1994 Emergency Department Visits (Total and for CO Poisoning) for Washington, Idaho, and Montana

State	Population*	Total ED Visits	ED Visits for CO	ED Visit Rate for CO (per 100,000 population)
Washington	5,343,000	1,806,531	725	13.6
Idaho	1,133,000	358,388	254	22.4
Montana	856,000	340,609	346	40.4

* Population data from Reference 5.

may be outdated (4). The present study was designed to investigate the current number of annual ED visits for CO poisoning in the Pacific Northwest, and to attempt to derive a national estimate of ED visits from the results.

MATERIALS AND METHODS

All 178 hospital emergency departments in the states of Washington, Idaho, and Montana were surveyed by mail in early 1995 with regard to their patient experience for the preceding calendar year. They were questioned about the total number of patients evaluated in their department in 1994 and asked to estimate the number of patients seen with acute carbon monoxide poisoning. A repeat mailing and subsequent telephone contacts (up to three) were performed as necessary to achieve a 100% response rate. Details of individual patient illnesses (etiology of poisoning with regard to intent or source of CO, laboratory values, outcome, etc.) were not collected.

Hyperbaric oxygen (HBO_2) treatment facilities in Washington, Idaho, and Montana were contacted by telephone to determine the number of patients poisoned with CO within the three states in 1994 who were treated with HBO_2. Because patients could have been referred for HBO_2 therapy to a nearer facility out of state, hyperbaric treatment centers located in contiguous states and Canadian provinces were also surveyed with regard to their experience treating patients poisoned within Washington, Idaho, and Montana in that year.

United States Bureau of the Census data were utilized to obtain the 1994 population base for states (5).

Estimation of the number of ED visits for CO poisoning within the entire United States was performed by extrapolating the number in the three state region to the 50 states and District of Columbia utilizing Bureau of the Census 1994 population data. The number was corrected for the known increased rate of CO poisoning in the Pacific Northwest by utilizing previously published data on age-adjusted death rates from accidental CO poisoning in the three states (1).

The number of patients poisoned with CO and treated with HBO_2 was divided by the number of patients evaluated in EDs for CO poisoning to determine the HBO_2 treatment rate.

RESULTS

Data were received from all 178 hospital emergency departments in the region studied (91 in Washington, 38 in Idaho, and 49 in Montana). In calendar year 1994, a total of 2,505,528 ED visits were reported in the three states, of which an estimated 1,325 were for CO poisoning (Table 1). The rate of ED evaluation for CO poisoning was 13.6 per 100,000 population in Washington, 22.4 per 100,000 in Idaho, and 40.4 per 100,000 in Montana.

Extrapolation of these figures to the entire United States was performed by the method described above. In 1994, the population of the three states studied was 7,332,000, and 253,009,000 in the other 47 states plus the District of Columbia (DC). Multiplying 1,325/7,332,000 times 253,009,000 projects 45,722 ED visits for the 47 states and DC. Adjustment for the fact that CO poisoning is slightly more common in the Pacific Northwest than the rest of the country was done by utilizing data for age adjusted CO death rates in the states as a correction factor (0.55 deaths per 100,000 in Washington, Idaho and Montana; 0.50 per 100,000 in the remaining states) (1). Multiplying 45,722 by 0.50/0.55 yields an estimated 41,565 annual ED visits in the states not surveyed. Adding this estimate to the data from the three states surveyed yields an estimated 42,890 total ED visits for CO poisoning in 1994 and a national ED visit rate for CO poisoning of 16.5 per 100,000 population.

In the same year, 91 patients poisoned with CO within the states of Washington, Idaho, and Montana were treated with HBO_2 (Table 2). Of these, 86 were treated within these three states and 5 referred to hyperbaric treatment facilities outside the states. Dividing 91 patients by the 1,325 total evaluated in EDs yields a regional HBO_2 treatment rate of 6.9%.

Table 2. Patients Poisoned with Carbon Monoxide (CO) in Washington, Idaho, and Montana in 1994 and Treated with Hyperbaric Oxygen (HBO_2)

HBO_2 Treatment Facility	Location of CO Poisoning		
	Washington	Idaho	Montana
Billings, MT	0	0	11
Portland, OR	2	1	0
Salt Lake City, UT	0	1	0
Seattle, WA	71	0	0
Spokane, WA	1	3	0

DISCUSSION

Since the estimate of 10,000 cases annually of nonfatal CO poisoning in the United States was originally published in the medical literature in 1974 (4), it has been referenced repeatedly by investigators in the field of CO poisoning as representative of the significance of the problem in the United States (6–16). In addition to the fact that the estimate is likely outdated, the figure may underestimate the total CO poisoning problem for some of the same reasons that current NEISS estimates do not reflect the total pool of individuals poisoned (see Introduction). Information obtained from one of the surviving authors of the commonly quoted 1974 report reveals that the estimate of 10,000 cases annually in the United States originated from data collected by the Injury Control Program of the Public Health Service in the late 1960s (personal communication with FB Oglesbay, co-author of reference 4). As with current NEISS figures, the 10,000 cases estimate also excluded CO poisoning cases due to motor vehicle or industrial exposures.

The current study demonstrates approximately 1,325 annual ED visits for CO poisoning in a three state region that contains only 2.8% of the US population. Even after accounting for the fact that the Pacific Northwest has a slightly higher rate of CO poisoning than the national average (1), one can extrapolate an estimate in excess of 40,000 annual ED visits in the United States for CO poisoning.

It should be recognized that these figures include only ED visits for recognized CO poisoning. The actual number of cases in the United States annually is likely to be significantly larger for several reasons. First, the signs and symptoms of CO poisoning are nonspecific. Resultant underdiagnosis of CO poisoning is well described and may occur in up to 30–50% of CO poisoned patients presenting to EDs (17–19). Second, not all patients are treated in EDs. Those treated in medical offices or clinics would not be represented in the current estimates, nor would those who die from poisoning before reaching medical attention. Finally, patients may attribute the nonspecific symptoms of CO poisoning (e.g., headache, nausea) to alternate causes such as viral illness, staying home from work or school but not seeking medical evaluation.

No attempt was made in this study to collect information about individual CO poisoning episodes to verify that each reported case was properly diagnosed. The surveys were mailed to ED medical directors and were completed by various ED staff (including medical directors, nurse managers, and administrative staff). Department logs were sometimes reviewed to obtain the information requested, while the data returned were estimates in other instances. Because of concern for this potential source of error, an additional test for validation of the results was sought. If one assumes that the ratio of those individuals dying of CO poisoning to those presenting to EDs with CO poisoning will be similar between states, then interstate relationships for CO visits and deaths should be similar. Relative ED visit rates for CO poisoning among the three states in the present study were Washington 1.00: Idaho 1.65: Montana 2.97 (13.6:22.4: 40.4, respectively, per 100,000 population). This compares to relative age-adjusted accidental CO poisoning death rates of Washington 1.00: Idaho 1.68: Montana 3.05 (0.41:0.69:1.25, respectively, per 100,000; Reference 1). The relationships are remarkably similar, providing support for the validity of the numbers reported. The higher death rate in Montana is typical of that seen in other Rocky Mountain states (1), presumably because high altitude and cold climate increase risk for CO exposure.

It is interesting to note that the current projection of nearly 43,000 annual ED visits in the US for CO poisoning yields a 5.7% national annual treatment rate with hyperbaric oxygen, using as a numerator a previously published figure for HBO_2 treatment of 2,355 CO cases annually in the US (20). As HBO_2 is typically reserved for only the most severely poisoned patients (20), this rate of HBO_2 treatment seems much more reasonable than the 23% rate that would be derived if the 10,000 total annual case estimate were utilized. It should be noted that virtually all patients poisoned severely enough with CO to warrant referral for HBO_2 therapy are initially seen in EDs. Therefore, the regional HBO_2 treatment rate measured in this study (6.9%) and the national treatment rate estimated (5.7%) should not be influenced to any significant degree by patients treated with HBO_2 without being seen in EDs. The similarity of these rates of hyperbaric treatment suggests that there is relatively little variation in application of hyperbaric oxygen therapy for CO poisoning between the states studied and the rest of the country, despite potential differences in the availability of hyperbaric chambers.

There is no doubt that CO poisoning is a significant health problem in the United States. It is hoped that an

enhanced awareness of the true magnitude of the problem will stimulate an increase in public education programs about carbon monoxide. By educating the public about the risk of CO, accidental poisoning may become less frequent.

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