Partnering with a medical specialty society to perform online public health surveillance

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SYNOPSIS

While accidental carbon monoxide (CO) poisoning is common, it is felt to be largely preventable through targeted public education. Development of effective education programs requires accurate epidemiologic information about the condition. Many acute, severe cases of CO poisoning are treated with hyperbaric oxygen (HBO_2) at hospital-based facilities staffed by members of the Undersea and Hyperbaric Medical Society (UHMS).

In 2008, the Centers for Disease Control and Prevention (CDC) began sponsoring a UHMS proposal to use online reporting by UHMS members of cases treated with HBO_2. This report describes development and implementation of the internet-based surveillance system, as well as its first year of operation. From August 2008 to July 2009, a total of 740 cases were reported by the 82 hyperbaric facilities participating nationwide. Extensive epidemiologic information about CO poisoning in the United States has been collected, and the utility of partnering with a medical specialty society for disease-specific surveillance demonstrated.

BACKGROUND

Carbon monoxide (CO) poisoning is a significant public health problem and a leading cause of unintentional poisoning deaths in the United States [1]. CO poisoning of all types accounts for an estimated 50,000 emergency department visits for the condition annually [2] and approximately 2,700 deaths per year [3]. Accidental morbidity and mortality usually result from the improper use of CO-emitting devices. However, this problem can be addressed through prevention efforts focused on public education regarding proper use of fuel-burning devices and the installation of CO alarms. The establishment of a public health surveillance system for CO poisoning would greatly assist these efforts by identifying populations at risk while monitoring for local or regional outbreaks.

Patients severely poisoned with CO are commonly referred to a hyperbaric treatment facility for hyperbaric oxygen therapy [4]. In the United States, most facilities treating acute CO poisoning are staffed by one or more members of the Undersea and Hyperbaric Medical Society (UHMS) and serve an important role as potential stakeholders in the surveillance of the condition. As such, partnering with the UHMS to identify patients treated for CO poisoning has the potential to identify one segment of the total population with this condition. Assuming that patients treated in hyperbaric chambers are an indicator or signal of regional activity, tracking those patients in real time has the potential to rapidly identify outbreaks of the condition, as well as collect demographic and clinical information that may be useful for future prevention efforts.

Early experience with online carbon monoxide case reporting

In the aftermath of Hurricane Katrina in 2005, medical centers in the Gulf Coast region were inundated with a number of people needing care or assistance. One problem was carbon monoxide poisoning due to improper use of gasoline-powered electrical generators during the power outages that followed the hurricane. Compounding this problem was a breakdown in normal disease tracking and monitoring infrastructure.

The Centers for Disease Control and Prevention (CDC) contacted the Undersea and Hyperbaric Medical Society for assistance in developing a system to track cases of carbon monoxide poisoning post-Katrina. The day after Hurricane Katrina struck – and daily thereafter for two weeks – the UHMS sent emails to all Gulf Coast members requesting that they report de-identified cases of carbon monoxide poisoning treated at their facilities. Reports were then submitted by email to a UHMS representative, who compiled the information and submitted it to the CDC on a daily basis for public health surveillance during the catastrophe.

Data from the reports highlighted the need for public health education on the use of portable generators, and results were subsequently published in an Early Release issue of the Morbidity and Mortality Weekly Report (MMWR) [5]. From August 29 to September 24, 2005, a total of 51 cases of CO poisoning were reported by UHMS members. Exhaust emissions from portable generators was the source of exposure for all cases except one. Further analysis revealed the rapidity with which data were reported in the absence of information from other medical facilities.

The universally positive nature of the experience raised the possibility that a permanent reporting system to routinely monitor similar cases of CO poisoning might be feasible. It was apparent that members of the UHMS were willing to report data on a voluntary basis for the good of public health and that this could be rapidly coordinated and collected through the Internet. It is the purpose of this report to describe the subsequent development and operation of that system. While a detailed summary and analysis of the demographic and clinical data that have been collected is the subject of another publication [6], selected results from the data will be highlighted here as examples.

TABLE 1. Data fields used in survey
(copy of online survey format is seen in Figure 1)

Hyperbaric facility reporting
Year of poisoning
Season
State where exposed
Patient
Age
Gender
Race/ethnicity
Primary language
English speaking
Educational level
History of prior CO exposure
Location during exposure
Activity during exposure
Pregnancy status
Symptoms
Source of CO
Fuel for source of CO
Continuous or intermittent exposure
Duration of exposure
Presence of CO alarm
Whether the CO alarm activated
Other persons exposed simultaneously
Normobaric oxygen treatment
Initial carboxyhemoglobin level
Delay to carboxyhemoglobin measurement
Arterial blood gas values
Evidence of cardiac Injury
Endotracheal intubation status
Details of initial hyperbaric oxygen treatment
Disposition after treatment
Reporter

METHODS

A panel of 38 questions requesting demographic and clinical information regarding a CO poisoning episode was initially compiled. Health Insurance Portability and Accountability Act (HIPAA) guidelines were utilized to insure that patient information was not identifiable. See Table 1 *(at right)* for data fields used in the survey. A commercial internet survey company (*www.surveymonkey.com*) was used to develop the questions into an online survey application. Two links were placed on the home page of the UHMS website (*www.uhms.org*) to direct potential participants to the online survey. The first link directs new users to a website where they can register their facility to participate in the program. The registrant is then provided a password to access the second link, where individual cases are reported to a secure site. The individual who submits the case data is subsequently mailed a $5 gift card for a national coffee company as a reward and an incentive for future reporting.

The system was piloted with four hyperbaric treatment facilities (Duke University Medical Center, Durham; Intermountain Healthcare, Salt Lake City; University of Pennsylvania Medical Center, Philadelphia; Virginia Mason Medical Center, Seattle) starting in December 2007. During the 10-week trial period, performed during the peak seasonal period for accidental CO poisoning, data on 60 patients were reported by the four facilities (range 7-35). This experience allowed ambiguous questions on the survey instrument to be rewritten, electronic survey formatting issues to be corrected, and other technical issues to be resolved.

Following the trial period, an official nationwide start date of August 1, 2008, was chosen. In preparation, details of survey development and results from the trial period were presented to the membership of the UHMS at the Society's Annual Scientific Meeting in June 2008 [7]. Facilities were encouraged to enroll prior to the national "go-live" date, but have been freely allowed to continue to enroll since that time. Subsequent requests for voluntary facility participation have been made at regional and national UHMS meetings, as well as in Society newsletters and other publications.

Registered facilities have access to the surveillance system via password to a secure website for case submission. On average, it requires 10 minutes to complete and submit the survey. A paper copy of the survey is also available for use in the event of a technology failure. Reporters are encouraged, but not required, to collect and submit the data during the two to three hours while the CO-poisoned patient is being treated in the hyperbaric chamber. In that way, information that would not be found in the medical chart later can be asked of the patient, and reporting would also be real-time. Submitted data are maintained securely at *surveymonkey.com* until downloaded by the operator.

Downloading data requires a password, known only to those who maintain the particular database. Currently, data are downloaded twice a week in the form of a Microsoft Excel® spreadsheet at the project coordinating center at Virginia Mason Medical Center, Seattle, Wash. Operation of the system requires only a few hours weekly from two staff members who are predominantly involved in data downloading, cleaning and storage, as well as survey maintenance and upgrading. Summary data for each reporter's facility is reported to them by email every six months and simultaneously to the CDC. In addition, on-demand reports are available to the CDC whenever requested.

In April 2010, participants were surveyed by email regarding the number of cases treated at their facility in 2009, for comparison with the number actually reported. Time delay to online case reporting was also queried. This was done to estimate the sensitivity of case identification from facilities participating in the system, as many facilities use more than one case reporter and confusion regarding specific case reporting responsibility could result in underreporting. Facilities were asked about timeliness of reporting to determine how close the system is to "real-time" surveillance.

RESULTS

The combined facility data were first summarized after one year of operation of the joint UHMS / CDC Carbon Monoxide Poisoning Surveillance Project (August 1, 2008 – July 31, 2009) [8]. A total of 82 reporting hyperbaric facilities were enrolled, located in 36 states. The total number of hyperbaric facilities treating acute CO poisoning in the United States is unknown. Through 12 months, 740 cases were reported nationwide by 52 facilities. Cases reported per facility ranged from 1 to 83 *(Figure 2, Page 651)*.

Sixty percent of the total cases were male, with an average age of 38 ± 20 years (mean ± SD; range 1 to 89). Primary language was English 85%, Spanish 11% and other 4%. Common sources of CO exposure were furnace 25%, motor vehicles 19% and generators 16%. Intent was accidental in 83% of the cases, intentional in 17%. Loss of consciousness occurred in 49% of patients, endotracheal intubation in 15%, and evidence of cardiac injury was seen in 30%. Following hyperbaric oxygen treatment, 53% were hospitalized and 47% discharged. Examples of the type of data obtained are demonstrated in Figure 1 *(Page 650)* and Figures 3-5 *(Pages 651-653)*.

Representatives of 26 reporting facilities responded to the April 2010 survey on calendar year 2009 reporting practices. Those facilities represented 59% of the 44 that had actually reported cases. The 26 facilities reported in the survey that they had treated a total of 523 cases of CO poisoning in 2009. Query of the database found that those same facilities had submitted information on 450 cases (86% of those they treated). The reporting rate for non-responding facilities could not be determined. Among respondents, 85% reported that they submit case data within 72 hours.

DISCUSSION

Thus far, this joint effort between the CDC and UHMS has demonstrated that it is feasible to develop an online surveillance system to monitor severe CO poisoning. The main purpose for developing the partnership was to design and implement timely surveillance for a preventable medical condition. The first year of operation demonstrated that this system provides prompt, ongoing surveillance with useful information about populations at risk, health behaviors and treatment practices.

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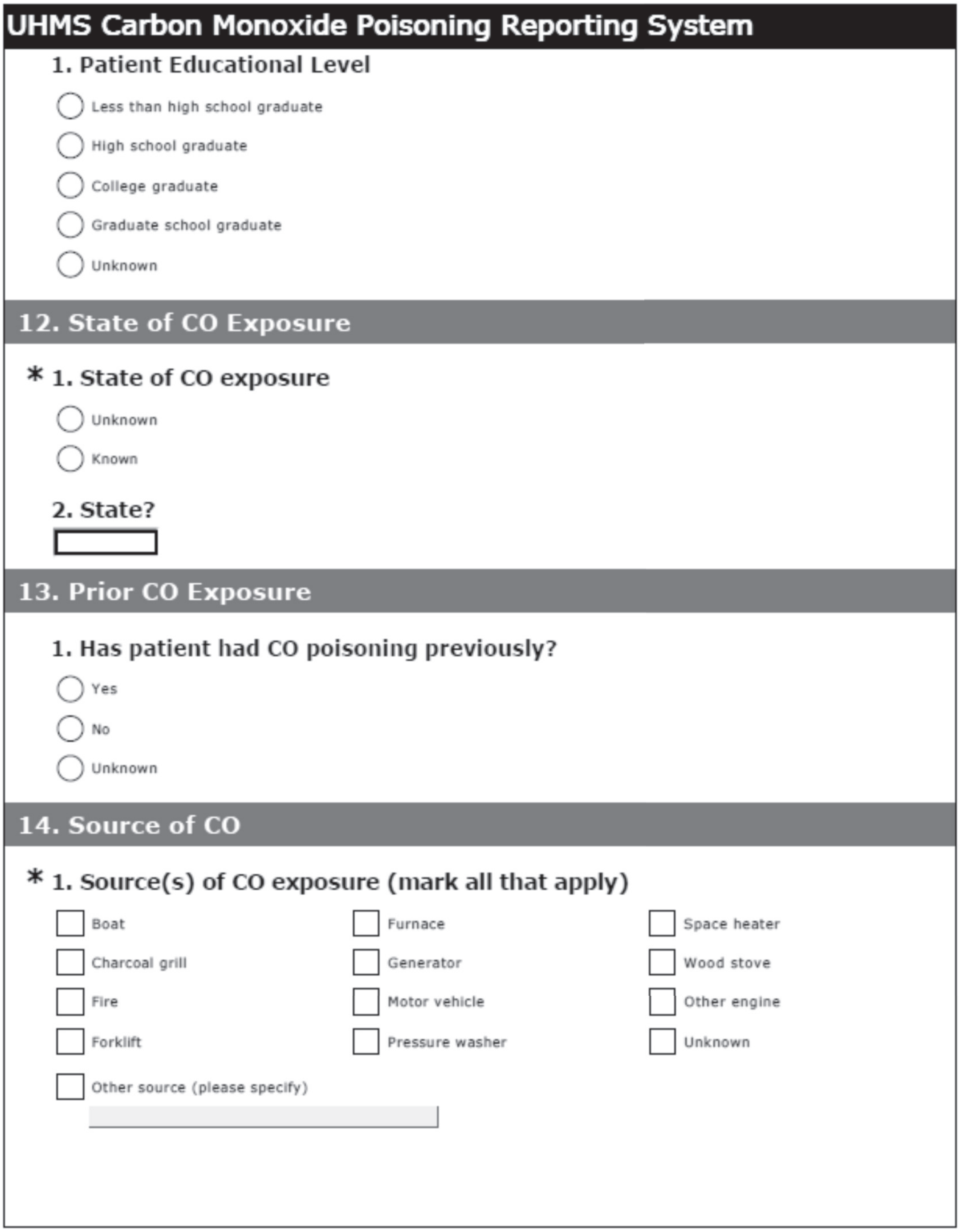
FIGURE 1. ***Sample of data input page from online survey***



UHMS Carbon Monoxide Poisoning Reporting System

1. Patient Educational Level

- Less than high school graduate
- High school graduate
- College graduate
- Graduate school graduate
- Unknown

12. State of CO Exposure

* 1. State of CO exposure

- Unknown
- Known

2. State?

13. Prior CO Exposure

1. Has patient had CO poisoning previously?

- Yes
- No
- Unknown

14. Source of CO

* 1. Source(s) of CO exposure (mark all that apply)

Boat	Furnace	Space heater
Charcoal grill	Generator	Wood stove
Fire	Motor vehicle	Other engine
Forklift	Pressure washer	Unknown

Other source (please specify)

FIGURE 2. ***Number of patients treated with hyperbaric oxygen for carbon monoxide poisoning per facility from August 2008 to July 2009 as reported via a joint UHMS/CDC online surveillance system***

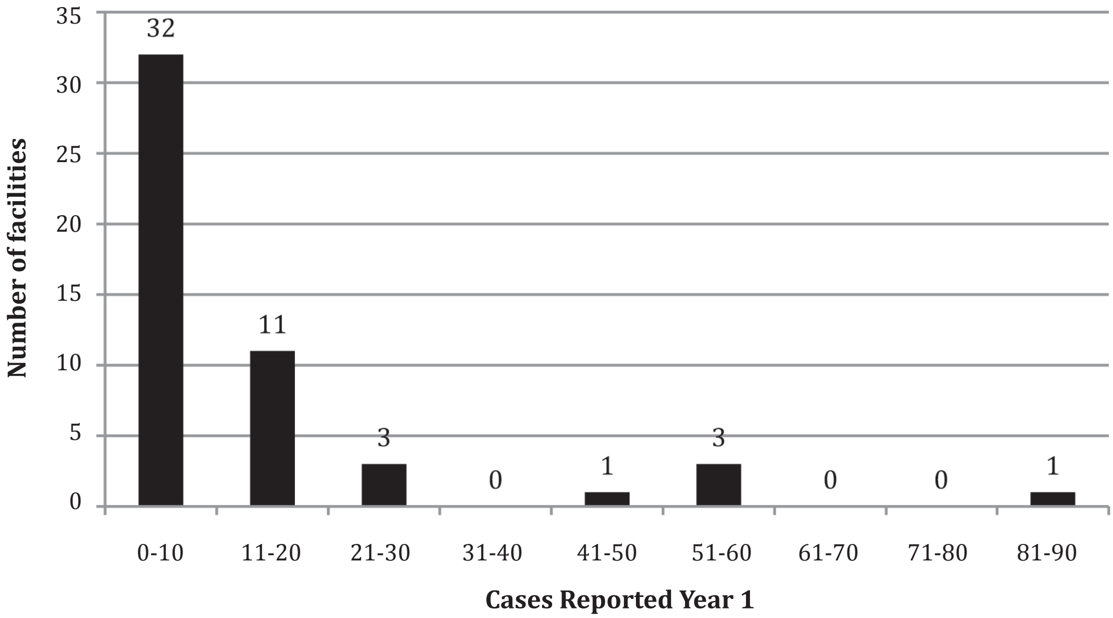


FIGURE 3. ***Sources of carbon monoxide in hyperbaric oxygen-treated cases reported from August 2008 to July 2009***

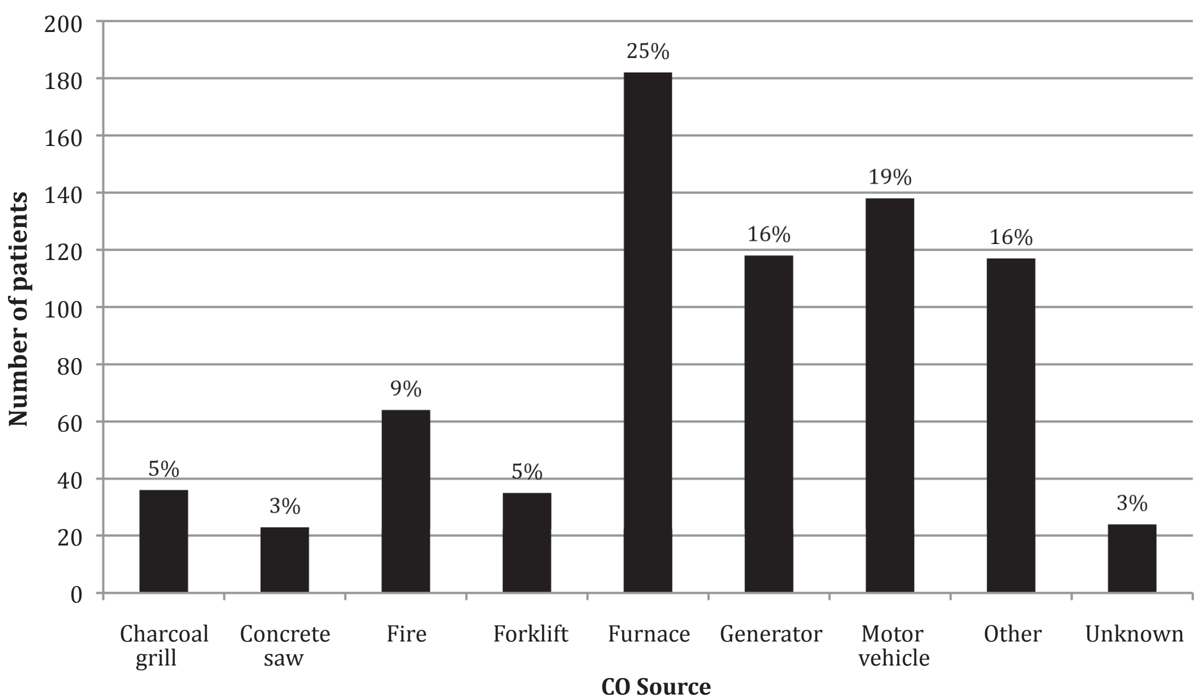
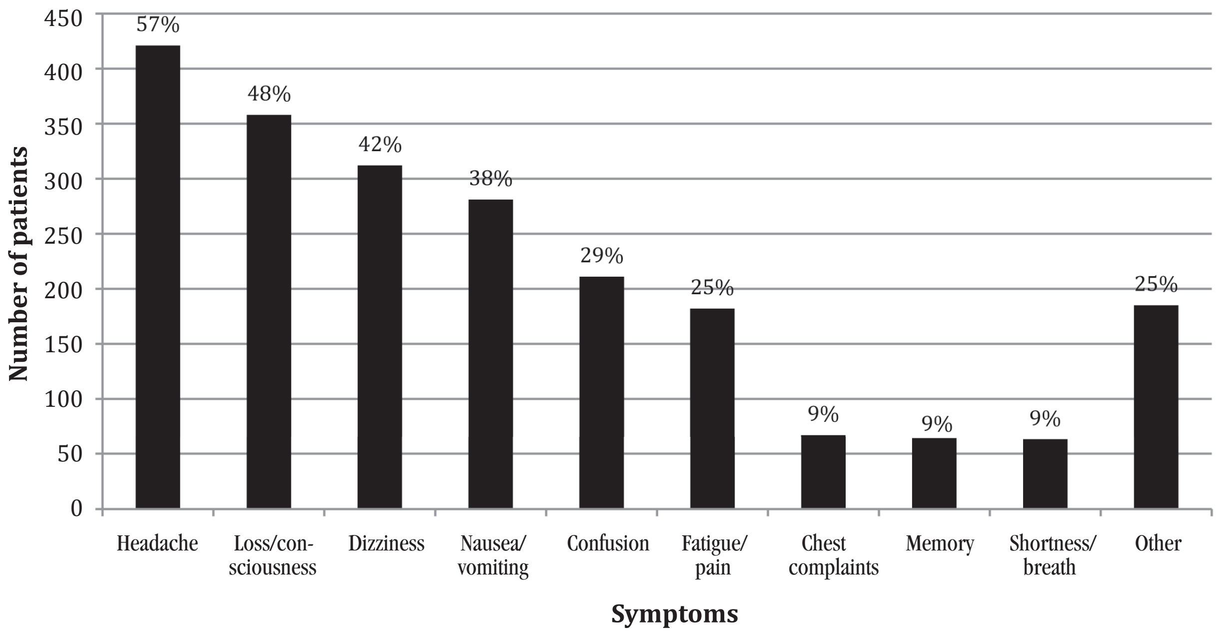


FIGURE 4. ***Symptoms of patients treated with hyperbaric oxygen for severe carbon monoxide poisoning, as reported via the joint UHMS/CDC online surveillance system from August 2008 to July 2009***



Because no single source provides such detailed information on this specific patient population, it is difficult to completely validate the system. However, other surveillance systems do collect some of the same variables on other subgroups of the total population of CO-poisoned patients. One of these, the Consumer Product Safety Commission (CPSC), publishes an annual report on non-fire CO deaths associated with the use of consumer products. Its most recent report provides data for calendar year 2006 [9].

Data from patients with non-fire CO poisoning associated with the use of consumer products were extracted from the current system database and are compared with similar 2006 CPSC data in Table 2 *(facing page)*. Limitations to this comparison include the facts that the data are separated in time by three years and that one system reports information on survivors while the other only non-survivors. Nonetheless, the findings from the two systems are remarkably similar with regard to age, sex, race, time of year and location of poisoning.

This hyperbaric system is unique with regard to the in-depth data reported on each case of carbon monoxide poisoning treated with hyperbaric oxygen, providing a level of detail not captured by other systems. Secondary data sources, such as rate-based or case-based surveillance, have several limitations that prevent complete understanding of the epidemiology of CO poisoning. Some of these include:

1. the lag time between occurrence and data availability;
2. short duration of the study period;
3. limited availability of important data fields; and
4. case definitions based upon carboxyhemoglobin levels [10].

Those patients treated with hyperbaric oxygen and reported in this system are seen as a potential signal of regional poisoning occurrence. Since most epidemics of CO poisoning occur when electrical power supplies are disrupted by a major storm or other natural disaster [11], the geographic area impacted is typically quite large, and cases treated with hyperbaric oxygen should begin to show up in the system if there is a significant amount of poisoning occurring.

Already the data are beginning to answer some long-standing questions about CO poisoning in the United States. For example, it is unknown what proportion of CO-poisoned patients presenting for medical care are hospitalized. The current data demonstrate that approximately one-half of patients treated with hyperbaric oxygen for severe CO poisoning are discharged home after treatment and not admitted to the hospital. Since those treated with hyperbaric oxygen are typically the more severely affected patients, those treated in the emergency department with normobaric oxygen and

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FIGURE 5. ***Estimated time delay from removal of patient from CO exposure environment to measurement of carbxyhemoglobin (COHb) level***

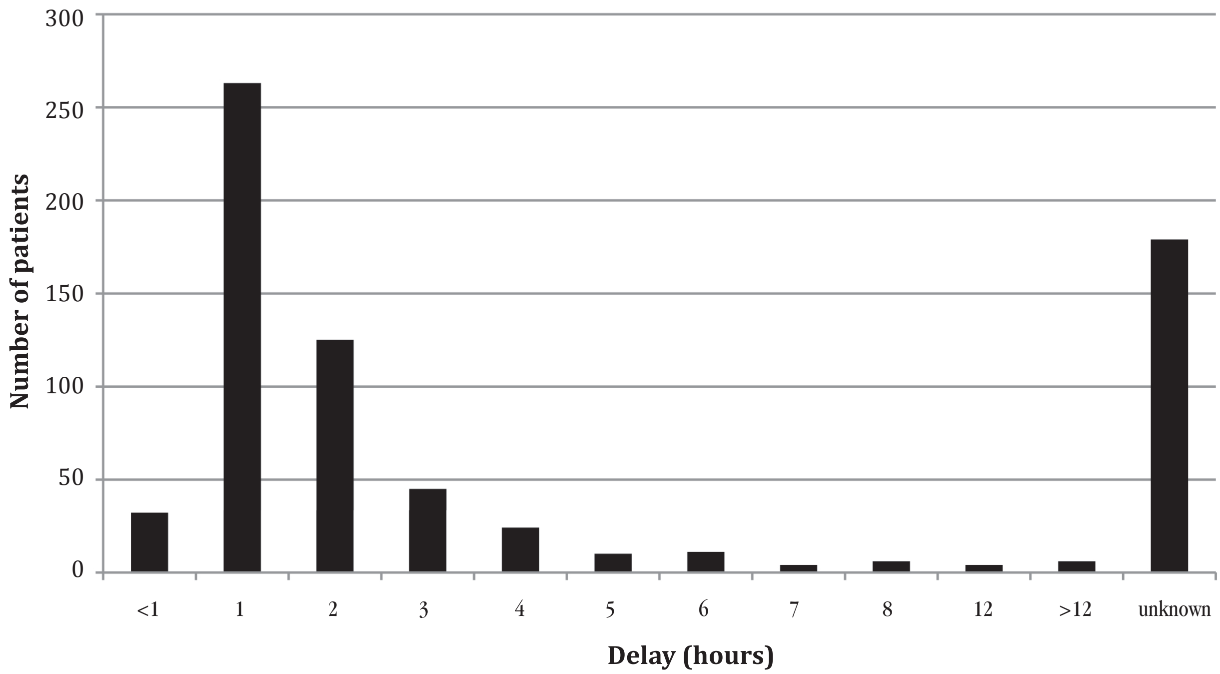

TABLE 2

Year 1 Data $n = 470$	Hyperbaric Surveillance System $n = 180$	CPSC 2006 Data
Age		
25-44 years	32%	34%
45-64 years	29%	32%
Sex	73% male	79% male
Race		
Black or African American	20%	56%
White (non-Hispanic)	56%	64%
Month of Poisoning		
November to January	41%	41%
June to August	16%	11%
Residential location of poisoning	77%	71%
CO Source		
Engine driven tools	39%	58%
Furnaces	39%	18%
Charcoal grills	8%	6%

Table 2. Selected data variables from cases of non-fire related CO poisoning associated with the use of consumer products. Comparison of patients treated with hyperbaric oxygen from 2008-2009 from the current system and 2006 victims reported by the Consumer Product Safety Commission [9].

not referred for hyperbaric oxygen treatment would be expected to have an even lower hospital admission/discharge rate. It therefore appears that less than one-half of patients with recognized CO poisoning in the United States are hospitalized.

Just as there are advantages to the current CO poisoning surveillance system, potential limitations exist. One of those is sensitivity. It has been estimated previously that approximately 1,500 CO-poisoned patients are treated with HBO_2 in the United States each year [12], suggesting a sensitivity of approximately 50% with the 740 patients reported in the first year of use of this tool. However, the estimation of HBO_2-treated patients was reported 10 years ago and may not be accurate today. Also, it is possible that enthusiasm for voluntary reporting was greatest at the initiation of this surveillance system. If reporting wanes, sensitivity could change.

A second potential limitation is the possibility of delayed reporting – again, since case reporting is voluntary. On Sept. 13, 2008, Hurricane Ike struck the Gulf Coast of Texas. A total of 84 cases of CO poisoning, including seven deaths, were identified by various mechanisms [13]. The UHMS system reported 15 cases treated with hyperbaric oxygen starting September 14 and ending September 21. The rapidity of the response was obviously dependent upon the willingness of volunteer reporters to enter data, but this did not appear to have been a negative factor. At least in this instance, the system identified cases treated with hyperbaric oxygen in near real-time fashion, allowing the CDC and the Texas Department of State Health Services to intervene and prevent additional exposures. The recent survey of 2009 facility reporting practices also suggested that timeliness of the system is quite good compared to other measures of carbon monoxide poisoning in the United States, such as emergency department visits, hospitalizations or mortality.

A final area of potential limitation relates to the stability of the system. It currently depends upon the Internet for data collection and transmission, two operators to download and process the data, and an institutional server to store the data. All three areas have been addressed. Participating facilities have been provided with hard copies of the survey questionnaire. They are encouraged to use it as a data collection tool, then enter the data online when finished, and retain the hard copy until they receive confirmation of data receipt by the coordinating center. Also, alternate staff are trained in the jobs of data downloading, cleaning and storage, as well as survey maintenance and upgrading. Each week when the database is updated, it is also copied to a laptop computer not connected to the primary storage network.

CONCLUSIONS

The joint UHMS/CDC carbon monoxide reporting system has been an initial success. Participation has been high, and an estimated one-half of cases of CO poisoning treated with hyperbaric oxygen in the United States are being reported. The system has proven responsive and timely, guiding the CDC to an area appropriate for potential intervention after Hurricane Ike.

Because of the extensive case data obtained in each report, valuable information should be forthcoming regarding the demographic status and clinical presentation of such patients [6], allowing development of targeted public education programs for this preventable condition. Finally, long-standing questions about CO poisoning are beginning to be answered because of the detailed level of data collected.

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