WISCONSIN MEDICAL JOURNAL

# Evaluation of Five Data Sources for Inclusion in a Statewide Tracking System for Accidental Carbon Monoxide Poisonings

*Marni Bekkedal, PhD; Kristen Sipsma; Ernest S. Stremski, MD; Kristen Chossek Malecki, PhD, MPH; Henry A. Anderson, MD*

## ABSTRACT

All accidental carbon monoxide poisoning should be preventable. Yet despite intervention efforts including promotion of inexpensive home carbon monoxide detectors, annual inspection of home gas and oil appliances, and general awareness campaigns, in 2002 there were 18 fatalities, 36 inpatient admissions, 351 emergency department visits and 117 poison center calls attributed to acute carbon monoxide exposure. The first step to help better focus public health interventions is adequate information on occurrences. The Wisconsin Environmental Public Health Tracking program identified and evaluated potential data sources for inclusion in a surveillance system for monitoring unintentional carbon monoxide poisonings. Criteria to evaluate the utility of the existing data systems were developed and included the number of new cases identified from that source, the circumstantial detail provided, timeliness of data availability, confidence that an actual exposure occurred, and the resources required to retrieve and summarize the data. Five candidate datasets were evaluated: emergency department visits, hospital inpatient stays, death certificates, Wisconsin Poison Center records, and newspaper reports. It was found that although there was some overlap between cases reported in the different datasets, each source provided unique cases. The sources also differed in the resources required for utilizing the data and the amount of circumstantial information provided. Based on the evaluation of the different sources, it was concluded that newspaper reports should not be included, but the other 4 data sources would each contribute substantially to establishing a comprehensive surveillance system for accidental carbon monoxide poisoning.

Dr Bekkedal is a research scientist supervisor with the Division of Public Health. Ms Sipsma is a student at the University of Wisconsin-Madison. Doctor Stremski is medical director at the Poison Center/Telephone Triage at the Children's Hospital of Wisconsin, Milwaukee, Wis. Dr Malecki is a CDC/CSTE Applied Epidemiology Fellow with the Wisconsin Division of Public Health. Doctor Anderson is chief medical officer with the Division of Public Health. Please address correspondence to: Marni Y.V. Bekkedal, PhD, 1 W Wilson St, PO Box 2659, Madison, WI 53701-2659; phone 608.267.3811; fax 608.267.4853; e-mail bekkemy@dhfs.state.wi.us.

## INTRODUCTION

Disease and hazard surveillance is the foundation of public health and is a critical first step in devising disease prevention activities that can be used by clinicians and public health practitioners to reduce the burden of disease. Efficient surveillance of health conditions requires maximizing case ascertainment while minimizing expenditure of resources and maintaining sufficient information to adequately characterize the problem. An effective system in environmental health provides adequate information to identify populations at risk and summarize details associated with the exposures. The Wisconsin Environmental Public Health Tracking (EPHT) program is working to develop such surveillance systems for specific environmental health priorities including carbon monoxide (CO) poisonings.[1] These efforts have included the identification of multiple sources of health-related data, and the systematic evaluation of each source for its utility in a carbon monoxide poisoning surveillance system for public health purposes.

The "astute clinician" remains the cornerstone of every public health surveillance program. The clinician has 2 responsibilities. The first is to recognize a condition and make and record the correct diagnosis. The second is to report the diagnosis to the surveillance system. A failure in either or both of these steps renders the surveillance system blind and may lead to inappropriate allocation of priorities.

The challenge to surveillance system designers is to

make the second "reporting" step as foolproof as possible, capturing the report directly from the step 1 record. The current means to avoid a separate reporting step has involved utilizing administrative data systems. The advent of electronic medical records that can be searched may help achieve the goal of 100% reporting.

Accidental carbon monoxide poisonings are a recognized problem in Wisconsin, particularly due to the significant periods of cold weather each year and the popularity of recreational activities that involve the use of appliances that can produce carbon monoxide gas.[2] Many common home appliances are potential sources of carbon monoxide gas, which results from incomplete fuel combustion.[2,3] For example, accidental CO poisonings are often the result of exhaust from gas furnaces, water heaters, stoves, and dryers; fireplaces, woodstoves, space heaters, and charcoal grills; and automobiles, lawn mowers, and snow blowers. The greatest danger is when such contamination occurs in confined, unventilated areas such as homes or recreational lodgings as is common during times of cold temperatures or other inclement weather.

Carbon monoxide is a gas without color, odor, or taste to indicate its presence in the environment, so exposure often occurs without warning. Additionally, the most common symptoms of mild to moderate carbon monoxide poisoning are sufficiently generic, ie headache, dizziness, and nausea, that a victim may misattribute their cause, delaying escape from exposure or the seeking of treatment. Likewise, clinicians may overlook the causative role of carbon monoxide in an elderly patient with chronic health conditions reporting such intermittent symptoms. Thus, low level exposures can go unrecognized, resulting in steadily increasing body burden and worsening symptomology.[4] The primary physiological response to carbon monoxide exposure is the formation of carboxyhemoglobin when carbon monoxide binds to hemoglobin in the blood. The reaction competitively displaces oxygen causing hypoxia[5] and potential adverse effects in multiple organ systems.[6] Tissue hypoxia and lipid peroxidation may also contribute to the adverse physiologic effects of CO.[7] At sufficiently high doses, death can be rapid and permanent disabilities can result after a severe poisoning even if recovery occurs.

To date, no single source of information on carbon monoxide poisonings provides sufficient information to accurately characterize the burden of, and associated risk factors for, carbon monoxide poisoning in Wisconsin. A comprehensive, multi-source surveillance program could enhance the state health department's ability to disseminate relevant information to physicians and health care professionals regarding CO poisoning awareness and risk factors in their communities. In an effort to identify necessary and sufficient sources of data for an enhanced carbon monoxide poisoning surveillance program, the Wisconsin EPHT program evaluated a year's worth of data from 5 separate data sources: emergency department visits, hospital inpatient records, death certificates, Wisconsin Poison Center records, and newspaper reports. Each source was evaluated for strengths and limitations related to the information included in the dataset (demographics, location and date of incident, and cause of exposure), the extent of staff time and resources required to retrieve and summarize the data, timeliness of data availability, and the level of confidence that an actual exposure occurred. The data-sets were further evaluated for the number of additional cases gained from an individual dataset's inclusion. Results will inform the decision for developing a routine, effective, and comprehensive surveillance system for tracking accidental carbon monoxide poisonings in Wisconsin. The surveillance information will then be used to improve the dissemination of reliable and accurate information regarding CO poisonings to physicians, other health care professionals and public health practitioners.

## METHODS

Data on incident cases of accidental carbon monoxide poisoning from January 1, 2002 to December 31, 2002 were collected, summarized, and compared. Five sources with varying levels of case ascertainment and exposure circumstances were examined.

*Data Sources*

1. *Emergency Department Visits:* The dataset includes information regarding visits to the state's emergency departments (ED) at 123 hospitals, and does not include data from Veterans' Administration hospitals. Additionally, it represents most, but not all, ED visits, as sometimes patients were excluded if they were held over for observation or were subsequently admitted as a hospital inpatient or for ambulatory surgery. Indeed, a systematic evaluation of the data from 2002 suggests the numbers typically underestimate true incidence.[8] Due to these limitations, the subset of data used for this project should be considered as a summary dataset.
2. *Inpatient Hospitalization Records:* Records were collected by the Department of Health and Family Services from the state's acute care, non-federal hospitals. Out-of-state hospitalizations for Wisconsin residents are not included in this dataset.

**Table 1.** A Comparison of the Types of Information Available from Each Dataset

| | ED Visits | Hospital Inpatient Discharge | Death Certificates | Poison Center Records | Newspapers |
|---|---|---|---|---|---|
| Age, sex and race of victim(s) | Age and sex only | Y | Y | Y | Sometimes |
| Cause of exposure | Some* | Some* | Some* | Y | Y |
| Location of the exposure | N | N | Y | Y | Often |
| Date of exposure | Y | Y | Y | Y | Y |
| Considered to be a confirmed exposure | Y | Y | Y | N | Y |
| Data available in a standardized database | Y | Y | Y | Y | N |
| Data entry required | N | N | N | Y | Y |
| When data are available | Quarterly | Quarterly | Quarterly | Real-time | Within a week |

ED=emergency department.
* Some information in the accidental injury code.

3. *Death Certificate Records:* Death certificate data were collected by the Office of Vital Statistics in the Department of Health and Family Services. The data were submitted from 72 County Register of Deeds and 2 city health offices, as well as from other states when deaths of Wisconsin residents occurred out-of-state.
4. *Wisconsin Poison Center Records:* Center personnel record all contacts into an electronic database. Cases were extracted from this larger dataset if the generic substance code for carbon monoxide (0106000) was found in any of the case's substance data fields. A total of 122 cases were found in the poison center's database and subsequently summarized.
5. *Newspapers throughout Wisconsin:* Using an on-line search engine, a listing of newspapers throughout Wisconsin was obtained, and individual key word searches (carbon monoxide, CO, poisoning) were conducted for those newspapers available on-line. While it is recognized that this method excludes a number of potential newspapers and reports that are not available on-line, it was determined a priori that on-line searches were the only feasible methods that could realistically be used for routine, ongoing surveillance. Continuous surveillance would not be possible if it were required that staff obtain and review hard copies of all state newspapers, so this approach was not employed or evaluated. A total of 48 cases were found via this method. It should be noted that if the number of people affected in the incident was not explicitly stated, it was assumed to be 1. The data were manually entered into an electronic database to facilitate future summarization.

*Case Identification*

When reviewing ED visits and hospital inpatient data, cases of accidental carbon monoxide poisonings were defined as Wisconsin residents with an ICD-9 code of 986 (toxic effect of carbon monoxide) as the primary or first other diagnosis, and E868.0-E868.9 (accidental poisoning by gases and vapors including utility gas, motor vehicle exhaust, incomplete combustion of domestic fuels, carbon monoxide from other sources, and unspecified carbon monoxide) in the accidental injury code were also included. For the death certificates, cases with ICD-10 codes of X47 (accidental poisoning by and exposure to other gases and vapors), Y16 (poisoning by and exposure to organic solvents and halogenated hydrocarbons and their vapors, undetermined intent), and Y17 (poisoning by and exposure to other gases and vapors, undetermined intent) as the underlying cause of death were used.

*Duplication of Records*

A case capture-recapture analysis was conducted to estimate the level of redundancy of cases found within the multiple data sources versus the number of additional cases that could be identified. Furthermore, the value of the types of data available from each dataset was assessed for its utility in an environmental health surveillance application.

## RESULTS

*Case Ascertainment*

Overall, the major differences in data sources were in the amount of effort required for data entry and extraction, and how much detail the source provided regarding the exposure scenario or cause of exposure (Table 1). In general, the records of ED visits, hospitalizations, and deaths provided the greatest number of cases and sufficient circumstantial information while requiring the fewest resources to retrieve and summarize the results, followed by poison center records, which provided the second greatest number of cases although with the least confirmation of an actual exposure. Such confirmation is difficult because recommendations by the poison center for health care facility evaluation may not be fol-

**Table 2.** Number of Injuries or Deaths from Accidental Carbon Monoxide Poisoning for Male and Female Wisconsin in 2002

| | ED Visit | Hospital Inpatient | Deaths | Poison Center | Newspaper |
|---|---|---|---|---|---|
| Male | 173 (49%) | 25 (69%) | 13 (72%) | 64 (55%) | 8 (19%) |
| Female | 178 (51%) | 11 (31%) | 5 (28%) | 51 (44%) | 3 (7%) |
| Unknown | 0 (0%) | 0 (0%) | 0 (0%) | 2 (2%) | 32 (74%) |
| Total | 351 | 36 | 18 | 117 | 43 |

ED=emergency department

**Table 3.** Number of Injuries or Deaths from Accidental Carbon Monoxide Poisoning of Wisconsin Residents in Each Month of 2002

| | ED Visit | Hospital Inpatient | Deaths | Poison Center | Newspaper |
|---|---|---|---|---|---|
| January | 26 (7%) | 3 (8%) | 2 (11%) | 14 (12%) | 0 (0%) |
| February | 31 (9%) | 1 (3%) | 3 (17%) | 18 (15%) | 1 (2%) |
| March | 29 (8%) | 6 (17%) | 2 (11%) | 8 (7%) | 0 (0%) |
| April | 27 (8%) | 5 (14%) | 1 (6%) | 19 (16%) | 0 (0%) |
| May | 28 (8%) | 3 (8%) | 1 (6%) | 2 (2%) | 13 (30%) |
| June | 26 (7%) | 0 (0%) | 0 (0%) | 4 (3%) | 6 (14%) |
| July | 19 (5%) | 0 (0%) | 0 (0%) | 4 (3%) | 2 (5%) |
| August | 20 (6%) | 1 (3%) | 6 (33%) | 2 (2%) | 3 (7%) |
| September | 17 (5%) | 4 (11%) | 0 (0%) | 4 (3%) | 0 (0%) |
| October | 30 (9%) | 6 (17%) | 2 (11%) | 10 (9%) | 11 (26%) |
| November | 57 (16%) | 3 (8%) | 1 (6%) | 10 (9%) | 3 (7%) |
| December | 41 (12%) | 4 (11%) | 0 (0%) | 22 (19%) | 4 (9%) |
| Total | 351 | 36 | 18 | 117 | 43 |

ED=emergency department

**Table 4.** The Number of Potential and Confirmed Duplicate Records in the Individual Datasets

| | ED Visits (351) | | Hospital Inpatient (36) | | Deaths (18) | |
|---|---|---|---|---|---|---|
| | Expected Matches | Actual Matches | Expected Matches | Actual Matches | Expected Matches | Actual Matches |
| Newspapers (43) | 21 | 4 | 0 | 0 | 9 | 5 |
| Poison Center (117) | 66 | 29 | 9 | 0 | 1 | 0 |

ED=emergency department

lowed, or results of their evaluation not provided back to the poison center. The detailing of newspaper reports provided the fewest cases and was identified with the greatest relative expenditure of resources.

*Availability of Demographic and Seasonal Data*

The data from each source were summarized for gender of victim and month of exposure to ascertain any emerging patterns consistent across the databases. It was found that the datasets did not differ significantly in their provision of demographic data, and all identified the date of the exposure. The male-female pattern is similar for hospital inpatients and deaths, and for ED visits and poison center calls, but dissimilar across the groups (Table 2). Newspaper reports had a very different pattern due to the large percentage of cases where the gender was unknown. As for seasonal patterns, the greatest frequency of reports occurred in different months for all 5 sources of poisoning cases (Table 3).

*Availability of Information on the Source or Cause of Exposure*

Sources of information regarding circumstances surrounding environmental exposures were also evaluated for each data source. The address for the location of exposure is available from the death certificates, but the information is not as detailed as that found from the poison center or in newspapers. Similarly, while the ED visit and hospitalization datasets do not provide details for how the accidental poisoning occurred, they do provide a code for supplementary classification of external causes for the poisoning that narrows the cause to such sources as a motor vehicle, a fire, or a domestic stove or fireplace. Thus, while some information regarding the specific cause of the accidental

poisoning can be gleaned from the 3 more widely used and standardized datasets, the most extensive details are found in poison center records and newspaper reports.

*Duplication of Data Sources*

Lastly, a case capture-recapture method was employed to determine the overlap in cases from the different sources, and thus further evaluate each dataset for its utility as part of a comprehensive surveillance system (Table 4). The total number of cases from the 5 different sources, prior to the elimination of duplicates, is 565. The total number from the electronic databases is 405, and it was assumed there were no duplicate cases between these sources. Based on the case capture-recapture procedure, it was found that inclusion of the poison center potentially added 70-88 cases, an increase of 17%-22% from the 405 cases retrieved from the 3 administrative datasets. Inclusion of the newspaper reports resulted in the capture of an additional 22-34 cases, an increase of 5%-8%.

## DISCUSSION

Reliable surveillance of accidental carbon monoxide poisonings is necessary for disseminating accurate information to physicians and public health practitioners regarding the risk of CO poisonings in their communities. There are multiple potential sources of information that could be included in a comprehensive surveillance system of accidental CO poisoning. For the 5 sources investigated in the current project, 3 of the sources are standardized, administrative electronic databases regularly utilized by Wisconsin health agencies for surveillance of a wide array of health effects: ED visit records, hospital inpatient discharge records, and death certificates. A fourth source was records from the Wisconsin Poison Center electronic database, and the fifth was a systematic examination of the state's newspapers for articles related to carbon monoxide poisoning. It was found that each dataset added cases not found in any of the other sources. Fewer duplicate records were found than would have been expected, but in many cases, insufficient information was available to determine whether or not 2 records were indeed exact matches. The greatest number of cases was found in ED visits, followed by poison center records, newspaper reports, hospital inpatients, and death certificates. When evaluated for the number of duplicate records across the sources, the data suggest a significant number of additional cases are available from the poison center records, but the number of cases ascertained from the newspaper reports is minimal in comparison to the effort required to retrieve and summarize the data. The gain in the number of cases or in the additional details regarding the incident are not outweighed by the cost in resources.

Further differences between the summarized data recorded from the individual sources were identified in the demographic and temporal patterns of the poisonings. Seasonal patterns were also divergent across the different sources. These data suggest it would be difficult, and likely inappropriate, to assume the distribution of cases and the associated exposure scenarios could be extrapolated from one data source for another. In other words, it would be inappropriate to exclude the use of a specific dataset because its results could be predicted from those in another database.

Additional sources of data, such as records from physician office visits, fire departments, or utility companies, have potential for inclusion in a comprehensive CO poisoning surveillance program. The methods employed here can be used as a template for evaluating such potential datasets in the future. This approach provides for assessing the number of cases that may be missed, as well as weighing the benefits of additional information for identifying high-risk populations and exposure circumstances against the costs of obtaining and summarizing the data.

The general conclusion is that a comprehensive and sustainable surveillance system for accidental carbon monoxide poisonings would ideally include cases from the following 4 datasets: ED visits, hospital inpatients, death certificates, and the Wisconsin Poison Center. The data are substantial, and include a sufficient number of cases and detail for summary reports identifying high-risk demographics and situations. The proposed surveillance system is sustainable and will likely provide useful public health information to physicians and other health care professionals on a routine basis into the future.

## REFERENCES


1. National Environmental Public Health Tracking Program. Available at: www.cdc.gov/nceh/tracking/projects/contacts/wi.htm. Accessed February 27, 2006.
2. State of Wisconsin Indoor Air Issues: Carbon Monoxide. Available at: www.dhfs.state.wi.us/eh/Air/pdf/CO.pdf. Accessed February 27, 2006.
3. Consumer Product Safety Commission. Carbon monoxide fact sheet, 1999.
4. Knobeloch L, Jackson R. Recognition of chronic carbon monoxide poisoning. *WMJ*. 1999;98:26-29.
5. National Institute for Occupational Safety and Health. Preventing Carbon Monoxide Poisoning from Small Gasoline-Powered Engines and Tools. Available at: www.cdc.gov/niosh/carbon2.html. Accessed February 27, 2006.
6. Scheerer A, Struttmann T. Carbon monoxide poisoning in Kentucky. *J Kentucky Med Ass*. 2002;100:447-453.
7. Thom SR. Carbon monoxide-mediated brain lipid peroxidation in the rat. *J Appl Physiol.* 1990;68:997-1003.
8. Svenson JE. Emergency department visits in Wisconsin 1998-2002: trends in usage and accuracy of reported data. *WMJ*. 2005;104(8):56-58.

# Wisconsin Medical Journal

The mission of the *Wisconsin Medical Journal* is to provide a vehicle for professional communication and continuing education of Wisconsin physicians.

The *Wisconsin Medical Journal* (ISSN 1098-1861) is the official publication of the Wisconsin Medical Society and is devoted to the interests of the medical profession and health care in Wisconsin. The managing editor is responsible for overseeing the production, business operation and contents of the *Wisconsin Medical Journal*. The editorial board, chaired by the medical editor, solicits and peer reviews all scientific articles; it does not screen public health, socioeconomic or organizational articles. Although letters to the editor are reviewed by the medical editor, all signed expressions of opinion belong to the author(s) for which neither the *Wisconsin Medical Journal* nor the Society take responsibility. The *Wisconsin Medical Journal* is indexed in Index Medicus, Hospital Literature Index and Cambridge Scientific Abstracts.

For reprints of this article, contact the *Wisconsin Medical Journal* at 866.442.3800 or e-mail wmj@wismed.org.