Method to Electronically Collect Emergency Department Data

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Study objective: To describe the development and completeness of an electronic injury-surveillance system, the Rural Injury Surveillance System (RISS).

Methods: The emergency departments of nine rural Iowa hospitals submitted information on all patients treated from May 1993 through June 1994.

Results: The EDs submitted information on 23,594 patients with 32,445 different injury, disease, or follow-up visits. On the basis of comparison with the handwritten ED logbook, 90% of visits were also available in the RISS. Of the visits recorded in the RISS, 99% were also recorded in the logbook. The proportion of missing diagnostic codes decreased from a high of 22.6% in May 1993 to 8.1% in June 1994. The proportion of missing external cause codes was about 25% at the end of the study period. The proportion of missing industry and occupational codes was less than 5% at the end of the study period.

Conclusion: Our findings show that complete, computerized, ED-based injury surveillance in rural EDs is possible and should be developed further.

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INTRODUCTION

Injuries treated at emergency departments are a justifiable cause for concern. First, such injuries account for more than 95% of all injuries treated at US hospitals. In addition to the pain, suffering, and disability that these injuries may cause, they cost an estimated $408 billion each year.[1] Furthermore, nonfatal injuries have a different distribution of external causes than fatal injuries. Falls, occupational injuries, and sports injuries are among the leading causes of nonfatal injury[2,3], whereas motor vehicles are the leading cause of injury deaths.[4]

ED-based surveillance offers a way to collect data on nonhospitalized injured patients. Establishing a hospital ED surveillance system has several advantages for injury research.[5] First, the ED is usually the first place a patient goes after sustaining an injury. Therefore recall of the external cause of injury is likely to be more accurate at the ED than it is later in the treatment process. Second, because the incidence of ED-treated injuries is substantially greater than the incidence of fatal injuries, ED surveillance systems are extremely useful in monitoring injury trends over time, detecting injury clusters, and serving as endpoints of evaluation studies where the occurrence of more severe injuries would be too rare.

The findings of the Northeast Ohio Trauma Study[6,7] and the Statewide Childhood Injury Prevention Program[8] suggest that ED-based data collection is both time-consuming and labor-intensive. This conclusion may have been the result of the abstracting process used to obtain information in both studies. One means of reducing the expense associated with collection of ED injury data is the use of computers.

Computer applications are becoming widespread in hospitals. They have been introduced into EDs mainly for clinical purposes and quality assurance.[9-13] Computerized, ED-based surveillance of diseases and injuries for epidemiologic purposes has not been addressed until recently.

In this report we describe the development and implementation of a software package called the Rural Injury Surveillance System (RISS), which permits collection of ED surveillance data by expansion of the ED logbook. This project, a collaboration between the University of Iowa and the Iowa Department of Public Health (IDPH), was aimed at determining the feasibility of ED data collection as part of the development of a coordinated, statewide trauma care delivery system.

MATERIALS AND METHODS

To design the RISS software, we first met with ED personnel and administrators of a small, a medium, and a large hospital to determine their data needs and our own. Next, we convened a 2-day workshop on relational databases in the spring of 1991, at which various stakeholders defined the individual fields in the database and the necessary relationships among them.

We then wrote the software and tested it in the field. The program was written in FoxPro version 2.5, a relational database.[15] Because users get a compiled version of the software, it is not necessary to have FoxPro installed on their PCs. Although the RISS will run on IBM-compatible PCs with a 386 central processing unit, a 486 machine or better, with at least 25 MHz of processing speed, is preferred. Hospitals should have a computer with at least 80 megabytes of hard disk space free and a printer. The use of a mouse facilitates data entry. The software requires at least 4 megabytes of random-access memory to run.

The program is menu driven and has many help screens to guide the user to the correct entry. If the user wishes, it is possible to bypass all help screens and enter the data directly.

Data are collected on patient demographics, employment, contact person, event information, arrival information, and the four previously mentioned state-mandated reports (Table 1). Because Iowa is considered a rural state and rural residents are at increased risk of injury[16,17], we specifically included a data item on the place of residence relative to the nearest city limit. However, "place of residence" may not adequately describe the reduced access to medical care among the rural population.

We used both free text and specific codes to describe the patient's industry and occupation. We opted to use the 1987 Standard Industrial Classification (SIC) and the 1980 Standard Occupational Classification (SOC) codes because their hierarchical structure permits easy classification of industry and occupation without the use of codebooks. Because of the large number of codes, we included only two of the four levels of each classification scheme. Several examples are given for each code in the software. If needed, both SIC and SOC codes can be converted to those developed by the US Census Bureau.[18]

In addition to the place of injury occurrence (external cause code 849), the user may enter as many as four E-codes from the ninth version of the *International Classification of Diseases (Clinical Modification)* (ICD-9 CM). The software uses all four available levels of codes to arrive at the final E-code. These screens were modeled after EPIC, a Centers for Disease Control and Prevention program that provides E-codes from medical records. In contrast, we used three of the five levels of the diagnosis codes (ICD-9 CM). We chose to limit the number of diagnostic codes to the first three digits because we expected that ED personnel would be unable to distinguish between more specific codes at this point in the treatment process.

We included emergency medical services (EMS) information to have the ability to link with the delivery of prehospital care to obtain additional diagnostic and event-related information. It was therefore necessary to include the name of the ambulance service and the unique ambulance run number.

At the hospitals' request, we included four mandated reporting requirements in the RISS: brain and spinal cord injury, farm injury, drug abuse warning network (Mini DAWN), and patient transfer information. The information from several data items, such as demographic information, is copied from the main part of the RISS into these reports, thereby avoiding duplicate data entry by the users.

Implementation of the RISS began initially in 10 predominantly small hospitals in northwest Iowa. Except for various forms of electronic systems to track billing information, these hospitals had no means with which to collect surveillance data electronically.

A survey of these hospitals showed that the average number of visits was 4,456 per hospital (range, 891 to 8,000). The percentage of injury-related visits of the total number of visits ranged from 1% to 45%.

Beginning in May 1993, we installed the software at each of the 10 participating hospitals. Training in the use of the software was provided by personnel at the IDPH to all hospital personnel working with the software. Every 3 months we met with the users to update them about software changes and to provide an opportunity for the hospitals to submit their data. In return, we provided technical assistance, submitted reports to hospitals, and made changes to the software as needed.

Seven of the 10 hospitals started data collection on May 1, 1993; the other three hospitals started in June, July, and August, respectively. Data were collected mainly from patient charts at participating hospitals by various hospital personnel including emergency medical technicians (EMTs), ED nurses, and respiratory therapists. All hospitals but one entered data after the patient was released.

Data entry for a routine visit took approximately 5 minutes. For a more complete visit, depending on the number and types of reports that had to be entered, it might have taken 2 to 4 additional minutes to complete the entire visit. Computers were located in the ED, EMT office, or medical records department as determined by individual hospitals. At this writing, data for more than 1 year are available for 9 of the 10 hospitals. One hospital had incomplete data because the resources for data collection and entry were lacking. Using the largest number of visits for a hospital that participated in the RISS (8,000) and an average of 6 minutes per visit, we calculated that it took fewer than .4 full-time equivalent employee to enter the data.

Nine hospitals have been entering data since the fall of 1993. We used data from May through December 1993 to validate visits.

To determine the completeness of the RISS database, we randomly selected 14 days (2 Mondays, 2 Tuesdays, etc) for the nine hospitals from the database and reviewed the ED logbook of each for the visits during these days. This information was compared with the information

Table 1.
Data elements included in the RISS.

Category	Data Elements
Patient demographics	Name, Social Security number, hospital number, date of birth, sex, marital status, race, address, place of residence relative to nearest city limit, method of payment
Employment	Industry (SIC), occupation (SOC), employer information
Contact person	Name, address, relationship to patient
Event information	Reason for visit, date and time of onset, Adult Trauma Score, ICD-9 N-codes, ICD-9 E-codes, place of occurrence, transferred facility, place of occurrence relative to nearest city limit, intentionality
Outcome	Disposition
Arrival information	Means and time of arrival, EMS company and run number
State-mandated reports	Brain and spinal cord injuries, farm injuries, drug-related conditions, patient transfer (COBRA)
Quality assurance	Time of arrival and examination at ED, time provider contacted and arrival, provider code and name, consultant codes

available from the RISS. Both the RISS and the ED logbook were systematically searched for visits that could not be located initially.

Four of the most important data elements collected in the RISS are the patient's diagnostic code, external cause of injury (E-code), the SIC, and the SOC. To assess the improvement in the capture of these data elements, we calculated the percentage of missing or unknown codes for each month of data collection. Missing and unknown codes were identified separately in the system.

RESULTS

During the study period, 1,126 visits were included in the RISS by the nine hospitals; 1,232 visits were recorded in the nine ED logbooks. Of all 1,126 visits recorded in RISS, 1,114 (99%) had also been recorded in the ED logbook. This proportion ranged from 94% to 100% at the nine hospitals (median, 99%).

Of all 1,232 visits recorded in the ED logbook, 1,114 (90%) were located in the RISS. This proportion ranged from 75% to 100% (median, 90%). These calculations include visits for which the date of visit was different in both systems but reflected the same visit.

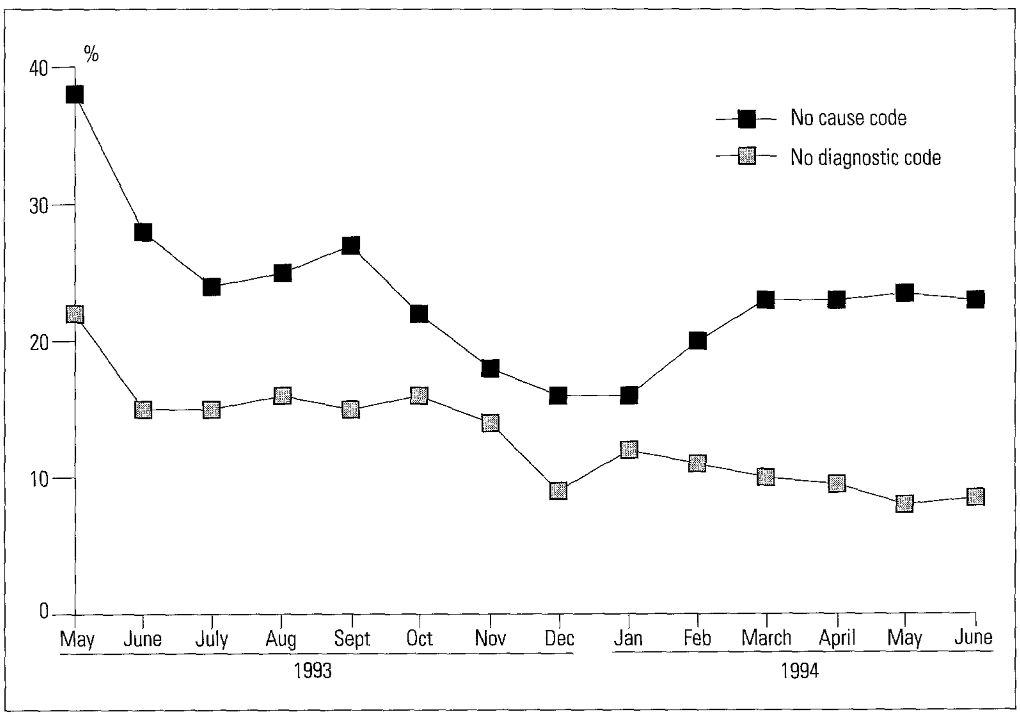
From May 1993 through June 1994, the participating hospitals submitted information on 23,594 patients with 32,445 different injury-, disease-, or follow-up–related visits. The average number of patients each month was 1,685 (range, 1,082 to 2,347). The average number of visits was 2,318 (range, 1,954 to 2,610). The total number of injury visits was 9,427 during this period (mean, 673 visits per month; range, 485 to 999 visits). All four codes were present for 50% of injury-related visits.

Regardless of the type of visit, we found that the proportion of visits without diagnostic codes decreased over time from a high of 22.6% during May 1993, the first month of operation, to 8.1% in June 1994 (Figure 1). The overall proportion of missing diagnostic codes during this period was 12.6%. This figure varied substantially by hospital (range, .2% to 43.0%).

The percentage of injury visits without E-codes showed a different pattern. It decreased from 36.7% in May 1993 to a low of 16.4% in December 1993 and January 1994. It then increased to about 25% in March 1994 and remained relatively constant. The percentage of missing E-codes showed a variation by hospital similar to that seen for the diagnostic codes.

The percentage of missing or unknown SIC codes of all patients had decreased substantially after 4 months of operation (Figure 2). Both percentages remained relatively constant after 5 months of operation, at about 4% and 12%. The minimum proportion of missing and unknown SIC codes by hospital was 2%, with highs of 23.0% and 33.6%, respectively.

Figure 1.
Diagnostic and external cause codes missing, over time.



The percentage of missing SOC codes showed a decline similar to that of the SIC codes but was slightly higher after 5 months of operation (Figure 2). The percentage of unknown SOC codes declined rapidly after implementation and remained constant after 5 months at about 4 percentage points lower than the percentage of unknown SOC codes. The minimum proportions of missing and unknown SOC codes by hospital were 2.4% and .9%, with highs at 33.2% and 26.3%, respectively.

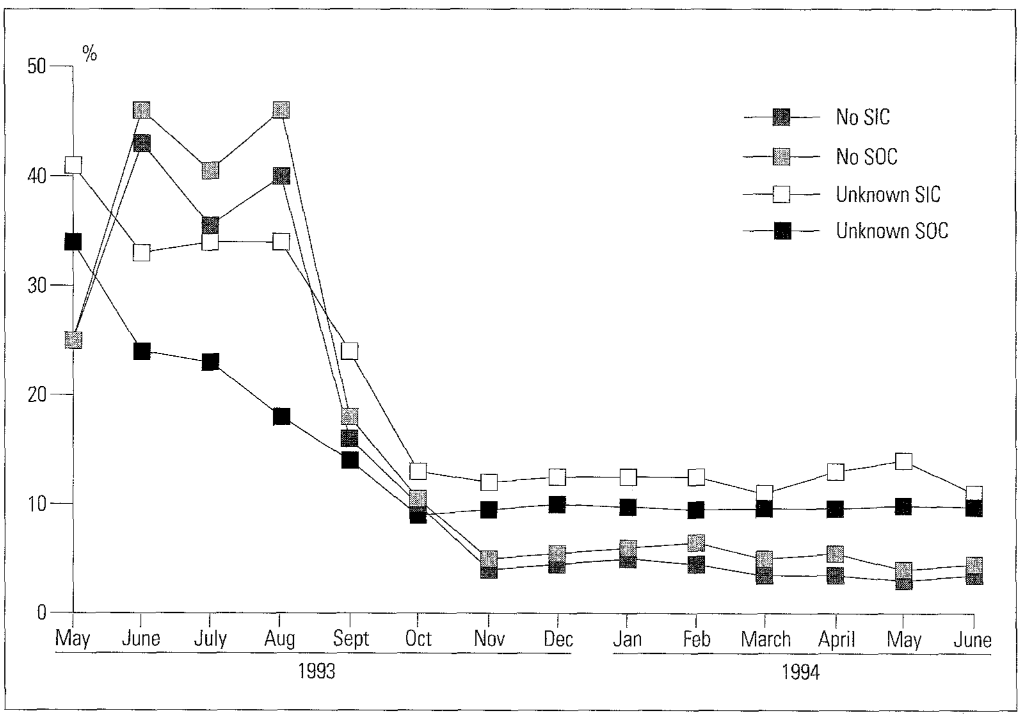
The decline in the proportions of missing and unknown SIC and SOC codes may have been due in large part to the addition of SIC and SOC categories on September 1, 1993, for patients who were not working, were retired, or were children. The SIC and SOC codes only classify persons who work. Both percentages, as well as the percentages of unknown SIC and SOC codes, remained constant after 5 months of operation. Both codes are of special interest for the identification of high-risk industries and occupations.

We also investigated the difference in demographic characteristics of those with valid or missing diagnostic codes, E-codes, and SIC or SOC codes (Table 2). We found that patients with missing diagnostic codes were slightly older than those with valid codes. No differences were found for E-codes. Females and nonwhites were more likely to have missing SIC or SOC codes.

DISCUSSION

The RISS was developed to serve the need of hospitals, as well as to permit injury surveillance. It provides at least three benefits to hospitals. First, the Joint Commission on the Accreditation of Healthcare Organizations (JCAHO) requires personnel at EDs to collect and maintain certain data elements on all patients, including patient identification, time and means of arrival, relevant history, prehospital care, diagnosis, tests ordered, and disposition.[14] The RISS is designed around this JCAHO requirement, and all essential data elements are included. Second, hospitals can use the system for quality-improvement activities. For example, case load may be determined by provider, diagnosis, outcome, and demographic characteristics of patients. Third, all mandatory reporting forms to federal and state government agencies are included. The federal government requires hospitals to collect data on all patients transferred to other acute care hospitals in accordance with the Congressional Omnibus Reconciliation Act (COBRA) regulation. In addition, Iowa hospitals are required by law to report a variety of conditions to the Iowa Department of Public Health, including brain and spinal cord injuries, farm injuries, certain occupational injuries, and several infectious diseases. The RISS provides these reports. Although written for use in Iowa, the software could be modified for use in other states.

Figure 2.
SOCs and SICs missing or unknown, over time.



The system also has multiple uses for injury researchers, including providing estimates of injury morbidity, detecting clusters of injury events, providing outcome measures to evaluate injury prevention interventions, and providing a source of cases for analytic research.

On the basis of our comparison of the information contained in the RISS database and that of the ED logbook, we conclude that the RISS captures the overwhelming majority of ED visits. Therefore it can be considered a tool with which to conduct ED injury surveillance.

The proportion of missing diagnostic codes decreased over time to about 12%. This percentage could be reduced by linkage to hospital billing systems. Of greater concern is the proportion of missing external cause codes, about 25% of all injury visits. These codes are essential for identification of target populations for injury-prevention and evaluation activities. We found no difference between valid and missing codes with regard to age, sex, and race. Educational efforts aimed at increasing the use of these codes will be implemented.

The percentage of missing and unknown SIC and SOC codes showed different patterns from the N- and E-codes. SIC and SOC codes showed dramatic declines over time. However, demographic characteristics were different between patients with and without valid SIC and SOC codes. This may have implications for the comparison of injury rates between specific types of industries and occupations and their differences in sex and race composition.

Several limitations of the RISS can be identified. First, data were not entered while the patient was in the ED as the RISS was originally designed. This means that the additional information not contained in the logbook was written down and subsequently entered into the computer. Second, the RISS is used without any communication to other hospital information systems. In some cases, billing systems collect a substantial amount of similar information also contained in the RISS. The inability to download data from existing hospital systems results in additional work for data-entry personnel. We are discussing with two large hospitals the downloading of some of their mainframe data into the RISS.

Another limitation of the RISS is that SIC, SOC, and diagnostic and E-codes have not been validated with regard to their accuracy. Several activities are currently under way to validate these codes. However, we are in the process of validating the E-codes by comparing our codes with those coded by a trained nosologist using the hospitals' medical records. Also, the National Institute of Occupational Safety and Health has recoded our SIC and SOC codes on the basis of the free text describing the patient's industry and occupation available in the RISS. Comparisons with the submitted SIC and SOC codes will be made. Comparisons of diagnostic codes collected by RISS with billing information will result in assessment of their accuracy and provide more detailed codes beyond the first three digits as used in the RISS.

The results of this study show that computerized injury surveillance can be conducted in rural EDs. The overwhelming majority of cases in the logbook were recorded in the RISS. A percentage of cases had missing or unknown codes for diagnosis, injury cause, industry, and occupation.

Table 2.
Demographic characteristics of patients with and without valid N-codes, E-codes, and SIC or SOC codes.

	N-Code		E-Code		SIC Code		SOC Code		
Features	**Valid**	**Missing**	**Valid**	**Missing**	**Valid**	**Missing**	**Valid**	**Missing**	**Total**
Age (years) [mean±SD]	40.7±28.0	44.8±2 8.2*	32.4±24.3	32.7±25.3	39.3±12.1	39.7±12.8	39.6±12.2	39.2±12.6	
Sex (%)									
Male	87.2	12.8	77.3	22.7	66.0	34.0*	58.6	31.4*	100.0
Female	86.5	13.5	77.3	22.7	60.6	39.4	64.0	36.0	100.0
Race (%)									
White	86.8	13.2	77.2	22.8	64.2	35.8†	67.4	32.6*	100.0
Nonwhite	84.9	15.1	72.5	27.5	53.0	47.0	49.8	50.2	100.0

*$P<.001$.
†$P<.01$.

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