FINAL PROGRESS REPORT

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LIST OF ABRREVIATIONS

BLS	Bureau of Labor Statistics
CNWR	Chart Not Work-related
CPSC	Consumer Product Safety Commission
CTS	Carpal tunnel syndrome
CWR	Chart work-related
CY -	Calendar year
DET	Massachusetts Division of Employment and Training
ED	Emergency department(s)
EDISS	Emergency Department Injury Surveillance System
FY -	Fiscal year
HDD	Hospital discharge datasets
IAW	Injury-at-work
ICE	International Collaborative Effort on Injury Statistics
ICECI	International Classification of External Causes of Injury
ISP	Injury Surveillance Program
LWR	Likely work related cases
MDPH	Massachusetts Department of Public Health
MVA	Motor vehicle accidents
NCIPC	National Center for Injury Prevention and Control
NEISS	National Electronic Injury Surveillance System
NHAMCS	National Hospital Ambulatory Care Survey
NIOSH	National Institute of Occupational Safety and Health
NIS	Nationwide Inpatient Sample
OIIC	Occupational Injury and Illness Classification System
OSHA	Occupational Safety and Health Administration
PNWR	Probable non-work-related
PVN	Predictive value negative
PVP	Predictive value positive
PWR	Probable work-related
SIC	Standard Industrial Classification
SOII	BLS Survey of Occupational Injuries and Illnesses
WC	Workers' Compensation Insurance

ABSTRACT

Many states are developing statewide data bases of emergency department records that can potentially provide useful information about occupational injuries. In September, 2001 MDPH received funding under NIOSH Grant RO1 OH04262 to evaluate the feasibility of using electronic medical records from the Massachusetts Emergency Department Injury Surveillance System (EDISS), a stratified sample of Massachusetts hospital emergency departments, to characterize the magnitude and distribution of occupational injuries treated in EDs in Massachusetts and to identify potential gaps in the traditional occupational injury data systems. The study aims were: 1) To estimate the sensitivity, specificity, and predictive value of two indicators of work-related injury in EDISS, independently and in combination, 2) To assess the extent to which information about employer, industry and occupation were included in the medical charts and/or the electronic systems of participating hospitals, 3) To estimate the accuracy of E-codes for work-related injuries, 4) To evaluate the feasibility of using two alternative coding protocols (Short ICECI and NEISS) for work-related injuries, and 5) To compare summary data on work-related injuries from EDISS and findings from the Massachusetts Survey of Occupational Injuries and Illnesses to identify potential biases in findings based on these alternative data sources.

EDISS cases with either Workers' Compensation (WC) designated as expected payer or an Injury-at-Work (IAW) value of "yes", or both, were considered probable work-related (PWR). All other cases were considered probable non-work-related (PNWR). Medical charts were reviewed for a stratified study sample of 1002 PWR and 250 PNWR cases drawn from injuries to persons aged 14 through 75 years treated in hospital EDs during the one year period March 1, 1999 through February, 2000. Chart abstractors recorded information on patient employment, injury circumstances and codes, and payment. Abstractors also assessed the "work-relatedness" of the injury based on narrative information in the chart, independent of the payer source and IAW field. E-codes were assigned by an expert E-coder based on the narrative injury descriptors. Findings from EDISS for the period October – September 2000 were compared with findings from the Massachusetts Survey of Occupational Injuries and Illness for the calendar year 2000.

The indicators of work relatedness (WC and IAW) had sensitivity, specificity and predictive value positive (PVP) of 83%, 98% and 85%, respectively, using the chart review assessment of work-relatedness as the gold-standard. However, the medical charts were an imperfect measure of work-relatedness because they capture only the information both queried and recorded by emergency department staff. Insufficient information (other than IAW or WC) to determine work relatedness, rather than contradictory information, largely accounting for the relatively low PVP. The use of the IAW field was infrequent and inconsistent across hospitals making it difficult to assess the value of this field in capturing work-related injuries to workers not covered or not applying for WC.

Employer name was present in 89% of the charts of work related cases reviewed, less so for non-work-related cases, and was available as a data field in all medical registration systems surveyed, suggesting this information is readily available for industry specific analyses and special studies.

External cause of injury E-codes were found to be accurate to four digits for 65% of work-related cases (59% overall), similar to or higher than previous studies. Using broad cause of injury categories typically used for injury surveillance, E-codes were accurate in 85% of cases (work-related and overall).

The comparison of EDISS data and the BLS SOII was problematic. The two systems covered different segments of the working population, used different broad case definitions, and used different nature and cause of injury coding systems that were difficult to reconcile. These systems should beseem as complimentary. The comparison did raise concerns about underreporting and sampling error in SOII at the state level that need to be further explored.

EDISS has the capability to capture a large and representative sample of injuries, both work related and non-work related, across a large and representative sample of the state population into a data set with considerable analytical flexibility, providing a powerful tool for conducting surveillance of workplace injuries. Improvements in the attribution of work-relatedness through more consistent use of the IAW field, and in the accuracy of e-codes, both of which could be addressed through training, would further enhance the value of EDISS. The feasibility of including of an activity field in electronic medical records should be explored to enhance the value of ED data in general and occupational surveillance. Practical methods for routinely using employer information should also be explored to enhance the ability to target surveillance and intervention activities.

SIGNIFICANT FINDINGS

The Massachusetts Emergency Department Injury Surveillance System (EDISS) – a comprehensive, statewide, electronic E-coded injury surveillance system based on data provided by emergency departments - can provide important information about work-related injuries at the state level that compliments information available through the Bureau of Labor Statistics Survey of Occupational Injuries and Illnesses (SOII). The quality of the EDISS data, the system's ability to capture information on both work-related and non-work-related injuries, and the analytic flexibility of the system make it a powerful tool for conducting of surveillance of work-related injuries. Improvements in the attribution of work-relatedness through more consistent use of the payment and IAW fields, and in the accuracy of E-codes, both of which could be addressed through training, would further enhance the value of EDISS for occupational injury surveillance.

To our knowledge this is the first study to assess the accuracy of hospital E-coding of work-related injuries specifically. The proportion of correct E-codes for all injuries found in this study (59%) was similar to or higher than that reported in other studies of non-occupational injuries (MacIntyre, et al, 1997; Schwartz, et al, 1995). Accuracy for work-related injuries was higher (65% correct to four digits). The finding of 85% accuracy of E-codes at the broad E-code level typically used in injury surveillance was a level of accuracy considered adequate for surveillance purposes, though there is room for improvement.

Use of the injury-at-work field (IAW) and workers' compensation (WC) as expected payer as indicators of work-relatedness together detected 83.6% of the injuries identified as work-related in the medical records, similar to previously reported findings in which patient interviews were used to confirm work-relatedness of select injuries (Sorok, et al., 1993). Medical charts, used as the gold standard to determine work relatedness in this study, are an imperfect measure of work-relatedness because they capture only the information both queried and recorded by emergency department staff. Further research using an external gold standard, e.g. patient interviews, to assess true sensitivity is needed.

The use of the IAW field was infrequent and inconsistent across hospitals. Standardized guidance to hospitals on how this data element is defined and how it is to be completed would be necessary to improve its usefulness (Pollock DA, et al, 1998). There was also some inconsistency in the use of WC as a payer option across hospitals that needs to be addressed.

Employer name was present in 89% of the charts of work-related cases reviewed, less so for non-work related cases, and was available as a data field in all medical registration systems surveyed. This suggests that it would be feasible to collect this information for ED cases electronically, though confidentiality concerns and the practical issue of coding thousands of ED cases are potential obstacles. At a minimum, state agencies should have legal access to the employer name information to facilitate targeted studies or periodic surveillance of targeted injuries.

The comparison of EDISS data to the data from the Massachusetts SOII was problematic. The two surveillance systems cover different segments of the working population, use different broad case definitions, and use different nature and cause of injury coding systems that are difficult to reconcile. These systems should be seen as complimentary. Whereas SOII has the distinct advantage of including information about industry and occupation, EDISS offers large sample size, analytic flexibility, information about race and ethnicity, and the ability to examine the contribution of work-related injuries to the overall injury burden, thus fostering comprehensive approaches to prevention. The comparative number of cases captured by the two systems raises concern about underreporting and sampling error in SOII at the state level that need to be further explored.

TRANSLATION OF FINDINGS

A number of states are developing statewide data bases of emergency department (ED) records that can potentially provide useful information about occupational injuries as well as other injuries at the state level. This study explored the feasibility of using a statewide, electronic E-coded* injury surveillance system for surveillance of work-related injuries. Findings indicate that a statewide ED-based injury surveillance system can serve as powerful tool for conducting surveillance of occupational injuries. The study also identified a number to steps to enhance the utility of ED data for occupational injury surveillance:

- The designation of payment by workers' compensation is a conservative but reasonable proxy indicator of work-relatedness to use in conducting surveillance of work-related injuries. However, more consistent use of the *Injury at Work* field is needed to improve the attribution of work-relatedness. Standardization of the use of this field across hospitals and training of medical coding personal could improve the capture of work-related injuries in those not covered or not applying for workers' compensation.

- Inclusion of a field for *Activity* at time of injury, rather than the more narrowly defined "injury at work" variable, would enhance the value of ED data for general, as well as occupational, injury surveillance and deserves consideration (Pollock DA, 1998).

- While *Cause of Injury* coding in the electronic ED data base is accurate enough for surveillance purposes, it could use improvement. Additional training of hospital-based E-coders is needed to enhance the accuracy of E-coding for all injuries, both work-related and non-work-related.

- The ability to document patterns of occupational injury by industry is important to target and evaluate prevention efforts in the state. Employer information is available in medical records of patients treated in EDs and should be made legally available to state agencies for injury surveillance purposes. The practicality of routinely collecting this information in electronic systems should be explored by states.

- Comparison of the estimated number of injuries treated in Massachusetts EDs with the Bureau of Labor Statistics estimates in the Massachusetts Survey of Occupational Injuries and Illnesses, which based on a sample employer injury logs raises, concern about possible underreporting on these logs. Sampling error in the BLS surveillance system is also a concern. Further research in which employer and workers' compensation and or ED data are directly compared is needed to address these issues.

In Massachusetts, findings from this study will be presented to Massachusetts hospitals, the Massachusetts Division of Health Care Finance and Policy, which currently maintains the statewide database of ED visits, and the Occupational Health Surveillance Advisory Board to the Massachusetts Department of Public Health to promote additional training for hospital E-coding staff and to initiate policy discussions about inclusion of the *Injury at Work*, *Activity* and *Employer* fields in the ED visit database.

* *Cause of Injury* is coded in a standardized manner according to the International Classification of Diseases.

SCIENTIFIC REPORT

Introduction

Nonfatal work-related injuries are a significant public health problem in the United States, imposing substantial human and economic costs. Surveillance of these injuries is essential for setting priorities to improve workplace safety. It provides information about the magnitude of occupational injury problems, identifies the industries, occupations, and workplaces where intervention efforts to improve worker health are most needed, and can distinguish populations of workers at high risk who merit special attention. Surveillance also provides information necessary to evaluate effectiveness of interventions and plays a key role in generating hypotheses about risk factors for further research. Surveillance data are important at the both the national and state levels, as well as within individual workplaces and communities (IOM, 1999; NIOSH, 2000).

In 1997, the Massachusetts Department of Public Health (MDPH) with support from the National Center for Injury Prevention and Control (NCIPC) developed a statewide, electronic E-coded surveillance system to track the incidence and causes of injuries treated in hospital emergency departments (EDs). This system, based on data from a representative sample of hospitals, is known as the Emergency Department Injury Surveillance System (EDISS). In September, 2001 MDPH received funding under NIOSH Grant RO1 OH04262 to evaluate the feasibility of using EDISS to characterize the magnitude and distribution of occupational injuries treated in EDs in Massachusetts and to identify potential gaps in the traditional occupational injury data systems. This report details the methods employed and results of this feasibility study. The discussion includes recommendations for enhancing ED surveillance systems to generate population-based surveillance data on work-related injuries that can be used to inform state and local prevention efforts. The final link in the research process, the dissemination of findings and recommendations about the surveillance evaluation to hospitals, injury prevention programs, surveillance programs and other data providers and users will take place over the coming year.

Background and Significance

Each year in the United States, approximately 6,000 workers die as a result of fatal occupational injuries at work and, according to the Bureau of Labor Statistics (BLS) an estimated 6 of every 100 full time workers - approximately 5.2 million individuals - sustain nonfatal injuries at work. Of these, close to a third are injured seriously enough to lose work time (BLS, 2002). Others have estimated that the true number of workers injured each year is closer to 14 million (Leigh, et al., 1997). The economic costs of occupational Injuries have been conservatively estimated at $142 billion annually (Leigh et al, 1997; NIOSH, 1998). The US Public Health Service has called for reducing the incidence of nonfatal occupational injury by 30% by the year 2010, and traumatic occupational injuries have been identified as a national occupational research priority. (USDHHS, 2000; NIOSH, 1996).

Occupational injuries and illnesses are a significant public health problem in Massachusetts, where over three million workers are employed in 186,000 establishments. Each year, on average, 65 workers sustain fatal occupational injuries, with fisherman, landscapers and construction workers facing the highest risks (MDPH, 2002). According to BLS, for every fatality, there are an estimated 1,900 non-fatal injuries and illnesses in Massachusetts – close to 123,000 work-related illnesses and injuries in 2001 - in the private sector alone (BLS, 2002). While the overall rate of occupational injuries and illnesses in Massachusetts is lower than the national rate (5.1 vs. 5.7 per 100 full time

workers in 2001), proportionally more Massachusetts cases result in days away from work (37% vs. 30%). (BLS, 2002). As will be discussed, these BLS estimates capture only part of the problem.

While BLS has established a comprehensive, nationwide surveillance system for traumatic occupational deaths, combining data from multiple sources, there is no parallel single system for non-fatal occupational injuries. Rather a number of data sources are used independently to document nonfatal injuries, and these sources vary widely in scope. The problems of under recognition and under reporting and resulting biases in these systems are not well understood, and there are important surveillance gaps.

Existing Data Sources for Non-Fatal Occupational Injuries

Survey of Occupational Injuries and Illnesses

The BLS Survey of Occupational Injuries and Illnesses (SOII) is the most commonly cited data source for nonfatal occupational injury statistics. SOII data provide national and state level statistics on injuries requiring more than first aid from a sample of private sector establishments. The sample omits important groups of workers including government employees, workers on small farms and the self-employed, which together comprise at approximately 22% of the workforce nationwide and 19% in Massachusetts. There has also been long-standing concern about the validity of employer record-keeping and there is consistent evidence that at least 25% of lost work day injuries in the eligible population are not recorded (Conway et al., 1998; Pransky et al., 1999; Seligman et al., 1988). The extent to which certain populations of workers or injury types may be systematically under-reported has not been evaluated. In many states, the SOII samples are small and cannot provide detailed state or local level data. Recently analysis of the Massachusetts SOII data suggests that the survey cannot generate any meaningful data beyond the broad industry and occupation for specific injury types other than for the most common injuries, such as strains and sprains or cuts and lacerations. During 1994-1997, workers' compensation lost time claims for carpal tunnel syndrome (CTS) in Massachusetts exceeded the estimated number of CTS cases in the Massachusetts SOII by 80% (Davis et al, 2004). Likewise the number of workers' compensation claims for lost time injuries filed by teen workers exceeded the BLS estimates of teen injuries resulting in one or more lost workdays in five of six years examined. (MPDH 2004, unpublished data.)

Workers' Compensation Data

Workers' compensation record systems can be a useful source of state-based information about occupational injuries. These administrative data systems vary markedly from state to state, and the scope of the information generated depends upon the local eligibility requirements for workers' compensation. In Massachusetts, for example, the database of cases is limited to injured workers who have lost at least five days of work as a result of their injuries. Like SOII, workers' compensation data exclude the self-employed and select groups such as postal workers. In some states, large self-insured employers may be missing from the state data sets (Silverstein, 1997). In addition, there is increasing evidence that many workers with traumatic injuries who are eligible may not apply for benefits (Biddle et al., 1998). There is also some evidence that certain populations of workers, for example younger workers, may be less likely to apply than others (Fingar et al., 1992; Brooks et al., 1996; Rosenman, 2000). The extent and implications of potential systematic omissions in these systems needs to be evaluated.

Hospital Based Injury Data

Many work-related injuries are treated in hospital settings. Serious injuries may result in hospital admissions, while others may be treated in emergency departments and released. Unlike traditional employer-based data sources, hospital based data will capture all treated injuries

regardless of industry and do not systematically exclude any specific segments of the workforce, such as the self-employed, household or public workers. These data may be less subject to political or economic factors that may influence the employer-based data sources such as workers' compensation and SOII. They also provide the opportunity to examine the contribution of work-related injuries to the overall burden of injury. Other potential advantages of using hospital based records for occupational health surveillance include: a) extensive information on patient characteristics, diagnoses, patient co morbidities, and medical services provided; b) the availability of E-codes that provide information about the external cause of injuries; c) existing systems for collecting hospital data by state agencies; large numbers of available records from which to derive statistically significant findings, and a low incremental costs of conducting surveillance studies using the available data. In addition, hospital based data systems provide useful information about the medical care costs associated with injury. These cost estimates can be important in defining the economic burden of workplace injury, and emphasizing the potential economic power of prevention. The drawback of using existing hospital data systems is that most do not contain specific information about the work-relatedness of health conditions being treated, and proxy indicators of work-relatedness such as payment by workers' compensation must be used. Also, information about industry and occupation are not currently included in most state and national hospital datasets limiting the usefulness of these data sources targeting specific sectors of the workforce for intervention without additional case follow-up.

In spite of the limitations, both hospital inpatient and emergency department data are underutilized and potentially valuable sources of state and local occupational injury data. As integrated surveillance systems become more feasible, and the need to minimize surveillance costs and provider burden increase, these sources must be re-examined and evaluated for their utility in occupational injury surveillance.

Hospital Discharge Data

Uniform hospital discharge datasets (HDD) are currently maintained in most states (Annest, 1996), and are a potentially important source of information about more severe occupational injuries. However, few surveillance studies have previously been conducted using HDD data to document work-related injuries. An analysis of 1997-1999 data from the Nationwide Inpatient Sample (NIS), revealed an estimated 209,139 hospitalizations for work-related injuries each year nationwide, which accounted for approximately .62% of all inpatient hospitalizations. The designation of workers' compensation as expected payer was used to identify work-related injuries in this analysis (Dembe et al, 2003) . Sorok et al. (1993) evaluated workers' compensation payer code as an indicator of work-relatedness for four injury types in the New Jersey hospital discharge database, using information collected through patient interviews as the gold standard. The sensitivity of this indicator was 83% and false positives were less then two percent. The authors have recently completed an analysis of HDD in Massachusetts, where the accuracy of expected payer is believed to be quite high, having improved over time since the changing health insurance climate has increased awareness of indicating the correct primary payer (Personal Communication: Jerry O'Keefe, 2004). During 1996-2000 there were over 20,000 hospitalizations for which workers' compensation was the designated payer, accounting for 1.2% of all hospitalizations for injuries among the working age population.

Emergency Department Data

Emergency department (ED) records are an important complementary source of information on a wide spectrum of occupational injuries. Data on injuries in the population at large indicate that ED visits outnumber hospital discharge cases by more than 10 to 1(Burt, 1995). Findings in Massachusetts reveal a similar picture: ED visits outnumber hospital admissions by at least 10 to 1 (MDPH, 2004a). It has been estimated that approximately one third of occupational injuries are

seen in the ED (CDC, National Health Interview Survey, unpublished data, 1998). Although injuries that are treated in outpatient settings or by private physicians would not be captured by an ED system, most of the moderate to severe nonfatal injuries would be seen in emergency departments. ED-based surveillance also has the potential for case follow-back and can serve as a case ascertainment source for more intensive study of targeted injuries or populations.

National Hospital Ambulatory Care Survey (NHAMCS) and National Electronic Injury Surveillance System (NEISS)

There are two national emergency department injury surveillance systems that have been used for occupational injury surveillance. The National Hospital Ambulatory Care Survey (NHAMCS) collects data on ED visits from a sample of US hospitals, including information in the charts about work-relatedness. Based on the 1996 survey, in which 396 hospitals from across the nation provided data, 12% (4 million) of an estimated 35 million ED visits for injuries were for work-related injuries. Information about work-relatedness was missing for about 25% of the visits (McCaig et al., 1997). While NHMANC provides important information about the relative contribution of occupational injuries to the overall injury burden, it does not include industry and occupation information and cannot provide state or local level estimates.

The National Electronic Injury Surveillance System (NEISS) collects data on consumer product related injury visits in a national sample of 91 hospital EDs. NEISS is designed to provide population-based estimates to monitor national trends in injury morbidity and also allows for follow-back studies to collect more detailed information from individuals about targeted injuries or injury mechanisms. Since 1995 NIOSH has had an agreement with the Consumer Product Safety Commission (CPSC) to collect data on all work-related injuries regardless of product involvement. NEISS supported staff in the participating hospitals abstract data from the records; data elements include employer name, occupation and industry for injuries identified as work-related. A comparison of NEISS data from one hospital in 1982-1986 with information abstracted from medical charts found that only 71% of eligible work-related injuries were recorded as such by NEISS. Identification of work-related injury is primarily based on expected payer being workers' compensation. Other than this early report, the sensitivity and predictive value positive of NEISS with respect to work-related injuries have not been formally evaluated. Nor has there been a systematic evaluation of different types of injuries by industry and occupation. While valuable for describing the national scope of the problem, NEISS data, like that from NHAMCS, cannot be disaggregated to the state level or local level, limiting its utility for state and local prevention.

Developing Emergency Department Surveillance Systems

Emergency department data in most states are not reported to a central repository, although this is changing. Recent advances in information technology make centralized data collection a possibility. A 1990 survey of Massachusetts acute care hospitals by the MDPH found that 56% did not have electronic ED logs and virtually none were E-coding their ED injury visits. However, by 1997, a survey of 34 randomly selected hospitals found that 70% were E-coding ED visits and retaining these data in electronic databases. In 1997, the MDPH, with support from the National Center for Injury Prevention and Control (NCIPC), implemented a statewide, electronic E-coded surveillance system to track the incidence and causes of all injuries treated in a representative sample of hospital emergency departments (EDISS). Since that time, and in part based on the EDISS experience, the Massachusetts Division of Health Care Finance and Policy (responsible for maintaining the HDD) has implemented a statewide emergency department database collecting data on emergency department visits from all hospitals in Massachusetts. Preliminary analysis of the statewide data for 2002, the first year of data available, there were 94,533 ED visits for which workers' compensation was designated as payer. Of these visits, 78%

were for treatment of injuries. These probable work-related injuries, identified using the designation of workers' compensation as payer, accounted for 14.5% of all ED visits for injuries among people of working age. (MDPH, 2004a.)

The challenge at hand is to integrate occupational injury surveillance into newly developing state-based ED injury surveillance systems in order to generate not only state but also local level data on occupational injuries to inform state and local prevention efforts.

Study Aims

The present surveillance research study was undertaken to evaluate the feasibility of using a statewide comprehensive injury surveillance system to characterize the magnitude and distribution of occupational injuries treated in EDs in Massachusetts and to identify potential gaps in the traditional occupational data systems. Initiated in 2000, the study addressed the following five specific aims:

1. To estimate the sensitivity, specificity, and predictive value of two indicators of work-related injury in the Emergency Department Injury Surveillance System (EDISS), independently and in combination, and determine if these measures of performance varied by population characteristics, including age and gender. Information in the medical charts was used as the gold standard in computing these measures

2. To assess the extent to which information about employer, industry and occupation was included in the medical charts and/or the electronic systems of participating hospitals and to assess the feasibility of obtaining this information as part of the routine electronic submission to the state.

3. To estimate the accuracy of E-codes for work-related injuries.

4. To evaluate the feasibility of using two alternative coding protocols (Short ICECI and NEISS) for work-related injuries.

5. To compare summary data on work-related injuries from EDISS and findings from the Massachusetts Survey of Occupational Injuries and Illnesses to identify potential biases in surveillance findings based on these alternative data sources.

Whereas Aim 5 initially included a comparison of EDISS data on work-related injuries to workers' compensation data as well, this was not possible because these data did not become available to MDPH for analysis within the grant period.

This study responds to the NIOSH call for integrating occupational health information into evolving public health data systems and addresses two NORA priority areas: traumatic injuries and surveillance research methods (NIOSH,2000; NIOSH, 1996).

Methods

Background of EDISS

In 1997, the Injury Surveillance Program (ISP) in the Massachusetts Department of Public Health (MDPH) was funded by the CDC Center for Injury Prevention and Control to develop a statewide, electronic E-coded surveillance system to track the incidence and causes of injuries treated in hospital emergency departments (EDs). The Massachusetts Emergency Department Injury Surveillance System (EDISS) collected ED data from a stratified sample of 12 Massachusetts hospitals for a 40 month period – June 1998-September 2001. Electronic administrative data was collected on all nonfatal, non-admitted visits assigned ICD diagnostic codes (in any field) in the range of 800-999, or any ICD External Cause of Injury codes (E-code) in the range of E800-E999. The information collected for each case included basic patient demographics, medical record numbers, diagnostic codes, and payer source. The complete list of data elements collected by EDISS is attached. (Appendix A). Information about patients seen in EDs and admitted into hospitals for observation was not reported to the surveillance system.

The EDISS hospital sample was selected to be representative of all Massachusetts EDs with respect to both hospital size (volume of patients treated) and geographic location. For EDISS hospital sample selection, acute hospitals with EDs (N=79) were categorized by Emergency Medical Service region. Within regions, hospitals were defined as high or low volume according to annual ED visits as reported to the Massachusetts Division of Health Care Finance and Policy. High volume hospitals were those with total annual ED visits greater than 26,027, the remaining hospitals were considered low volume. One high volume and one low volume hospital were randomly selected from each region. If any hospital in the random sample was unable or unwilling to provide electronic E-coded data for all injury visits, the next available hospital was selected. Since local population-based data are most useful for developing local injury prevention initiatives, six sites selected with certainly were added to the core sample to gain population based coverage in diverse communities. To estimate statewide incidence from the sample of hospitals that participated in EDISS, sample estimates were multiplied by the ratio of the total number of ED visits in Massachusetts to the number of ED visits in the reporting hospitals

Since EDISS was implemented, and in part based on the EDISS experience, the Massachusetts Division of Health Care Finance and Policy has developed a statewide database that includes data on emergency department visits from all hospitals in Massachusetts. A comparison of the projected statewide numbers and rates of all injuries in EDISS 2001 with actual numbers and rates for all injuries in the full statewide ED data for 2002, the first year for which these data were available, found substantial similarity between the data sets, indicating that the EDISS sample of hospitals represented all Massachusetts hospitals well. A similar comparison of injuries for which workers' compensation was designated as payer in EDISS 2000 (72,651) with the ED 2002 data (73,517), found that the EDISS sample of hospitals also represented the distribution of work-related injuries in all Massachusetts hospitals well.

Definition of Work-Relatedness in EDISS

Among the data elements collected by EDISS were two indicators of work-relatedness: payer source designated as Workers' Compensation (WC) and an injury-at-work field (IAW). Payer source information was submitted by all 12 participating EDISS hospitals, however, WC was not an option at two of the hospitals; data for the IAW field was only submitted by four hospitals. EDISS cases with *either* WC designated as payer *or* an IAW value of "yes", or both, were

considered *probable work-related* (PWR). If neither of these criteria were met, the cases were considered *probable non-work-related* (PNWR).

Study Period, Sample Frame, Size, and Selection

Aims 1 through 4 required the collection of detailed information from medical charts to confirm data provided in the electronic records and to determine the availability of information in the charts relevant to effective surveillance of work-related injuries. A study sample of PWR and PNWR cases was drawn from injuries to persons aged 14 through 75 years treated in hospital EDs during the one year period March 1, 1999 through February 29, 2000, and reported to EDISS. PWR cases were oversampled in a 4:1 ratio because the primary interest was in the characteristics of the PWR cases. A total sample size of 1200, collected in the 4:1 PWR:PNWR ratio, was determined to provide sufficient precision in the calculation of sensitivity and predictive value positive. Cases were selected from each hospital using stratified proportional sampling using SAS version 8, SAS SURVEYSELECT. An approximate ten percent (10%) over-sampling was designed to allow for missing medical records during the chart audit process resulting in a total sample of 1310 cases (1048 PWR, 262 PNWR).

Data Abstraction

A data abstraction form for completing chart reviews was developed in consultation with medical records, occupational injury and emergency department surveillance experts. These forms were designed to collect the following information from the medical record: employer's name and address (up to two), employer's industry (up to two), patient's occupation (up to two), and the location of each of these within the actual medical record; the presence of an "injury-at-work" field in the medical record and the information in that field; the primary payer listed for the visit; the E codes listed for the visit, and narrative information about the circumstances of the injury, including the activity the patient was engaged in at the time of the injury, as well as the cause, location, tools/equipment involved, and the intent of the injury. One of the data abstractors, a nationally renown E-coding expert, assigned validation E-codes based on the narrative injury descriptions in the charts and recorded the validation E-code and a "validation" ruling describing the relationship between the medical chart E-codes and the newly assigned E-codes. Validation rulings were categorized as shown in Table 1.

Abstractors were also asked to provide their assessment of "work-relatedness" of the injury based on narrative information in the chart, independent of the payer source and information in the "injury-at-work" field. Consistent with national guidelines (Jenkins, 1993) , a work-related injury was defined as any injury incurred by an individual while doing work for compensation, while arriving at or leaving work but on employer premises, while doing agricultural production activities or working as a volunteer for an organized group. Self-inflicted injures at work were excluded. Possible responses to this assessment were 1) work-related, not active military 2) work-related, active military 3) not work-related 4) not sure if work-related (with space for explanation) and 5) unspecified. Sports and motor vehicle related injuries not specifically identified in the records as work-related were considered to be not work-related. For cases that were work-related, the abstractors were asked to list the source(s) of work-related information within the chart. Cases for which data abstracters designated work-relatedness as "unsure" were reviewed by occupational health experts, and, where possible, reassigned as work-related or not work-related. Injuries consistent with occupational titles but not clearly specified as work-related in the narrative, e.g., fall from roof by roofer, were designated work-related.

For a subsample of cases, abstractors were also asked to collect information about several additional data elements that are needed to code injuries according to the International Classification of External Causes of Injury (ICECI) and National Electronic Injury Surveillance System (NEISS) coding systems. A sample data abstraction form is attached (Appendix B).

Chart reviews were performed by a contracted medical records consulting firm. An initial four hour training session about the study goals and the definition of work-relatedness was provided for the data abstracters. Training materials are attached (Appendix C).

The information abstracted from each record was entered into an ACCESS database. Employer and industry information was classified according to the Standard Industrial Classification (SIC) System (Office of Management and Budget, 1987). SIC codes for employers were obtained from the Massachusetts Division of Employment and Training (DET), which maintains this information for purposes of unemployment compensation insurance. Where SIC codes were not available in the DET database, codes were assigned using commercially available business databases or information about specific company activities available on the internet. Where these information sources failed, SIC codes were assigned by a trained industry coder if the company name gave sufficient information to code the establishment (e.g., ABC Construction, XYZ Bakery).

Table 1. Validation codes for assessing accuracy of E-codes assigned in ED medical charts

Ruling Number	Description
1	Completely correct cause and place of occurrence
2	Cause of injury documented – correct code
3	Cause of injury documented – incorrect code
4	Cause of injury not documented – correct code
5	Cause of injury not documented – incorrect code
6	Place of occurrence documented – correct code
7	Place of occurrence documented – incorrect code
8	Place of occurrence documented – missing code
9	Place of occurrence not documented – correct code
10	Place of occurrence not documented – incorrect code
11	Place of occurrence not documented – missing code
X	Not an injury
Y	No E-code assigned by hospital

Sensitivity, Specificity and Predictive Value

The sensitivity, specificity, and predictive value positive/negative of the two indicators of work relatedness (payer = WC and IAW = yes) were calculated using the chart abstractors' assessment of work-relatedness as the "gold standard." Part of the intent of these analyses was to compute these measures for WC and IAW separately and in combination. However, due to the infrequent and inconsistent use of the IAW field across hospitals, sensitivity was not calculated for IAW alone as an indicator of work-relatedness. Sensitivity was calculated for WC + IAW and WC only. Separate measures were calculated for three age groups (14 to 25, 25 to 55, and 55 to 75 years old) and by gender. Specificity and predictive value (positive and negative) were computed

in a similar fashion, again assuming that the narrative information in the chart as the gold standard.

To estimate sensitivity, specificity and the predictive values (positive and negative), it was necessary to take into account the different sampling fractions for the PWR and PNWR cases. Sample weights were calculated as the inverse of the probability of being sampled:

$1/p_i = N/n_i$

Where p_i = the sampling fraction for the stratum
i = the stratum, probable work-related or probable non-work-related
n_i = the number of records in the study sample stratum
N = the number of records in the EDISS stratum

Table 2. Sampling weights for calculation of sensitivity, specificity, and predictive values

	Sampling Weights	
	PWR	**PNWR**
EDISS	17.78	362.03
Males	17.32	410.85
Females	18.88	319.08
Age 14- 24	18.00	362.16
Age 25-54	17.54	360.92
Age 55 -75	19.83	366.00

PWR = Probable work-related
PNWR = Probable not work-related

Weights were calculated for PWR and PNWR cases for all of EDISS, for each gender, and the three age categories. Weighted cell counts for determining sensitivity, specificity and predictive values were then calculated using the cell counts in the cross-tabulation of EDISS and chart designation of work-relatedness multiplied by the applicable sampling weight. The weighting scheme is illustrated in Figure 1. Sampling weights are shown in Table 2.

Availability of Employment Information in Emergency Department Records

The presence of employer's name and address (up to two), employer's industry (up to two), patient's occupation (up to two), and the location of each of these within the actual medical record were collected in the medical record abstraction. Simple frequencies were calculated to assess the availability of information about work-relatedness of injury and employment variables

Figure 1. Application of sampling weights for calculation of sensitivity, specificity, and predictive value positive and negative

Cells counts from chart review

		Chart Review Work-related: Yes	Chart Review Work-related: No	
PWR	Yes	a	$n_1 - a$	n_1
	No	$n_2 - d$	d	n_2
		$a + (n_2 - d)$	$(n_1-a) + d$	

Weighted cell counts

		Chart Review Work-related: Yes	Chart Review Work-related: No	
PWR	Yes	w_1a	$w_1(n_1 - a)$	w_1n_1
	No	$w_2(n2 - d)$	w_2d	w_2n_2
		$w_1a + w_2(n_2 - d)$	$w_1(n_1-a) + w_2d$	

PWR = Probable work-related in EDISS.
w_1 = sampling weight for PWR Yes
w_2 = sampling weight for PWR No

in the medical charts for the PWR and PNWR cases in the study sample. These frequencies were weighted using the weights in Table 2 to generate estimates of information availability for EDISS as a whole.

To assess the feasibility of routinely collecting available employment information as part of the surveillance system, telephone interviews were completed with medical record or information technology staff at each of the 12 EDISS hospitals. Respondents were asked if the electronic medical records for patients treated in EDs had separate fields for employer name, industry, or occupation and, if so, whether this information was collected as part of the patient registration process.

Validation of E-Codes

Validation E-codes assigned by the expert E-coder were compared to the E-codes on the face sheets of the medical charts. Validation E-codes were also compared to the E-codes contained in the electronic EDISS data using strict comparison criteria (exact code match) and broad comparison criteria. Broad agreement was based on 16 Cause of Injury categories in the proposed ICD-9 Framework for Presenting Injury Data developed by the International Collaborative Effort (ICE) on Injury Statistics (NCHS, 2004). The Cause of Injury categories and the E-codes included in each category are given in Appendix D. The proportion of EDISS E-codes matching the validation E-codes was computed as a measure of the validity of the EDISS data.

Alternate Injury Coding Systems

The abstracted information on the presence of data elements needed to code injuries according to the ICECI and NEISS coding systems was examined to determine the feasibility of coding injuries under these alternate systems using the information available in medical charts. The proportion of reviewed PWR and PNWR charts having the data necessary to code the injuries according to ICECI and NEISS systems was computed as a measure of the feasibility of using these alternate coding systems.

Comparison of Data on Occupational Injuries Treated in Emergency Departments with Findings from the Massachusetts Survey of Occupational Injuries and Illnesses (SOII)

EDISS

For purposes of generating a descriptive epidemiology of occupational injuries treated in Massachusetts EDs and comparing findings to those based on MA SOII, the full EDISS dataset for the fiscal year 2000 (Oct 1999-September 2000) was used. Only eleven of the twelve hospitals that reported data during the study period for Aims 1 through 4 reported data during this period. To estimate statewide incidence of injuries, injury-types, injuries-by-cause, and body part affected from the sample of hospitals that participated in EDISS, the number of injuries in EDISS was multiplied by the ratio of the total number of ED visits for injuries in Massachusetts to the number of ED visits for injuries in the reporting hospitals:

$$I_{i,state} = I_{i,\,EDISS} \times V_{state} / V_{EDISS}$$

where $I_{i,state}$ = the estimated number of injuries in category i for Massachusetts FY2000
$I_{i,\,EDISS}$ = the number of injuries in category i in EDISS FY2000
V_{state} = the total number of ED visits in Massachusetts FY2000
V_{EDISS} = the total number of ED visits in EDISS FY2000

For FY2000, the ratio of total ED visits in Massachusetts to total ED visits in EDISS was 6.12.

Massachusetts Survey of Occupational Injuries and Illnesses

Data on occupational injuries in Massachusetts during 2000 was obtained from the Survey of Occupational Injuries and Illnesses (SOII) conducted by the Massachusetts Department of Labor and Industries in collaboration with the Bureau of Labor Statistics (BLS). SOII provides annual estimates of the number and incidence rates of occupational injuries and illnesses among private sector workers at the state level. Estimates are based on a sample of illness and injury logs maintained by private sector employers as required under OSHA record-keeping guidelines (OSHA logs). Recordable work-related injuries and illnesses include those that require medical treatment other than first aid, involve loss of consciousness, restriction of work or motion, or transfer to another job (BLS, 1992). Excluded from the survey are self-employed workers, farms with fewer than 11 workers and employees of federal, state and local government agencies. In 2000, the Massachusetts survey sample included approximately 5,600 establishments statewide. Sample design and estimating procedures are described elsewhere (BLS, 1997).

SOII requires participating employers to provide summary information on all recordable injuries and illnesses copied directly from OSHA logs, information about the number of employee hours worked, and more detailed information on worker demographics and the illness or injury (nature of injury, body part affected, sources of injury and event or exposure) for cases involving days away from work. Survey staff code the characteristics (nature of injury, event, source and body part) of cases with days away from work according to the Occupational Injury and Illness Classification (OIIC) system (BLS, 1992). Total injuries in the MA SOII are tabulate as those that are checked off as injuries on the OSHA 200 logs submitted by employer. These may include conditions that are ultimately not coded as injuries by BLS staff. For detailed comparison of EDISS with the MA SOII cases with days away from work, injuries were defined as those that were coded as Traumatic Injuries and Conditions (OOIC Division 0) in the SOII.

Results

Specificity, Specificity, and Predictive Value

From March 1, 1999 to February 29, 2000, 108,328 injuries were treated in emergency departments (ED) at the 12 EDISS hospitals and reported to MDPH. Of these, 17,820 were identified as PWR injuries using the two indicators of work-relatedness; 12,921 were identified solely through the designation of workers' compensation (WC) as payer; 2,530 solely through the designation of injury at work (IAW), and 2,369 through both. Table 3 shows the number of injuries treated in EDs at each hospital by designation of work-relatedness.

Table 3. Distribution of injuries treated in emergency departments by work-relatedness designation and by hospital, Massachusetts EDISS, March 1999-February, 2000

Hospital	Probable Non-Work-Related	Probable Work-Related			
		Workers' Compensation only	Injury at Work only	WC and Injury at Work	Total work-related
Berkshire	8,524	0	1,663	0	1,663
Cape Cod	13,768	1,708	0	0	1,708
Charlton	11,313	3,629	0	0	3,629
Fairview	2,970	0	622	0	622
Falmouth	5,997	1,131	0	0	1,131
Harrington	3,737	888	0	0	888
Holy Family	6,476	1,181	0	0	1,181
Milford/Whitinsville	3,672	765	0	0	765
Salem/North Shore	8,566	58	164	1,128	1,350
St. Luke's	12,914	2,496	0	0	2,496
Sturdy Hospital	7,706	100	81	1,241	1,422
Tobey	4,865	965	0	0	965
Total	90,508	12,921	2,530	2,369	17,820

It had been anticipated that inclusion of an IAW field in EDISS would increase the yield of work-related injuries to include injuries to patients not covered by or eligible but not applying for workers' compensation. However, the use of this field differed substantially across hospitals, providing insufficient data to make a useful comparison between the two EDISS indicators of work-relatedness. Eight of the hospitals used only the designation of WC in the payer field and never checked the IAW field. In two hospitals, WC was never used as payer option and work-related injuries were indicated only by the IAW field. In only two hospitals, Salem/North Shore and Sturdy, were both indicators used. In these two hospitals, 245 out of 2772 PWR injuries (8.8%) were identified by the IAW field only. While it would be expected that all WC cases should also have been designated as IAW, 158 (5.7%) of the PWR injuries in these two hospitals were identified as such only by designation of WC as payer. These cases may reflect coding errors or omissions and raise the suspicion that many of the IAW only cases may also be coding errors or omissions. This uncertainty in the coding in these two hospitals and the inconsistency of the coding across the EDISS hospitals made it difficult to assess the added value of using the IAW field to capture work-related injuries.

Table 4 shows the demographic characteristics of injury cases by work-relatedness for all cases reported to EDISS during the study period and for the chart review study sample. Whereas males comprised 48.2% of the Massachusetts population, they accounted for 55.6% of all cases reported to the EDISS hospitals ($p < 0.05$) and 53.6% of al PNWR cases ($p<0.01$) (US Census, 2000). Males, who comprised 51.4% of the Massachusetts workforce, accounted for 68.4% of PWR cases ($p<0.001$) (US Census, 2000). Patients seeking treatment for PWR injuries were proportionately more likely than the PNWR cases to be in the 24-55 year old age group. The converse was true for the patients in the younger (14-24 years) and older (55-75 years) age groups.

Table 4. Distribution of injuries by gender and age group and work-relatedness, EDISS and the study-sample, Massachusetts, March 1999 – February, 2000

	EDISS			Study Sample		
	All Injuries (%)	**PNWR Injuries** (%)	**PWR Injuries** (%)	**All Injuries** (%)	**PNWR Injuries** (%)	**PWR Injuries** (%)
Gender						
Male	60,263 (55.6) [a]	48,069 (53.1) [a]	12,194 (68.4)[b]	821 (65.6)	130 (46.8)[c]	691 (70.3)
Female	48,064 (44.4)	42,438 (46.9)	5,626 (31.6)	431 (34.4)	133 (53.2)	298 (29.7)
Age (yrs.)						
14-24	32151 (29.7)	27886 (30.8)	4265 (24.0) [d]	314 (25.1)	77 (30.8)	237 (23.7)
25-54	61811 (57.1)	49446 (54.6)	12365 (69.4) [e]	842 (67.3)	137 (54.8)	705 (70.4)
55+	14366 (13.3)	13176 (14.6)	1190 (6.7) [d]	96 (7.7)	36 (14.4)	60 (6.0)
Totals	108000	90000	17000	1252	250	1002

[a] The proportions of males all EDISS and EDISS PNWR cases is significantly greater than proportion of males in Massachusetts population(48.9%) $p < 0.001$.
[b] Proportion of male EDISS PWR cases is significantly greater than proportion of males in Massachusetts workforce (51.4%). $p < 0.001$.
[c] The proportion of PWNR males in the study sample is significantly less than the proportion in EDISS, $p = 0.046$.
[d] The proportions of PNWR injuries is significantly greater than the proportion of PWR injuries in 14-24 and 55-75 year ages groups ($p < 0.001$).
[e] The proportion PWR injuries is greater than the proportion of PNWR injuries in the 24-55 year old age group ($p < 0.001$).

Initially 1,048 PWR cases and 262 PNWR cases were selected for inclusion in the study sample. Of these 1310 cases, 1252 (94.8%) had medical records available for review (Table 4). The proportion of PWNR cases in the study sample that were male was significantly less than the proportion in EDISS, (p=0.046), otherwise, the age and gender distributions of the 1252 PWR and PNWR cases in the final study sample did not differ significantly from the age and gender distributions of the PWR and PNWR cases in EDISS as a whole (Table 4).

The medical chart abstractors reported independent assessments of work-relatedness based on review of narrative information in the medical records for 1246 of the 1252 cases in the study sample (Six cases had insufficient information to assess work-relatedness). The results of this chart review are shown in Table 5. Of the 1002 PWR cases reviewed, 859 were confirmed as work-related by chart review (Chart work-related (CWR), eight were determined to be non-work-related (Chart Not Work-related (CNWR)), and 127 were classified as unsure or work-relatedness was not specified by the expert (including two of the six cases with insufficient information). Of the 250 PNWR cases, nine were classified as CWR, 223 were confirmed as non-work-related (CNWR), and 14 were classified as unsure/ unspecified (including 4 with insufficient information). For calculating sensitivity, specificity, predictive value positive and negative, the unsure/unspecified cases were grouped with the CNWR cases. The counts from the study sample were multiplied by the stratum specific sampling probabilities shown in Table 2 to yield the weighted observations shown in Table 6. Table 7 shows the estimated sensitivity, specificity, predictive value positive, and predictive value negative of the EDISS indicators for work-relatedness calculated from the weighted observations for EDISS overall, by gender and by age category.

Table 5. Distribution of injuries by work-relatedness as determined by EDISS indicators and by chart review

		Chart Review Work-Related			
		Yes	No	Unsure	Total
EDISS Probable Work-Related	Yes	859	8	135	1002
	No	9	223	18	250

The sensitivity of the two EDISS indicators of work-relatedness combined was 83.6%, indicating that the EDISS indicators captured 83.6% of the injuries designated as work-related based on review of the medical records. It is notable that for a significant proportion of the cases reviewed, the data abstractors could not find information about the work-relatedness of the injury (other than the payer and IAW fields in the medical records) and rated work-relatedness as "unsure." In only 8 of the 1002 EDISS PWR cases reviewed (Table 5) was there evidence in the medical records that contradicted the EDISS work-related indicators. The large number of cases for which the determination of work-relatedness was uncertain did not have a large impact on sensitivity. When all the EDISS PWR /Chart Unsure cases were assigned to EDISS PWR/Chart WR category, the sensitivity increased by approximately 2% to 86%. However, the cases with uncertain Chart WR status had a large impact on the predictive value positive (PVP). The PVP of the EDISS work-related indicators was 85.7%, indicating that there was no narrative information confirming work-relatedness in the medical records for approximately 14% of the EDISS PWR cases. However, as indicated above, less than 1% of the PWR cases had information indicating that the injury was NOT work-related. The somewhat low predictive value positive was due primarily to this lack of information about work-relatedness in the medical records rather than the presence of contradictory information. The PVP calculated excluding the Chart Unsure cases increased to approximately 99%. The specificity of the EDISS indicators was very high 97.7%,

indicting that only 2.3% of CNWR injuries are misclassified as work-related using the payer and IAW information reported to EDISS.

Table 6. Weighted distribution of injuries by work-relatedness as determined by EDISS indicators and by chart review

		Chart Work-Related		
		Yes	No[a]	Total
EDISS Probable Work-Related	Yes	15307	2513	17820
	No	3311	87197	90508
Total		18619	89709	108328

[a] Expert work-related "No" category includes cases that were judged unsure in the review of medical records

The large number of cases with ambiguous information about work-relatedness indicates that the narrative information in the medical chart is a less than perfect gold-standard for determining work-relatedness. The National Electronic Injury Surveillance System uses any information in ED records – payment data as well as narrative notes – to identify work-related injuries (Jackson, 2001). A second analysis was carried out using the NEISS approach. Likely work related cases (LWR) were defined as those for which either the EDISS indicators or the chart review indicated work-relatedness and the fraction of the LWR cases captured by each of the information sources was examined. The total number of LWR cases was 15,307 + 3,311 + 2,513 = 21,131 (Table 6). Of these, EDISS captured 84% (17,820/21,131) and the chart review captured 88% (18,619/21,131).

The sensitivity of the EDISS indicators was significantly lower for males than females (78.6% and 88.1%, respectively ($p < 0.001$)). Specificity, PVP, and predictive value negative (PVN) were similar across genders. Under the assumption that the chart review assessment of work-relatedness is a gold-standard, these findings indicate that work-related injuries sustained by men were less likely to be identified as work-related using the EDISS indicators than work-related injuries to women. However, given the limitations of the chart review as an indicator of true work-relatedness, these findings could indicate that chart review did a poorer job of capturing work-related injuries to women because chart information was limited; perhaps women injured at work were not asked about the place of occurrence of injury as often. This interpretation is supported by the PVP, which was lower in women than men, indicating that, of the PWR injuries to women, fewer were confirmed as work-related by chart review. However, the proportion of cases for which work-relatedness was unsure was not substantially different in men and women, which would be expected if chart information were collected differentially.

Sensitivity also differed significantly across the age groups being lowest (72.5%) in the 14-24 year old age category and highest (100%) in the 55-75 year old age category ($p<0.001$ in pair-wise comparisons). Predictive value negative was significantly higher and PVP was significantly lower in the oldest age group compared with the other two ($p<0.05$ in pair-wise comparisons). The number of PWR cases ages 55-77 years in the study sample was relatively small (36) and there were no misclassified WR cases in this age category. This likely overestimates the actual sensitivity and predictive value negative for this group and underestimates the variance associated with the comparisons of these results. For example, shifting one count from the PWNR/CNWR

Table 7. Estimated sensitivity, specificity, predictive value positive and negative of EDISS indicators of work-relatedness, Total EDISS and by gender and age groups, Massachusetts, March 1999 – February, 2000

	% Sensitivity (95% CI)[a]	% Specificity (95% CI)[a]	% Predictive Value Positive (95% CI)[a]	% Predictive Value Negative (95% CI)[a]
All injury cases	83.6 (81.1, 86.1)	96.9 (95.2, 98.7)	85.7 (83.6, 87.9)	96.4 (94.1, 98.7)
Male	78.6[b] (75.3, 81.8)	96.5 (94.0, 99.0)	86.5 (84.0, 89.0)	94.0 (89.7, 98.3)
Female	88.1[b] (84.1, 92.1)	97.9 (95.8, 100.0)	83.9 (79.7, 88.0)	98.5 (96.4, 100.0)
Age 14-24	72.5[c] (66.5, 78.4)	98.3 (95.8, 100.0)	89.5 (85.5, 93.4)	94.8 (89.8, 99.7)
Age 25-55	85.4[c] (82.6, 88.2)	96.4 (94.0, 98.8)	85.5 (82.9, 88.1)	96.3 (93.2, 99.5)
Age 55-75	100.0[c]	97.6 (93.5, 100.0)	73.3[d] (62.1, 84.5)	100.0[d]

[a] 95% confidence interval.
[b] Sensitivity is significantly different across genders $p < 0.001$
[c] Sensitivity is significantly different across age categories; $p < 0.001$
[d] Predictive value positive and predictive value negative 55-75 age group is significantly different from the two younger age groups; $p < 0.05$.

cell to EDISS PNWR/CWR decreases the sensitivity to about 70% and the PVN to 97% and only the difference in sensitivity between the 25-55 and 55-75 age groups is significant. Specificity was similar across age groups.

The extent to which these differences reflect age-related differences in the collection and documentation of information about work-relatedness in the narrative medical record is not known. The low sensitivity in younger age group may be indicative of failure of young workers to apply for or be eligible for workers' compensation. There is some evidence that young workers injured on the job are less likely to apply for workers' compensation than older workers (Brooks and Davis, 1996; Fingar, 1992; Biddle, 1998). The low sensitivity may also indicate an increased likelihood that younger workers were asked about location of injury; however, as for the gender comparison, the proportion of cases for which work-relatedness was unsure was not substantially different across age groups.

Table 8 shows the sensitivity, specificity, predicative value positive and predictive value negative of using payer workers' compensation alone as an indictor of work-relatedness. In these calculations the two hospitals in which Workers' Compensation was not a payer option have been excluded. The values for sensitivity, specificity, predicative value positive and predictive value

negative were generally very similar to those for the combined work-relatedness indicator (Table 7). The patterns of differences across genders and age groups were also very similar, though the magnitudes of the differences were generally smaller among the measures for WC only. Sensitivity of WC as an indicator of work-relatedness was not significantly different across genders. Sensitivity was significantly different across age groups. The lower sensitivity in the younger age group when using WC as an indicator may be indicative of failure of young workers to apply for or be eligible for workers' compensation, as noted above for the combined work-relatedness indicator.

Table 8. Estimated sensitivity, specificity, predictive value positive and negative of Workers' Compensation (WC) as an indicator of work-relatedness, All EDISS and by gender and age groups, Massachusetts, March 1999 – February, 2000

	% Sensitivity (95% CI)[a]	% Specificity (95% CI)[a]	% Predictive Value Positive (95% CI)[a]	% Predictive Value Negative (95% CI)[a]
All injury cases	83.0 (80.3, 85.7)	97.4 (95.6, 99.2)	87.2 (85.0, 89.4)	96.4 (94.0, 98.8)
Male	80.7 (77.3, 84.1)	96.9 (94.1, 99.6)	88.6 (86.0, 91.2)	94.3 (89.8, 98.8)
Female	84.9 (80.2, 89.7)	98.0 (95.8, 100.0)	84.2 (79.7, 88.7)	98.1 (95.7, 100.0)
Age 14-24	74.4[b] (68.0, 80.7)	98.7 (96.3, 100.0)	91.8[c,d] (87.9, 95.6)	95.3[e] (90.3, 100.0)
Age 25-55	85.1[b] (82.0, 88.1)	96.8 (94.3, 99.3)	87.1[c,d] (84.4, 89.8)	96.2[e] (92.9, 99.5)
Age 55-75	97.4[b] (92.5, 100.0)	97.2 (92.4, 100.0)	70.4[d] (58.2, 82.5)	99.8[e] (98.3, 100.0)

[a] 95% confidence interval.
[b] Sensitivity is significantly different across age categories; $p < 0.003$ in pair-wise comparisons.
[c] Predictive value positive is marginally significantly different between 14-24 and 25-54 age groups; $p=0.054$ in pair-wise comparison.
[d] Predictive value positive in 55-75 age group is significantly different from the two younger age groups; $p< 0.01$ in pair-wise comparisons.
[e] Predictive value negative in 55-75 age group is marginally significantly different from the two younger age groups; $0.10 <p< 0.05$ in pair-wise

Table 9. Availability of employer information, EDISS, Massachusetts, March 1999 – February, 2000

	PWR Injuries N= 1002 (%)	PNWR Injuries N=250 (%)	All EDISS Estimated[a] (%)
Employer Name	890 88.8%	106 42.4%	50.0%
Employer Street Address	768 76.6%	91 36.4%	43.0%
Employer City/Town	772 77.0%	88 35.2%	42.1%
Employer State	700 69.9%	83 33.2%	39.2%
Employer Zip code	423 42.2%	35 14.0%	18.6%
Total	1002 100.0%	250 100.0%	100.0%

[a] Proportion of all EDISS cases estimated using proportions of PWR and PNWR cases and sampling weights from Table 2.

Availability of Employment Information in Medical Records

Medical record abstractors were directed to search the medical records for information about three distinct employment variables: patient's employer, industry - independent of employer- and occupation. As shown in Table 9, the review of records for employer information found that employer name was more likely available for the PWR cases (89%) than the PNWR cases (45%) ($p< 0.001$). When the PNWR cases reported as not-working were excluded, employer name was available for 62% (120/193), still less often than for the PWR cases, which by definition should have all been employed. Applying the sampling weights from Table 2, it is estimated that 54% of all cases reported to EDISS during the study period had information about employer name in the medical records.

Self-employed individuals comprise approximately 6.7% of the working population in Massachusetts and are known to have high occupational injury rates (MDPH, 2003). It is noteworthy that only one of the PWR cases in the sample was identified as self-employed. This is not surprising because self-employed workers were not eligible for workers' compensation during the period of the study[1], and payment by workers' compensation was used to identify the great majority of the PWR cases in the sample. Of the 9 PNWR cases identified as having work-related injuries in the medical record review, only one was identified as self-employed.

Of the 998 cases for which employer names were provided, street address and zip code of the employer were available for about 77% of the PWR cases and about 36% of the PNWR cases. Trained industry coders were able to assign Standard Industrial Classification codes to 98.1% of the PWR and 55.2% of the PNWR cases with employer name information (87.8% and 42.0% of all PWR and PNWR cases, respectively).

[1] In 2003, Massachusetts insurance laws were changed providing self-employed workers the option of purchasing workers' compensation insurance.

Information about the industry in which the injured individual was employed, independent of employer name, was available for only 13% of the PWR cases and 4% of the PNWR cases respectively. Information about occupation was more likely available for the PWR cases than the PNWR cases (34% vs. 18%).

Because employer name and industry can both be classified according to standard industry coding schemes, they were examined in combination. Of the PWR cases, 89.5% had either employer name *or* industry provided compared to 76.0% of the PNWR cases and 88.9% of WC cases.

The location of information about employer, industry and occupation within the medical record is summarized in Table 10. The Face Sheet was the most useful source of information about all three variables, followed by accident reports for employer name and summary sheets for industry and occupation information. Clinical notes had information about employer, industry, and occupation in less than 1% of all cases and less than 7% of cases for which some employer, industry or occupation information was available.

Table 10. Location of employment information in the medical records, EDISS sample, Massachusetts, March 1999 – February, 2000 [a]

Location of information within chart	Employer name n= 1087	Industry n = 136	Occupation n= 398
Face sheet	957 88.0%	91 66.9%	318 79.9%
Clinical notes	11 1.0%	6 4.4%	29 7.3%
Summary report	21 1.9%	20 14.7%	40 10.1%
Industrial accident report	208 19.1%	5 3.7%	0 0.0%
Work injury report	4 0.4%	0 0.0%	2 0.5%
Other[b]	51 4.7%	3 2.2%	3 0.8%
Location not coded	116 10.7%	2 1.5%	93 23.4%

[a] Proportions may add to greater than 100% because information may appear in more than one place in the medical chart.
[b] Includes TRA, billing forms, return to work evaluation form, previous hospital record, ambulance report, treatment orders, and missing

Telephone interviews conducted during 2004 with admitting or registration staff at the 12 EDISS hospitals revealed that all of the 12 had separate fields for employer name, for occupation, and for injury at work in their electronic medical record data systems. None had a separate field for industry. In all hospitals, the employment information was collected by admitting staff as part of the patient registration process. In 4 hospitals the collection of employer name was considered mandatory. Ten of the hospitals used electronic medical registration software purchased from MEDITECH, a leading software vendor in the health care informatics industry. One hospital was planning to switch to MEDITECH registration software in the near future.

Table 11. Distribution of cause of injury E-code validation rulings for PWR and PNWR cases, EDISS, Massachusetts, March 1999 – February, 2000

Validation Ruling	PWR Injuries (%)	PNWR Injuries (%)	All EDISS Estimated [a] (%)
1. Completely correct cause and place of occurrence	66 (6.6)	33 (13.2)	(12.1)
2. Cause of injury documented – correct code	559 (55.8)	101 (40.4)	(42.9)
3. Cause of injury documented – incorrect code	295 (29.9)	87 (34.8)	(33.9)
4. Cause of injury not documented – correct code	11 (1.1)	2 (0.8)	(0.8)
5. Cause of injury not documented – incorrect code	38 (3.9)	8 (3.2)	(3.3)
X. Not an injury	7 (0.7)	8 (3.2)	(2.8)
Y. No E-code assigned by hospital	10 (1.0)	6 (2.4)	(2.2)
Missing a ruling	17 (1.7)	5 (2.0)	(2.2)
Total	1002 (100.0)	250 (100.0)	(100.0)

[a] Proportion of all EDISS cases estimated using proportions of PWR and PNWR cases and sampling weights from Table 2.

Accuracy of E-Codes

Primary E-codes for cause of injury were assigned on the face sheets or in the charts for 1234 of the 1252 injuries in the study sample. A second cause of injury E-code was assigned in 10 cases and a third E-code was assigned in only 1 case for a total of 1245 E-codes assigned by the hospitals. Among the 985 PWR cases, 979 E-codes (972 primary codes, 98.7%) were assigned and 266 E-codes (262 primary codes, 98.1%) were assigned among 267 PNWR cases. This represents a very complete record, particularly considering that E-codes were not mandated for injury cases in EDs at the time of the study. Transcription errors were less than one percent: E-codes for six cases in the electronic EDISS records were different from the E-codes appearing on the face sheets and four cases were missing e-codes in the EDISS records.

The E-codes found on the face sheets/charts were validated by an experienced coder. The results of the validation of the cause/intent e-codes are shown in Table 11. Among PWR cases, 63.5% had correct E-codes for cause/intent (sum of rulings 1, 2, and 4). Among PNWR cases, 54.6% had correct E-codes for cause/intent. The projected proportion of correct E-codes in EDISS was 55.2%.

There were 978 PWR injury cases for which EDISS had electronic E-codes (Rulings 1, 2, 3, 4, or 5) and validation E-codes were available (Seven cases [Ruling X] were judged not to be injuries

by the expert coder). Of these, 634 (64.7%) E-codes were accurate to four digits based on the validation E-code. Among the 236 PNWR cases with electronic E-codes in EDISS (Eight cases [Ruling X] were judged not to be injuries by the expert coder), 135 (57.2%) were accurate to four digits based on the validation E-code. The difference in the proportions of correct E-codes between PWR and PNWR cases was statistically significant ($p < 0.005$). Using the sampling weights from Table 2, it was estimated that 59.2% of all EDISS cases had accurate E-codes at the four digit level.

Broad agreement was based on 16 Cause of Injury categories proposed in the ICD-9 Framework for Presenting Injury Data (NCHS, 2004), which is designed to promote consistency is reporting for surveillance of injuries. Broad agreement was found for 845 (84.3%) of PWR cases and 212 (84.8%) of PNWR cases. Using the sampling weights from Table 2, it was estimated that 84.7% of all EDISS cases were coded into the correct Cause of Injury categories recommended for general surveillance purposes.

Place of Occurrence E-Codes

Place of occurrence E-codes were present on the face sheets or in the medical charts in 449 of the

Table 12. Distribution of place of occurrence of injury e-code validation rulings for PWR and PNWR cases, EDISS, Massachusetts, March 1999 – February, 2000

Validation Ruling	PWR Injuries (%)	PNWR Injuries (%)	All EDISS Estimated[a] (%)
1. Completely correct cause and place of occurrence	66 (6.6)	33 (13.2)	(12.1)
6. Place of occurrence documented – correct code	25 (2.5)	17 (6.8)	(6.1)
7. Place of occurrence documented – incorrect code	37 (3.7)	7 (2.8)	(2.9)
8. Place of occurrence documented – missing code	109 (10.9)	57 (22.8)	(20.8)
9. Place of occurrence not documented – correct code	11 (1.1)	7 (2.8)	(2.5)
10. Place of occurrence not documented – incorrect code	310 (30.9)	4 (1.4)	(6.4)
11. Place of occurrence not documented – missing code	427 (42.6)	113 (45.2)	(44.8)
X. Not an injury	3 (0.3)	1 (0.4)	(0.3)
Missing a ruling	15 (1.5)	12 (4.8)	(4.3)
Total	1002 (100.0)	250 (100.0)	(100.0)

[a] Proportion of all EDISS cases estimated using proportions of PWR and PNWR cases and sampling weights from Table 2.

1002 (43%) PWR cases and 68 of the 250 (27%) PNWR cases (Table 12). The submission of place of occurrence E-codes to EDISS varied considerably by hospital. No place of occurrence E-codes were submitted by 5 of the 12 EDISS hospitals. Among the remaining hospitals, submission of this code on the sampled cases ranged from 11.4% to 91.1% (not adjusted for sampling weights).

Validation rulings were completed for place of occurrence E-codes in 987 of the PWR cases. E-codes were validated correct (Rulings 1, 6, 9) in 102 (10.2%) of the PWR cases, incorrectly coded (Rulings 7, 10) in 347(34.6%), and missing codes in 536 (53.5%) of the validated cases. Among the PNWR cases, validation rulings were completed for 238 cases. E-codes were validated correct (Rulings 1, 6, 9) in 57 (22.8%) of the PNWR cases, incorrectly coded (Rulings 7, 10) in 11(4.4%), and missing codes in 170 (68.0%) of the validated cases.

In 30 of the sample cases, the place of occurrence E-codes submitted to EDISS was different than those found on the face sheets. In 21 of these cases, the face sheets had place of occurrence E-codes that were not captured in EDISS. In 4 cases, EDISS captured E-codes where the face sheets had no E-codes. In the remaining 5 cases, the E-codes in EDISS were incorrect.

Information for Alternate Coding Systems

The medical chart abstractors determined the presence or absence of information required for ICECI coding for 395 PWR cases and 98 PNWR cases. The proportions of reviewed PWR and PNWR charts having the data necessary to code the injuries according to selected ICECI categories are shown in Table 13. The fraction of PWR cases (21.0%) that had information on the location of the injury was substantially less than the number of PNWR cases (42.9%) that had this information. Intent of injury (intentional or unintentional) was available in nearly all cases reviewed (98.2% and 95.9% of cases for PWR and PNWR, respectively). Mechanism information was more frequently available for PWR injuries than for PNWR injuries (95.2% vs. 88.8%, respectively). The completeness of the detailed information on mechanism of injury differed across mechanisms. Stab/Pierce and struck by injuries had detailed information on mechanism for greater than 95% of cases for both PWR and PNWR cases. Work-related motor vehicle accidents (MVA) had detailed information less often than the PNWR MVA (77.8% vs. 94.4%, respectively). Information on the use of safety equipment was available for less than 5% of PWR cases and only 16% of PNWR cases.

Descriptive Epidemiology of Work-Related Injuries in Massachusetts: Comparison of Findings from EDISS, Fiscal Year (FY) 2000, and the Massachusetts Survey of Occupational Injuries and Illnesses (SOII) Calendar Year (CY) 2000

Differences in injury case definitions and segments of the working populations captured in EDISS and SOII render comparisons of injury information in these two data sources difficult. Detailed information on demographic and injury characteristics in SOII was limited to cases for days away from work (DAW), and not all individuals with work-related injuries treated in ED's necessarily missed work. In turn, not all work-related injuries were treated in ED's. It has been estimated, although these estimates are somewhat outdated, that approximately one third of work-related injuries are treated in EDs (CDC, National Health Interview Survey, unpublished data, 1998). In addition, the EDISS probable work-related cases were identified predominantly though payer information, thus included cases eligible for workers' compensation. These included public

Table 13. Presence of information for ICECI coding, EDISS, Massachusetts, March 1999 – February, 2000

	Probable Work-related injuries				Probable Non-work-related Injuries			
	n	Information in chart (%)	No Information in Chart (%)	Missing (%)	n	Information in chart (%)	No Information in Chart (%)	Missing (%)
Location	395	83 (21.0)	311 (78.7)	1 (0.3)	98	42 (42.9)	56 (57.1)	0 (0.0)
Intent	395	388 (98.2)	6 (1.5)	1 (0.3)	98	94 (95.9)	3 (3.1)	1 (1.0)
Intent detail Assault	9	7 (77.8)	2 (22.2)	(0.0)	6	5 (83.3)	1 (16.7)	(0.0)
Mechanism	395	376 (95.2)	19 (4.8)	0 (0.0)	98	87 (88.8)	7 (7.1)	0 (0.0)
Mechanism detail MVA	18	14 (77.8)	3 (16.7)	1 (5.6)	18	17 (94.4)	1 (5.6)	0 (0.0)
Mechanism detail Struck by	91	87 (95.6)	0 (0.0)	4 (4.4)	20	20 (100.0)	0 (0.0)	0 (0.0)
Mechanism detail Stab/Pierce	91	91 (100.0)	0 (0.0)	0 (0.0)	15	15 (100.0)	0 (0.0)	0 (0.0)
Mechanism detail Fire	17	15 (88.2)	1 (5.9)	1 (5.9)	0	0 -	0 -	0 -
Mechanism detail Poisoning	1	1 (100.0)	0 (0.0)	0 (0.0)	2	2 (100.0)	0 (0.0)	0 (0.0)
Mechanism detail Other	51	50 (98.0)	1 (2.0)	0 (0.0)	6	6 (100.0)	0 (0.0)	0 (0.0)
Safety Equipment	395	17 (4.3)	378 (95.7)	0 (0.0)	98	16 (16.3)	82 (83.7)	0 (0.0)

sector workers in MA, who comprise approximately 12% of the workforce. Injuries to public sector workers were not captured in SOII. Differences in injury coding schemes used in EDISS and MA SOII also make comparisons difficult. The EDISS data were coded according to the International Classification of Disease (nature of injury, external cause and body part), whereas the SOII was coded according to the Occupational Injury and Illness Classification System (type of injury, event and body part). These classifications systems do not have equivalent nature and cause of injury categories. For these reasons, the comparisons in this section focus largely on rankings and proportions rather precise counts. They are intended to determine whether the two surveillance systems target the same populations and injury types and events for intervention, to elucidate potential biases in relying on either system alone, and identify directions for future surveillance research.

In developing descriptive statistics from the EDISS data, the more inclusive combined indicator of work-relatedness (WC and/or IAW), rather than WC only, was used in order to be able to describe the occurrence of work-related injuries in a sample more fully representative of all Massachusetts Hospitals. Using WC only as the indicator would have required eliminating the two hospitals that did not have WC as an expected payer option, introducing a potential for bias when comparing the EDISS results to statewide estimates from other sources. As discussed in prior sections, the IAW variable was used inconsistently across the hospitals reporting in EDISS, making it difficult to address the utility of this field in identifying work-related injuries not paid by workers' compensation. While some statistically significant differences in the nature and causes of injuries between those identified as PWR by WC and those identified as PWR by IAW were found (data not shown), these differences were inconsistent, depending on the inclusion or exclusion of the two hospitals using only IAW to indicate work-relatedness. The sensitivity and specificity of WC only and WC+IAW were similar, suggesting that, in those hospitals where WC was not used, IAW functioned as a surrogate for WC, and the combined indictor provided a more representative picture of statewide injuries occurrence.

Table 14. Estimated number and distribution of work-related injuries by gender and age, EDISS, FY 2000, and MA SOII, CY 2000

	EDISS PWR Injuries	SOII DAW Injuries
Total	87485	49660
	100.0%	100.0%
Gender	58030	32246
Male	66.3%	64.9%
Female	27736	17296
	31.7%	34.8%
unknown	1720	418
	2.0%	0.1%
Age group	7644	1476
16-19	8.7%	2.8%
20-24	13525	5709
	15.5%	11.3%
25-34	25686	13697
	29.4%	27.6%
35-44	22938	13866
	26.2%	27.9%
45-54	12632	9724
	14.4%	19.8%
55-64	5061	3952
	5.8%	8.0%

PWR = Probable work-related
DAW = Days away from work

The total number of work-related injuries in Massachusetts projected from the EDISS sample was 87,485, approximately 13% of all projected injuries treated in Massachusetts hospital EDs during FY 2000. These injuries represented approximately 69% of the estimated 127,300 total injury cases reported by SOII for CY 2000(BLS, 2002a), slightly higher than the 61% reported in a previous nationwide study comparing ED findings with SOII estimates (MMWR, 2001) The projected number of work-related injuries treated in EDs was 43% higher than the estimated 49,660 injuries in SOII involving one or more days away from work (Table 14). This difference is likely explained in by the inclusion of less severe or disabling injuries as well as injuries to public sector workers in EDISS, although underreporting in SOII likely also contributes.

As shown in Table 14, the proportions of males and females were similar in EDISS and SOII, but the proportions of

Table 15. Estimated number and distribution of work-related injuries by race/ethnicity, EDISS, FY 2000, and MA SOII, CY 2000

Race/Ethnicity	EDISS PWR Injuries	SOII DAW Injuries
White	67252.68	31745
	76.9%	63.9%
Black	2907	2250
	3.3%	4.5%
Hispanic	2362	5109
	2.7%	10.3%
Asian	245	570
	0.3%	1.2%
American Indian	1891	50
	2.2%	0.1%
Other	1432	
	1.6%	0.0%
Unknown/ missing	11395	9937
	13.0%	20.0%

cases in some age categories differed substantially. Proportionately more cases were in younger age groups in EDISS whereas proportionately more cases were older in SOII. These differences may indicate that younger workers who are injured are more likely to suffer less severe injuries that do not result in days away from work, although there is also evidence that younger injured workers are less likely than older injured workers to apply for workers' compensation (Rosenman, 2000). Alternatively, this difference may arise because older workers are more likely to have more work-related injuries resulting in days away from work.

As shown in Table 15, there were substantial differences in the racial and ethnic distributions of the EDISS and SOII cases. The racial and ethnic distribution of the EDISS cases also differed substantially from the racial and ethnic make-up of the general population of Massachusetts[2] These differences have been observed in previous analyses of EDISS data (Holly Hackman, Personal communication) and likely arise from the geographic distribution of the hospitals in EDISS, which disproportionately selects from some local concentrations of ethnic and racial groups.

Tables 16, 17 and 18 show the distribution of injury types, external causes of injury, and body part affected, respectively, for EDISS cases and for SOII days away from work injury cases in descending order of frequency in EDISS. The rank order of the nature of injury categories was generally similar in EDISS and SOII (Table 16). This was also true for external causes of injury (Table 17), except for the absence in SOII of a category comparable to Cut/Pierce, which accounted for 20% of EDISS injuries. The rank order of body parts affected was very different between EDISS and SOII, owing mostly to the predominance of torso injuries (Table 18) in SOII.

The proportional distribution of some of the most common injuries types differed markedly. There were proportionately many more strains and sprains among the SOII cases and both proportionally and absolutely many more open wounds and superficial injuries and burns – likely less serious injuries or less disabling injuries - among the EDISS cases. The preponderance of strains and sprains (56%) in SOII may in part be due to the fact that less serious or disabling

[2] Massachusetts working population is approximately 90.9% white, 5.9% black, 3.2% other races, and 5.7% Hispanic (BLS, 2002)

Table 16 Types of injuries in work-related in EDISS projected MA, FY 2000 compared to BLS SOII 2000

Type of injury	EDISS PWR Injuries	SOII DAW Injuries
Sprains & strains	28434 32.5	27825 56.0
Open wounds	23629 27.0	4880 9.7
Superficial injury/contusion	19755 22.6	5962 12.0
Fractures	4663 5.3	3459 7.0
System wide & late effects	3299 3.8	--[a]
Burns	2962 3.4	1053 2.1
Unspecified injury	2148 2.5	2624 5.3
Crushing	8887 1.0	460 0.9
Internal organ	606 0.7	0 0.0
Dislocation	551 0.6	491 1.0
Amputations	294 0.3	84 0.2
Nerve injury	31 0.0	35 0.1
Blood Vessel	12 0.0	[a]
Missing injury code	214 0.2	0 0.0
Not comparable		2882 5.8
Total	87485 100.0	49660 100.0

[a] No comparable type of injury category in BLS SOII.

injuries - are not captured, thus inflating the strains and sprains category, but may also be due to the differences in the injury coding systems used. Sprains and strains in SOII likely include a large number of musculoskeletal disorders of the back that would be coded as illnesses in the ICD-9 coding system used by hospitals and thus not be reported in EDISS. This discrepancy in coding was supported by the over-representation in SOII relative to EDISS of injuries caused by overexertion (Table 17) and injuries to the torso (Table 18).

The proportions of less common injuries that tend be more severe (i.e., fractures, crushing injuries, amputations, and dislocations) were similar in both EDISS and SOII. Thus, both systems gave similar relative weight to these injuries from a prevention perspective. Of interest, EDISS captured a substantially greater number of injuries in each of these "severe" injury categories. Most notably EDISS captured three times as many work-related amputations as SOII. Similar findings regarding amputations have been reported in Michigan (Stanbury et al, 2003). While this may indicate that a substantial fraction of amputations do not require days away from work, the large difference may also be an artifact of the sampling regime of the SOII, resulting in an undercount of a relatively rare event. The SOII injury count estimates are based on a sample of illness and injury logs (OSHA logs) maintained by private sector employers. While the overall estimates derived from the sample may be representative of actual counts, confidence intervals for rare events, such as amputations, will be large and in any given year could represent a large under- or over-estimate of the actual number of amputations in the state.

Table 17. External causes of work-related injuries: EDISS statewide estimated for FY 2000 and BLS CY 2000

Cause	EDISS PWR Injuries	SOII DAW Injuries
Overexertion	19517 22.3	15596 31.4
Cut/Pierce	18605 21.3	--[a]
Struck by/against	14082 16.1	11212 22.6
Falls	12791 14.6	8785 17.7
Caught between objects	3715 4.2	2263 4.6
Fire/Burn	3072 3.5	37 0.1
Foreign body entering eye	2754 3.1	--[a]
Not Specified	2730 2.0	532 1.1
Transportation accident	2479 2.8	2130 4.3
Machinery	2222 2.5	[b]
Natural/ Environmental	1506 1.7	--[a]
Poisoning	520 0.6	545 1.1
Other/NC	2307 0.5	8560 17.2
Missing e-code	1187 1.4	0 0.0
Total	87485 100.0	49660 100.0

[a] No comparable external cause of injury category in BLS SOII.

Underreporting of injuries in SOII may also be a factor.

Figures 2, 3 and 4 illustrate the analytical flexibility and additional insights regarding work-related injuries afforded by a large, comprehensive, population-based injury surveillance system. Figure 2 shows the distribution of the nature of injury by age group for the EDISS sample. The proportion of injuries that were fractures increased with age whereas the proportions of open wound and burn injuries decreased substantially from the two youngest age groups to a roughly constant level in the older age groups. Trends involving the <16 and ≥64 age groups should be interpreted with caution due to the relatively low number of total work-related injuries in these groups (62 and 129, respectively).

A comprehensive injury surveillance system such as EDISS also allows for measuring the contribution of work-related injuries to the injury burden overall and within injury categories. Figure 3 shows the proportion of all injuries that were work-related by injury type. Work-related injuries accounted for over a third of three injury types: crushing injuries (43%), amputations (41%), and burns (37%). These proportions were substantially greater than the average 19% of all injuries that were work-related. Figure 3 also illustrates the large differences in these proportions by race. Among non-whites, 67% of amputations were work-related and internal organ injuries were nearly twice as likely to be work-related in non-whites compared to the general population.

Figure 4 is similar to Figure 3, showing the proportion of all injuries that were work-related by external cause of injury. The large contribution of work to certain causes of injury was evident, with 62% of all machinery injuries, 36% of burn injuries, and, 32% of injuries caused by being caught between or in objects being work-related. Racial and ethnic disparities are also apparent in this figure: 82% of machinery injuries in non-whites were work-related and nearly 40% of burn and caught in/between injuries in non-whites were work-related.

Table 18. Body Part Injured: EDISS statewide estimated for FY 2000 and BLS CY 2000

Body Part Injured	EDISS PWR Injuries	SOII DAW Injuries
Upper Extremity	39909 45.6	10132 20.4
Lower Extremity	13562 15.5	11095 22.3
Other head, face, neck	8048 9.2	4477 9.0
Vertebral Column injury	7907 9.0	[a]
Torso	7081 8.1	21516 43.3
System wide & late effects	3299 3.8	196 0.4
Other, Unspecified, not comparable	1074 1.2	1990 4.2
Traumatic Brain Injury	404 0.5	254 0.5
Missing Body Part Code	6187 7.1	
Total	84046 100.0	49660 100.0

Figure 2 Nature of work-related injuries by age group

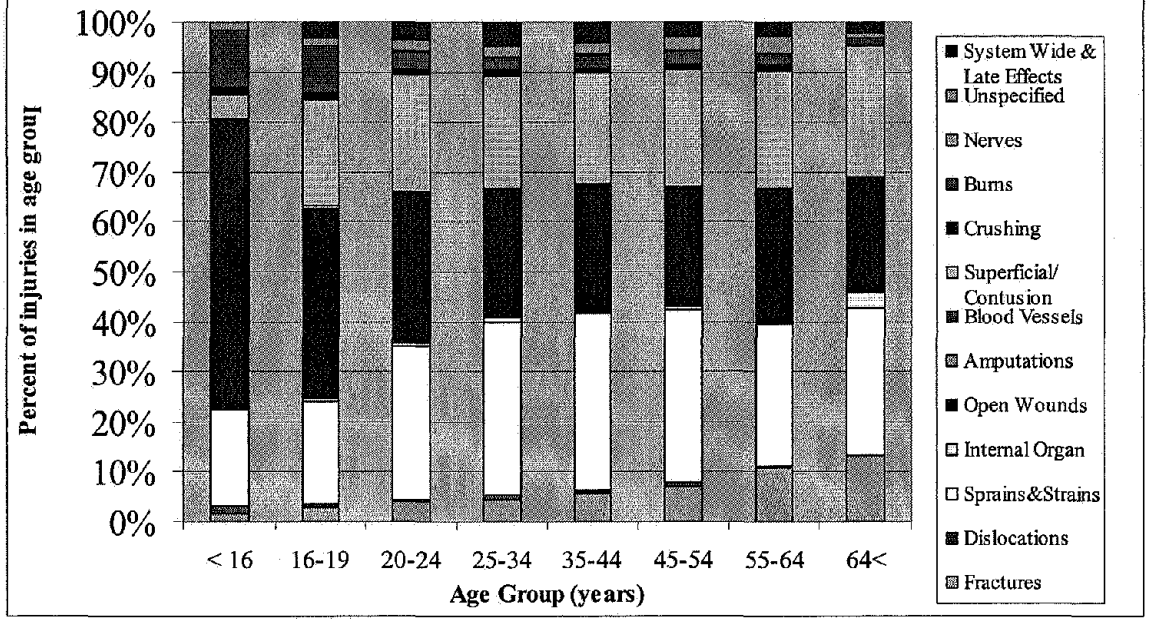


Figure 3 Work-related injuries as a percent of all injuries by injury-type, All EDISS, White, and Non-White

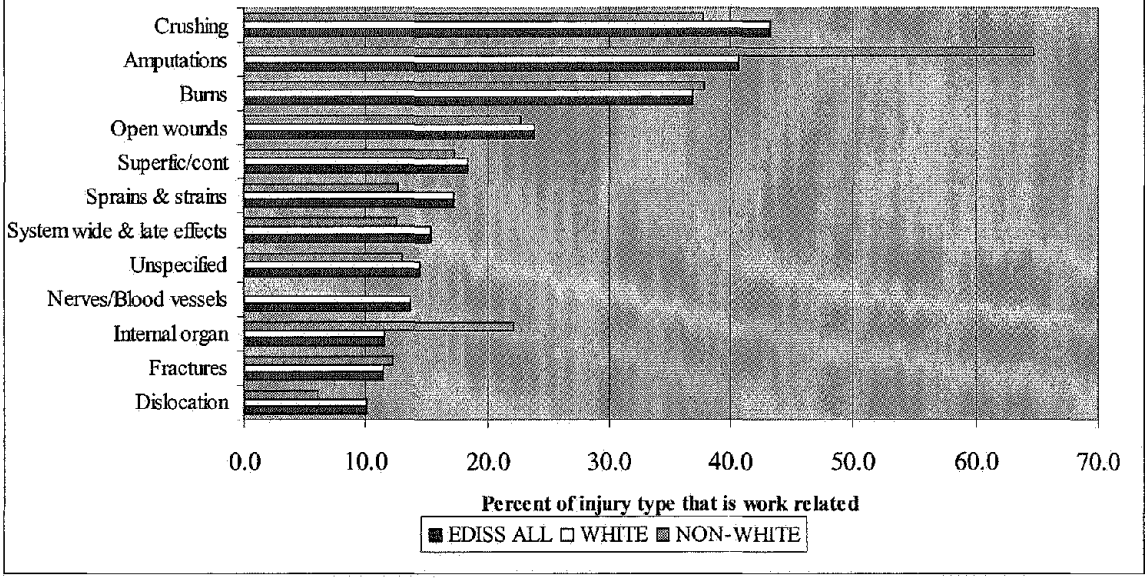
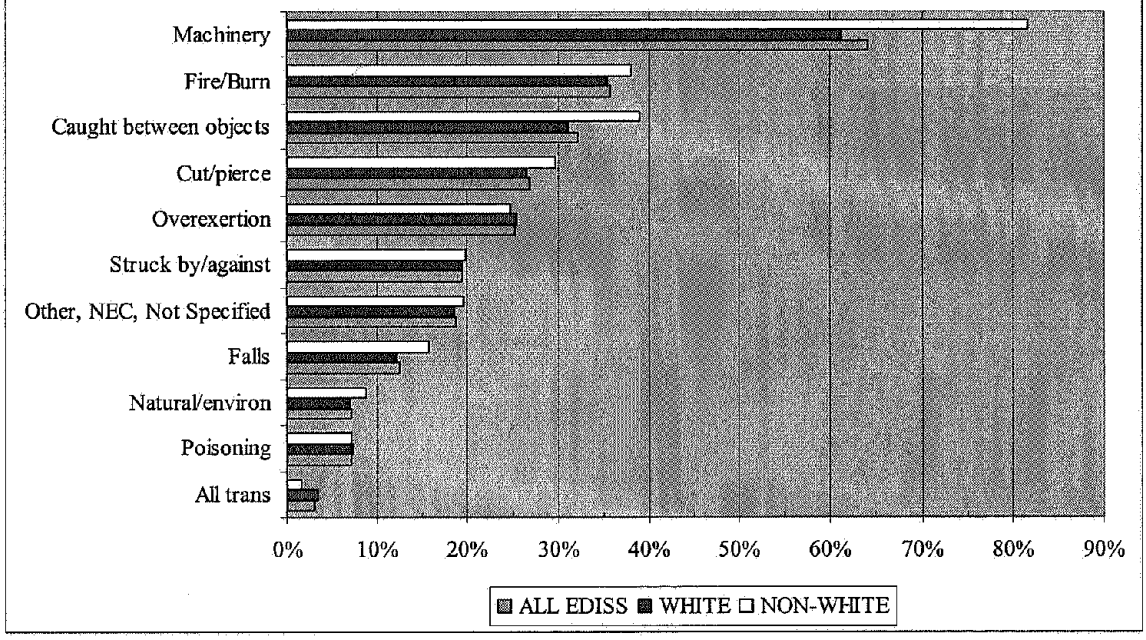


Figure 4 Work-related injuries as a percentage of all injuries by external cause
All EDISS, White, and Non-White



Discussion

In this study the feasibility of using comprehensive electronic, E-coded ED records for population-based surveillance of work-related injuries at the state level was explored. The findings indicate that ED data can serve as a useful source of information for surveillance of work-related injuries. The electronic data submitted through the Massachusetts Emergency Department Injury Surveillance System (EDISS) was found to be accurate in a large majority of cases with regard to the indicators of work-relatedness and broad external cause of injury information. Additional information useful for injury surveillance (e.g., employer name) was frequently available in the medical charts. A comparison of the EDISS injury data to BLS SOII was problematic, due to differences in cases definitions and coding. Neither system captures the full extent of the problem. These systems should be seen as complimentary.

Sensitivity, Specificity, Predictive Value of work-related indicators

Medical charts (excluding payer and the IAW variable), used as the gold standard in this evaluation, are an imperfect measure of work-relatedness because they capture only the information both queried and recorded by ED staff. Health care providers often fail to ask patients about work-relatedness of their conditions (Sama, et al, 2003). Because they are focusing on treatment issues, ED providers may fail to record detailed injury circumstances in the medical record. In addition, injured workers may not inform ED staff that their injuries occurred at work (Jackson, 2001) Patients' willingness to report their injuries as work-related and to apply for workers' compensation is likely affected by a wide range of social and economic factors; these include the availability of other health insurance, avoidance of hassles in applying for compensation, fear of discrimination by current or future employers based on workers' compensation history, legal employment status and immigration status, and personal relationship with the employer (Azaroff, et al, 2002). It is not known how emergency department staff document injuries in those situations in which the provider's perception of work-relatedness of injury is inconsistent with information provided by the patient. For these reasons, the measures of sensitivity, specificity and predictive value in this study are most appropriately interpreted as measures of the degree to which the information that is reported to EDISS reflects the information contained in medical records rather than assessment of the ability of the EDISS to reliably detect true work-related and non-work-related injuries treated in EDs.

Use of the IAW and WC indicators combined detected 83.6% of the injuries identified as work-related in the medical records. Sensitivity using the more commonly available WC indicator alone was lower, as expected, when all hospitals, including the two that did not have a workers' compensation option in the payer field, were included. The more meaningful measure of sensitivity for the WC indicator computed after excluding these two hospitals (83.0%) was only slightly lower than for the combined indicator. This was similar to the sensitivity of the WC indicator reported by Sorok et al. (1993) in a study of hospitalized severe occupational injuries in which patient interviews were used as the gold standard.

The predictive value positive in this study was somewhat lower than the 98% reported by Sorok et al. (1993), who did not have the large fraction of cases with ambiguous information on work-relatedness. The comparatively low PPV found in the EDISS data was explained primarily by lack of any information about work-relatedness in the medical records rather than evidence contradicting work association. McCraig et al (1997) also found that work-relatedness was unknown for a substantial fraction of all NHAMCS emergency department injury visits in 1996, where an Injury at work field was used to define work-relatedness. In the present study, when

only the cases with clear chart information were considered, both sensitivity and specificity were very similar to those reported by Sorock, et al (1993).

It should be noted that severity of injury is a strong predictor of a worker's likelihood of applying for WC (Rosenman, et al, 2000) and the severe injuries examined in Sorock, et al (1993) are more likely to have been paid for by WC. Because EDISS includes all work-related injuries, both severe and not-so severe, the true sensitivity of the indicators is likely less than reported by Sorok, et al. (1993). Given the broad scope of this study, and the limitations discussed above, the indicators can be seen to have performed very well for purposes of occupational injury surveillance. Future studies of the sensitivity and predictive value of these indicators of work-relatedness should employ external sources of information, such as patient interviews, as the gold-standard.

Whereas it had been hypothesized that the IAW variable would enable the system to detect work-related injuries among individuals not covered or not using WC, the use of the IAW field was inconsistent, making interpretation difficult. In the two hospitals where both indicators were used, the IAW field increased the number of identified PWR cases by 8% (slightly more than the 6.7% self-employed in MA). Standardized guidance to hospitals on how this data element is defined and how it is to be completed would be necessary to improve its usefulness (Pollock, et al, 1998). Targeted studies to assess the added value of IAW in hospitals where staff have been trained to use this field are recommended.

While location of injury was sometimes recorded, location is not synonymous with work-relatedness as work-related injuries may occur on roads, in schools, and in places of recreation, making it impossible to rule out work associations in cases that occur in these locations. An activity variable would be more informative than a location variable for surveillance of work-related injuries. Whereas the ICD-9 includes a second E-code for location, the more recent ICD-10-CM, currently used for coding state mortality data, has the capacity to capture information about both location and activity at time of injury, with work being one of the activity options (WHO, 1994). The eventual adoption of the ICD-10-CM as the coding standard for inpatient records may prove to be impractical for EDs. The option of including an activity at time of injury field, rather than the more narrowly defined "injury at work" variable currently used by some hospitals, has been recommended and deserves consideration (Pollock, 1998). An activity field would be more useful to injury epidemiologists in general, but possibly less attractive to hospital administrators, who may consider the direct query about work-relatedness as important for reimbursement purposes.

Availability of Employment Information in Medical Records

Industry information is commonly used as a proxy for exposure to workplace hazards in occupational epidemiology. Employer information can be coded to industry or used to directly assess injury patterns among employees of individual establishments. The finding that employer name was present in the charts of PWR cases and as a data field in all medical registration systems has important ramifications for occupational epidemiology. Because neither EDISS nor the new statewide ED system in MA routinely include data fields for employer information it was not possible in this study to assess the extent to which this available information is computerized and included in the electronic data systems within hospitals. However, experience collecting ED data as part of an ongoing surveillance system for work-related injuries to teens in Massachusetts, which are required to be reported under public health regulations, indicates that computerized data on employer is available for over 95% of the cases. This suggests that it would be feasible to collect this information for ED cases electronically posing little if any additional burden on the

hospitals. Confidentiality concerns and the practical issue of coding employer information for thousands of ED cases are potential obstacles to doing so that need to be addressed.

Inclusion of employer name among the data elements reported could possibly lead to the identification of individual patients in the statewide ED dataset. This should not be insurmountable, as there are other patient identifiers such as birth date that are collected and precautions are in place to protect confidential data. Coding reported employer information is more challenging as this is a labor intensive and thus costly activity. While Massachusetts does have an electronic dataset that includes employer names in conjunction with industry classification codes that is maintained for purposes of unemployment insurance compensation, automated coding is difficult for a variety of reasons including variations in spelling establishment names, multiple codes per establishments, continual changes in the roster, and legal issues that arise in linking government datasets. While routine collection and coding of all employer information for all work-related injuries may not be feasible, at a minimum state agencies should have legal access to the employer name information for targeted studies or for periodic surveillance of targeted injuries.

Information about the patient's occupation and about the industry where employed was seldom documented and a substantial shift in hospital practices would be required to routinely collect this information. The fact that there is currently a field for occupation in the medical registration systems used by all of the hospitals in this study suggests that collecting occupational information might be the more viable option of the two. The practicality of coding the data again would be an issue. An automated coding system for industry and occupation has been developed on the basis of data collected on death certificates, but it has been found to be less useful in coding data from other sources and this system is not being updated (NIOSH, 2001). One option to may be the use of electronic checklists of the most pertinent occupation or industry categories in the state that could be used by hospital registrars. This would facilitate both data collection and coding.

Accuracy of E-codes

To our knowledge this is the first study to assess the accuracy of hospital E-coding of work-related injuries specifically. The proportion of correct external cause of injury codes for all injuries found in this study (59%) was similar to or higher than those reported in other studies of non-occupational injuries (MacIntyre, et al, 1997; Schwartz, et al, 1995). Accuracy for work-related injuries was higher (65% correct to four digits). Accuracy of place of occurrence codes was poor overall (20.7% correct to four digits), and, in contrast to the event codes, was worse for PWR injuries (10.2% and 22.8% correct for PWR and PNWR injuries, respectively). This may be a result of the confusion between place of injury and activity at time of injury. For example, when chart information is recorded, either on paper or electronically, a prior note in the record of the work-relatedness of the injury may suggest to a provider or recorder that a place of occurrence e-code is not necessary. This underscores the need for standardization of methods for recording work-relatedness, or more generally, activity, in hospital records. Further, the relatively high rates of errors in e-coding at the detailed level found in this and other studies (40% or greater), indicates a need for additional training for medical records staff, particularly in assigning place of occurrence codes.

The finding that there was 85% accuracy at the broad external cause of injury level typically used for injury surveillance purposes indicates a level of accuracy that is adequate for surveillance purposes, though there is room for improvement. However, the levels of accuracy achieved for the broad range of injuries and causes in this broad, population-based data may not extend to individual types of injuries or causes. Some types of injuries and/or causes may be prone to

systematic error, such as reported for e-coding of drowning cases (Smith and Langeley, 1998). Further analysis of the types of E-codes that are misclassified, and of the degree to which these errors are random or systematic, would be useful in interpreting injury surveillance findings based on ED data.

Comparison of findings from EDISS and the Massachusetts Survey of Occupational Injuries and Illnesses (SOII)

A clean comparison between the EDISS data and the BLS SOII was difficult. The two systems cover different segments of the working population, use different broad case definitions, and use different nature and cause of injury coding systems that are difficult to reconcile. The surveillance research question is whether the two systems point to similar prevention priorities. SOII findings based on cases with days away from work placed greater emphasis on strains and sprains as a concern, however, there was evidence that many of the injuries reported as strains and sprains in SOII may have been coded as musculoskeletal conditions of the back (considered illnesses in the ICD –9 coding scheme) in the ED and thus not captured by EDISS. A more reasonable comparison might include the back conditions treated in ED's, which will be possible to do in the new statewide data base of *all* ED visits. Not unexpectedly, SOII finding placed greater emphasis on cuts and lacerations and superficial contusions, many of which may not result in lost worktime. Considering just the more comparable nature and cause of injury categories, EDISS and SOII provide similar pictures of the relative importance of these injury types and external causes. Whereas finding with respect to gender were similar and consistent with previous research. EDISS captured proportionately more younger workers, which may reflect the relative severity of their injuries. This remains to be further explored.

The numbers of injuries from the two surveillance systems provide ambiguous information about the potential magnitude of the occupational injury burden in Massachusetts. According to findings from the 1988 National Health Interview Survey, one third of medically treated or lost time occupational injuries are treated in EDs. Applying this figure to the estimated 87,485 EDISS cases, yields a crude estimate of 262,000 work-related injuries in MA, far more than the SOII estimate of 127,300 total injuries, even when the SOII estimate is adjusted upwards to account for the 12% public sector workers in Massachusetts. Shifts in delivery of urgent medical services since 1988 or differences unique to Massachusetts, a highly urbanized state with an extensive emergency medical service system, may account for some of this discrepancy. However, a similar discrepancy was observed when NEISS findings were compared with national SOII estimates (Jackson, 2001). Differences in the estimated number of some of the more severe injuries in EDISS and SOII, most notably the amputation findings, also raise questions about under-reporting in SOII, although sampling error is a likely explanation when considering these relatively rare events. Several ongoing studies in which workers' compensation and SOII data are directly compared should provide important insights into this problem (Personal communication: K. Rosenman, L. Boden.)

The comparison of EDISS and SOII findings does elucidate broad advantages and disadvantages of these two surveillance systems. The SOII is an important source of information for surveillance of work-related injuries. The data are comparable across state and time. The attribution of work-relatedness in SOII is complete for the injuries reported, and detailed information about injury type, event, body part affected and source is available for cases resulting in one or more lost work days. Most important in comparison with EDISS, is the availability of industry and occupation information as well as employment data necessary to calculate injury rates by industry. However, SOII has well known limitations. The estimates are based on a sample of private workplaces, excluding the public sector, the self-employed and persons on

small farms, and are subject to sampling error particularly for rare events. The level of reporting relative to the actual number of workplaces injuries is known to be low (Conway and Svenson, 1998; Pransky, et al., 1999). SOII is not designed to provide reliable data on specific injury types in specific industries at the state level. In addition, given the relatively small sample size in MA and BLS strict publication criteria, the ability to stratify by more than one factor is limited.

The capacity to capture a large and representative sample of ED treated injuries, both work-related and not work related, across a large and (mostly) representative sample of the state population into a data set with considerable analytical flexibility makes EDISS a powerful tool for conducting surveillance of work-related injuries. EDISS, and state ED data in general, can provide not otherwise available information on the magnitude, nature and cause of ED treated work-related injuries in the state working population, both public and private sector. Although not explored in this study, ED data can also provide information about work related injuries at the local level. The number of cases is large and relatively rare events can be captured. Cross-tabulations by gender, race (with recognized error in EDISS) injury type, cause of injury and body part affected can be examined to help target intervention activities and further research. Because the systems captures information about all injuries, it allows for assessing the contribution of work-related injuries to the overall injury burden and thus fosters integrated approaches to prevention that cross public health disciplines (e.g. injury control and occupational health).

A current limitation of the ED data system for occupational injury surveillance is the lack of an explicit indicator of work-relatedness. As reported here, the widely available WC indicator does not capture all cases. However, it can be considered adequate for surveillance purposes, and could be improved through outreach to hospitals to encourage consistent use of the WC option. . Improvements in the attribution of work-relatedness through more consistent use of the IAW field, and in the accuracy of e-codes, both of which could be addressed through training, would further enhance the value of EDISS. The feasibility of including of an activity field in electronic medical records should be explored to enhance the value of ED data for general and occupational injury surveillance. The lack of employer, industry and occupation information in ED –based surveillance systems is another limitation, more difficult to address. Practical methods for routinely using employer information should also be explored to enhance the ability to target surveillance and intervention activities. SOII and ED- based surveillance should be seen as complimentary approaches, both providing important information needed to guide and evaluate state efforts to prevent work-related injuries.

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PUBLICATIONS

Two publications are in progress and will be completed in the next year. Findings will be presented at the June 2005 annual meeting of the Council of State and Territorial Epidemiologists.

GENDER AND MINORITY STUDY SUBJECTS

There were no gender or minority exclusions in this study. Gender and minority distribution reflected that of the populations covered by the hospitals included in the EDISS sample.

MATERIALS AVAILABLE FOR OTHER INVESTIGATORS

The data abstraction form used to collect information on employment and injury circumstances from emergency department records is available to other researchers. It can be obtained from the Principal Investigator on request.