

Evaluation of a state based syndromic surveillance system for the classification and capture of non-fatal occupational injuries and illnesses in New Jersey

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Background: This preliminary study evaluates a real-time syndromic surveillance system to track occupationally-related emergency room visits throughout New Jersey.

Methods: Emergency Department (ED) chief complaint fields were evaluated from 79 of 80 hospitals in NJ in 2014, using work-related keywords and ICD-9 E-codes, to determine its ability to capture non-fatal work-related injuries. Sensitivity analysis and descriptive statistics, were used to evaluate and summarize the occupational injuries identified.

Results: Overall, 11 919 (0.3%) possible work-related ED visits were identified from all ED visits. Events with the greatest number of ED visits were slips, trips, and falls (1679, 14%). Nature of injury included cuts, lacerations (1041, 9%). The part of the body most affected was the back (1414, 12%). This work-related classifier achieved a sensitivity of 5.4%, a specificity of 99.8%, and a PPV of 2.8%.

Conclusions: This evaluation demonstrated that the syndromic surveillance reporting system can yield real-time knowledge of work-related injuries.

KEYWORDS

injuries, occupational, syndromic surveillance, work-related

1 | INTRODUCTION

One of the most important steps in injury and illness prevention and control is surveillance.¹ Traditionally syndromic surveillance is used as an early warning system for outbreaks, to observe trends, and provide real-time data for public health officials responsible for investigating and responding to potential outbreaks in their communities.² Currently, syndromic surveillance has not been widely applied to identify occupational injuries and illnesses. Therefore, this study evaluated a real-time syndromic surveillance tool to identify work-related Emergency Department (ED) visits throughout New Jersey (NJ).

Current surveillance for non-fatal work-related injuries and illnesses is based primarily on the use of Universal Billing (UB) data on Hospital Discharge (HD) and Emergency Department (ED) visits.

However, there are some limitations with using UB for occupational surveillance. One limitation is the method used to determine work-relatedness. This is done by filtering the data using workers' compensation as a primary insurance payer; however, these estimates of work-related non-fatal injuries greatly under-report the true burden. Often workers may not file a claim because they may not feel it necessary to miss work; other insurance is used to pay for the expenses; or the less severe an injury is the less likely a claim will be filed^{3,4} also, workers' compensation does not pay for self-employed, agricultural workers, or federal workers, or include all injuries.^{5,6} Another limitation is the time delay in receiving reports of work-related injuries and illnesses in the UB. While data have been available from the UB records of New Jersey's emergency departments for many years, these datasets are available only after a lag time of 3 months and information on industry or occupation is not consistently provided by

the hospital. This slow time scale allows the use of billing records for summary public health surveillance; however, it does not allow rapid public health intervention when required.

Non-fatal work-related injury and illness data are also obtained from the Bureau of Labor Statistics (BLS). BLS conducts an annual Survey of Occupational Injuries and Illnesses (SOII) to establish an estimate of occupational injuries and illnesses in participating states; however, there is well-recognized under-reporting to SOII. The design of the survey uses small samples and excludes over 20% of the workforce, for example in NJ it includes employed persons who are 16 years or older for the same calendar year but excludes out-of-state residents, the military, self-employed individuals, farms with fewer than 11 employees, and federal agencies. Other reasons that may contribute to the undercount are that it is based on unaudited self-reported data from employers and there is about a 2 year lag time on SOII data.⁷⁻⁹

EpiCenter was developed for early detection and monitoring of the health of communities using chief complaints from people seeking acute care in hospital emergency rooms to identify health trends. EpiCenter has traditionally been used to detect disease outbreaks, but is also being used to provide data on environmentally-related emergency room visits that are occurring throughout the state. For example, during Hurricane Sandy, EpiCenter was used to conduct daily analysis using hurricane-related keywords (eg, Sandy, carbon monoxide, flood, storm, power outage, and hurricane) to provide the New Jersey Department of Health (NJDOH) Office of Emergency Preparedness staff and state/local epidemiologists updates from about 90% of NJ emergency departments. The daily summary report included the top five facilities with highest hurricane-related visits, and major complaints (eg, carbon monoxide poisoning, injury/cuts, chest pain, oxygen needs). EpiCenter is also currently being used as a real-time surveillance system to track heat-related illnesses and carbon monoxide poisoning.

Other studies have shown that incorporating multiple data sources for occupational health surveillance can help identify additional work-related cases and provide useful information of the distribution of work-related injuries.^{10,11} Incorporating syndromic surveillance data from EpiCenter, along with hospital discharge data, may help enhance the classification and capture of work-related non-fatal injuries with possible improved efforts at prevention. Therefore, this preliminary study will evaluate the use of a real-time surveillance tool to track a variety of occupationally-related emergency room visits throughout the state via EpiCenter.

2 | MATERIALS AND METHODS

EpiCenter was developed for early event detection and monitoring of the health of communities. EpiCenter is a statewide syndromic surveillance system used by several state and local public health agencies (including NJDOH) to detect, track, and characterize health events such as pandemic influenza, infectious disease outbreaks, environmental exposures, and potential bioterrorism in real-time.

EpiCenter collects, manages, and analyzes the ED data for surveillance of certain defined syndromes, and provides access to public health and hospital users via a desktop application in a secure browser. Real-time ED data are currently collected from 79 of 80 NJ acute care hospitals and satellite emergency departments by Health Monitoring Systems Inc.'s (HMS) EpiCenter system. It uses de-identified information on patient symptoms, pre-diagnostic information, and chief complaints to identify health trends using real-time reporting. Keywords in the chief complaint field are assessed in comparison to pre-determined syndrome definitions, and the system automatically alerts public health agencies when an unusual pattern or trend is occurring by symptom, patient residential location, or hospital. Even without pre-determined syndromes, the data can also be searched for key text and disease conditions.

To help identify work-related injuries and illnesses through syndromic surveillance a work-related classifier had to be developed. Classifiers are specific to certain events such as chemical exposure, influenza, Ebola, or tree related injuries, and are composed of keywords related to those events that can be searched for in the chief complaint fields. A collection of keywords specific to work-related injuries and illnesses was developed by manually assessing the free text chief complaint data fields found in the electronic ED records for visits submitted to EpiCenter (Table 1). Syndrome definitions were developed by NJDOH, Occupational Health Surveillance staff in collaboration with other staff with experience developing and validating a variety of syndrome definitions. To help evaluate the selected work-related keywords, ICD-9 E-codes (external cause codes) currently used to search hospital and emergency discharge data for occupational injuries and illnesses in universal billing data (Table 2), were compared to the keywords and were also used to help identify any additional work-related keywords in the chief complaint field. Note that facilities began using ICD-10 codes October 2015. This study has not evaluated the syndromic surveillance system with the new ICD-10 codes.

Once the work-related keywords were identified, EpiCenter ED data from January to December 2014 were evaluated to validate the work-related classifier based on work-related keywords and ICD-9 E-codes. SAS 9.2 was used to search the chief complaint fields for work-related keywords and the ICD-discharge code fields for ICD-9 E-codes. Sensitivity, specificity, and positive predictive value (PPV) were calculated for both the initial list of work-related keywords and the final list of keywords. Cases were considered "true positives" if keywords matched the ICD-9 E-codes. If cases did not have keywords that matched the ICD-9 E-codes they were considered to be "false positives." Descriptive statistics were also used to evaluate and summarize the occupational injuries identified in EpiCenter.

The appropriate Institutional Review Boards reviewed and approved the study as part of requirements for the National Institute of Occupational Safety and Health (NIOSH) funded grants. Written or documented informed consent, assent has been waived pursuant to the Federal regulations for the protection of human subjects at Title 45, Part 46.116(d).

TABLE 1 Work-related keywords used to search chief complaint fields for occupational injuries and injuries

Included keywords	Excluded keywords
Initial keyword list	
JOB; AT WORK; @WORK; @ WORK; WORK RELATED; OCCUPA ACCIDENT WORK; WORK ACC; WORK INJ; WHILE WORK; WORKERS COMP; WORKER'S COMP; WORK MANS COMP; WORKMENS COMP	WORKOUT; WORK UP; WORK NOTE; LABWORK; LAB WORK; BLOODWORK; BLOOD WORK
Final keyword list	
JOB; AT WORK; @WORK; @ WORK; WORK RELATED; OCCUPA ACCIDENT WORK; WORK ACC; WORK INJ; WHILE WORK; WORKERS COMP; WORKER'S COMP; WORK MANS COMP; WORKMENS COMP; WORKPLACE; WORK COMP; WORKMANS COMP; WORK WOUND; WORKMENS COMPENSATION; WORK-RELATED	WORKOUT; WORK UP; WORK NOTE; LABWORK; LAB WORK; BLOODWORK; BLOOD WORK

3 | RESULTS

First, the chief complaint fields for 2014 were searched for work-related ED visits using the initial list of created keywords (Table 1); 7554 ED visits were identified as possible work-related injuries. Next, the ICD-discharge code fields were searched for work-related ED visits using the work-related ICD-9 E-codes, an additional 3994 ED visits were identified as possible work-related injuries, resulting in a total of 11 548 possible work-related ED visits using the initial keywords plus ICD-9 E-codes. Of the possible work-related ED visits, 214 (2%) had both positive work-related keywords and positive ICD-9 E-codes. This classifier achieved a sensitivity of only 5.1%, a specificity of 99.8%, and a PPV of 2.8% (Table 3).

The chief complaint fields of the cases identified by ICD-9 E-codes, were further reviewed manually for additional work-related keywords not previously identified. Upon review, six additional work-related keywords were identified. These new keywords were added to the initial list to create a final work-related keyword list (Table 1). Using the updated list of keywords, the chief complaint fields were searched a third time for work-related ED visits; 7937 ED visits were identified as possible work-related injuries, which found over 350 more ED visits than the initial list of keywords. Of the possible work-related ED visits, 226 (2%) had both positive work-related keywords and positive ICD-9 E-codes. The addition of these new keywords slightly increased the sensitivity to 5.4% (Table 4).

Overall, of the 79 hospitals in NJ reporting to EpiCenter, there were a total of 3 877 255 ED visits in 2014. Using the final list of work-related keywords and E-codes, 11 919 (0.3%) possible work-related ED visits were identified from all ED visits reported to EpiCenter. Events that resulted in the greatest number of ED visits were slips, trips, and falls (1679, 14%), followed by injury by other person (186, 2%), and transportation incidents (151, 1%). Nature of injury included cuts, lacerations (1041, 9%); burns (255, 2%); and sprains, strains, tears (185, 2%). The parts of the body most affected were the back (1414, 12%); hand (1186, 10%); and head (934, 8%). Of the 11 919 visits 959 (8%) indicated Workers' Compensation as payer. Keywords related to Workers' Compensation were often associated with events such as falls (106, 11%) and injuries to the back (142, 15%), head (74, 8%), and hand (72, 8%). (Table 5) Of the 3982 ED visits identified by ICD-9 E-codes; the most commonly used ICD-9 E-codes were E000.0, Civilian activity done for income or pay, (2796, 70%) and E849.3, Place of occurrence: industrial place and premises, (1774, 45%).

Further evaluation of the possible work-related cases also showed that the chief complaint fields may be able to provide additional information into the cause of injury or illness that happened at work, when available. For example, for cuts and lacerations, chief complaint fields contained information such as "cook cut right thumb on soup can lid while at work"; "cut right second finger on slicer at work while cleaning"; and "accidentally cut herself at work with a box cutter." Evaluation of the chief complaint field also showed how injuries were

TABLE 2 Work-related ICD-9 E-codes used to search ICD-discharge fields for occupational injuries and illnesses

ICD-9	Definition
E000.0	Civilian activity done for income or pay
E000.1	Military activity
E800-E807	Railway accident among railway employee (4th digit = 0)
E830-E838	Water transport accident among crew, Dockers and stevedores (4th digit = 2 or 6)
E840-E845	Air and space transport accidents among crew and ground crew (4th digit = 2 or 8)
E846	Accidents involving powered vehicles used solely within the buildings and premises of industrial or commercial establishment
E849.1	Place of occurrence: farm building/land under cultivation
E849.2	Place of occurrence: mine or quarry
E849.3	Place of occurrence: industrial place and premises

TABLE 3 Sensitivity, specificity, and positive predictive value of work-related initial keywords

	(+) ICD-9 E-codes	(-) ICD-9 E-codes	Total
(+) work-related keywords	214	7554	7768
(-) work-related keywords	3994	3 865 493	3 869 487
Total	4208	3 873 047	3 877 255

Sensitivity: 5.1%.

Specificity: 99.8%.

Positive Predictive Value: 2.8%.

sustained to certain parts of the body, such as the eye: “burn to both eyes engine oil work related”; “flash burns to eyes at work, photo keratitis”; and “piece of metal in eye while grinding at work.” Accidents involving certain types of machinery or equipment were also identified: “patient states he was at work and struck by forklift which propelled him into a wall and has headache and small laceration over left eye” and “caught left arm in leaf blower at work.”

4 | DISCUSSION

Although, using ICD-9 E-codes to validate the work-related keywords did not generate satisfactory measures of sensitivity and positive predictive values, the chief complaint field still provides useful information to describe work-related injuries and illnesses that are seen in the ED. The chief complaint field could provide information on body part affected; cause of injury (falls, struck by, lifting, etc.); type of injury (laceration, fracture, burn, etc.); and if the injury involved machinery or equipment (forklifts, hand tools, etc.), all useful in helping create more focused education and outreach.

One limitation of this evaluation is that not all hospitals are currently providing ICD-codes through EpiCenter. Submission of ICD-codes through the syndromic surveillance system is voluntary and currently around 14 to 30% of NJ hospitals will submit them. Also, Workers' Compensation as primary payer, which is used to identify work-related cases in hospital and emergency discharge data, is not available through EpiCenter unless it is mentioned within the chief complaint. There are no specific occupational ICD-codes, which may have contributed to a low specificity and sensitivity. Most the cases are

coded based on the location of the injury like 844.9, unspecified site of knee and leg; or may be a general code such as 799.9 other unknown and unspecified cause. Health care practitioners may also assign diagnoses differently, which can also contribute to decreased sensitivity and specificity. It is also difficult to determine occupation and industry from the chief complaint field. The NJDOH, Communicable Disease Service staff, who are experienced in developing and validating a variety of syndrome definitions, are currently working with hospitals to have them submit triage notes along with their ED data which may provide more detailed information on work-relatedness. Currently less than 10 hospitals in NJ are providing triage notes through EpiCenter. Besides providing more detailed information on the ED visit, studies have shown that the addition of triage notes to syndromic surveillance can help in increasing the sensitivity and improve syndrome definitions.^{12,13} It should also be noted that syndromic surveillance is going to be state dependent. Not all states will have the same system to collect ED visits and may be provided with more or less information than other states.

This preliminary evaluation demonstrated that the syndromic surveillance reporting system has the potential to yield real-time knowledge of a small percentage of work-related injuries. The inclusion of ICD codes and triage notes would improve the number of cases identified. Occupational surveillance currently involves collecting data on potential cases on a quarterly or yearly basis from UB datasets, often long after the diagnosis was made. However, EpiCenter allows staff to identify illnesses in nearly real-time so a rapid response can be initiated, reducing further risk of occupational injuries and illness. For example, EpiCenter has already been evaluated as a rapid response system for occupational chemical exposure events. The chief complaint is searched for keywords related to chemical exposure such as “chemical,” “vapor,” “toxic gas,” “inhaled gas,” etc. If two or more ED visits are identified as chemical exposure within 24 h from the same facility or county, staff are alerted immediately via e-mail. Once the alert is received, the case is evaluated through the secure EpiCenter website and additional information such as the patients date of birth, gender, visit number, and patient ID are obtained. This information is used when contacting the ED to obtain additional information on the case such as what chemical the patient was exposed to; how they were exposed; and if it was work-related. Between January 2014 through December 2015, 242 chemical exposure alerts were sent in real-time, via e-mail, by EpiCenter. Of these, 85 (35%) were confirmed occupational related chemical exposures. Occupational events detected via EpiCenter chemical alerts have included: five lifeguards treated for eye and respiratory irritation after being exposed to chlorine at a waterpark; 28 employees exposed to diisocyanate during an explosion at a foam factory; seven workers at a grape repacking facility exposed to methyl bromide while packing and eating grapes; and six firefighters exposed to a UV-curable liquid coating during a fire at a warehouse. If it is determined the case is a public employee the NJ Public Employee Occupational Safety and Health (PEOSH) is notified to respond, otherwise the regional Occupational Safety and Health Administration (OSHA) office is notified.

TABLE 4 Sensitivity, specificity, and positive predictive value of work-related final keywords

	(+) ICD-9 E-codes	(-) ICD-9 E-codes	Total
(+) work-related keywords	226	7937	8163
(-) work-related keywords	3982	3 865 110	3 869 092
Total	4208	3 873 047	3 877 255

Sensitivity: 5.4%.

Specificity: 99.8%.

Positive Predictive Value: 2.8%.

TABLE 5 Number of non-fatal work-related injuries by case characteristic reported via EpiCenter in NJ, 2014

	Final keywords only	ICD-9 E-codes only	Total
Workers' compensation as payer	956	3	959
Event or exposure			
Falls slips trips	1327	352	1679
Injury by other person	141	45	186
Transportation incidents	135	16	151
Animal and insect related incidents	79	66	145
Overexertion in lifting or lowering	46	0	46
Struck by object	14	1	15
Caught in object equipment material	12	2	14
Nature of injury or illness			
Cuts lacerations	582	459	1041
Burns	157	98	255
Sprains strains tears	175	10	185
Punctures (except gunshot wounds)	25	10	35
Fractures	10	4	14
Bruises contusions	8	5	13
Soreness pain	6	7	13
Amputations	2	2	4
Part of body affected			
Back	1067	347	1414
Hand	758	428	1186
Head	634	300	934
Arm	480	203	683
Knee	423	243	666
Shoulder	311	220	531
Foot	307	176	483
Eye	285	158	443
Ankle	269	163	432
Wrist	202	132	334
Neck	178	86	264
Toe	47	32	79
Source of injury illness			
Biological	170	68	238
Chemicals chemical products	40	21	61
Ladders	18	7	25
Machinery	10	1	11
Hand tools	7	1	8
Forklift	5	2	7

This preliminary study has shown that occupational injuries and illnesses can be identified through syndromic surveillance; however, further analyses is needed to compare the syndromic surveillance data with current occupational health data sources such as hospital and emergency discharge data and SOII. A few states have begun evaluating the extension of a real-time syndromic surveillance tool

to identify work-related ED visits, but syndromic surveillance is not widely used in occupational health surveillance. Evaluating the ability and performance of a new and existing surveillance data source to capture work-related injuries and illnesses may lead to enhancements in current data collection methods. For example, identifying gaps can lead to improved, standardized methods, including better case

definitions, reporting procedures, and data collection tools. Also, other states will be able to adopt these new data collection methods and build upon them to enhance their own surveillance systems.

5 | CONCLUSION

Surveillance is an important step in injury prevention and control, providing beneficial information to direct interventions.¹ Understanding the factors which can result in non-fatal work-related injuries and acute exposures may reveal opportunities for work-place interventions, leading to the prevention of both non-fatal and fatal injuries and illnesses. By employing a real-time, independent data source, the classification and situational awareness of work-related injuries and illnesses could be greatly enhanced, allowing for a better understanding of the burden of non-fatal work-related injuries and illnesses, and for quicker response.

AUTHORS' CONTRIBUTIONS

All authors contributed to the conception and design of the study; drafting and revising the work critically for important intellectual content; approving the final version of the manuscript for publication; and both agree to be accountable for all aspects of the study to ensure that any questions related to the accuracy or integrity of any part of the study are appropriately investigated and resolved. Marija Borjan was responsible for the acquisition, analysis, and interpretation of the data needed for the study.

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DISCLOSURE (AUTHORS)

The authors declare no conflicts of interest.

DISCLOSURE BY AJIM EDITOR OF RECORD

Steven B Markowitz declares that he has no conflict of interest in the review and publication decision regarding this article.

DISCLAIMER

None.

REFERENCES

1. STIPDA: Injury Surveillance Workgroup 5. Consensus recommendations for injury surveillance in state health departments. State and Territorial Injury Prevention Directors Association, Atlanta, GA. 2007.
2. Henning KJ. What is syndromic surveillance? *MMWR CDC*. 2004; 53:5–11.
3. Shannon HS, Lowe GS. How many injured workers do not file claims for workers' compensation benefits? *Am J Ind Med*. 2002; 42:467–473.
4. Rosenman KD, Gardiner JC, Wang J, et al. Why most workers with occupational repetitive trauma do not file for workers' compensation. *J Occup Environ Med*. 2000; 42:25–34.
5. Pransky G, Snyder T, Dembe A, Himmelstein J. Under-reporting of work-related disorders in the workplace: a case study and review of the literature. *Ergonomics*. 1999; 42:171–182.
6. Rosenman KD, Kalush A, Reilly MJ, Gardiner JC, Reeves M, Luo Z. How much work-related injury and illness is missed by the current national surveillance system? *J Occup Environ Med*. 2006; 48: 357–365.
7. Ruser JW. Examining evidence on whether BLS undercounts workplace injuries and illnesses. *Monthly Lab Re*. 2008; 131:20.
8. Leigh JP, Marcin JP, Miller TR. An estimate of the US government's undercount of nonfatal occupational injuries. *J Occup Environ Med*. 2004; 46:10–18.
9. Spieler EA, Gregory RW. Counting matters: implications of undercounting in the BLS survey of occupational injuries and illnesses. *Am J Ind Med*. 2014; 57:1077–1084.
10. Davis LK, Grattan KM, Bullock LF, Ozonoff A, Boden LI. Use of multiple data sources for surveillance of work-related amputations in Massachusetts, comparison with official estimates and implications for national surveillance. *Am J Ind Med*. 2014; 57:1120–1132.
11. Kica J, Rosenman KD. Multisource surveillance system for work-related burns. *J Occup Environ Med*. 2012; 54:642–647.
12. Ising AI, Travers DA, MacFarquhar J, Kipp A, Waller AE. Triage note in emergency department-based syndromic surveillance. *Adv Dis Surv*. 2006; 1:34.
13. Scholer M, Ghneim G, Wu S et al. Defining and applying a method for improving the sensitivity and specificity of an emergency department early event detection system. *J Am Med Inform Assoc Annu Symp Proc*. 2007; 11:651–655.

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