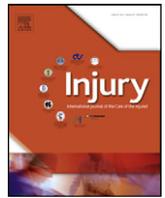




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Occupational amputations in Illinois 2000–2007: BLS vs. data linkage of trauma registry, hospital discharge, workers compensation databases and OSHA citations

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ARTICLE INFO

Article history:
Accepted 10 January 2012

Keywords:
Amputation
Occupational injury
Injury surveillance
Data linkage
Traumatic injury
Trauma registry
Hospital discharge data
Workers compensation
BLS Survey of Occupational Injuries and Illnesses
OSHA citations

ABSTRACT

Background: Workplace amputation is a widespread, disabling, costly, and preventable public health problem. Thousands of occupational amputations occur each year, clustering in particular economic sectors, workplaces, and demographic groups such as young workers, Hispanics, and immigrants.

Objectives: To identify and describe work related amputations amongst Illinois residents that occur within Illinois as reported in three legally mandated State databases; to compare these cases with those identified through the BLS-Survey of Occupational Injuries and Illnesses (SOII); and to determine the extent of direct intervention by the Occupational Safety and Health Administration (OSHA) for these injuries in the State.

Methods: We linked cases across three databases in Illinois – trauma registry, hospital discharge, and workers compensation claims. We describe amputation injuries in Illinois between 2000 and 2007, compare them to the BLS-SOII, and determine OSHA investigations of the companies where amputations occurred.

Results: There were 3984 amputations identified, 80% fingertips, in the Illinois databases compared to an estimated 3637, 94% fingertips, from BLS-SOII. Though the overall agreement is close, there were wide fluctuations (over- and under-estimations) in individual years between counts in the linked dataset and federal survey estimates. No OSHA inspections occurred for these injuries.

Conclusions/recommendations: Increased detection of workplace amputations is essential to targeting interventions and to evaluating program effectiveness. There should be mandatory reporting of all amputation injuries by employers and insurance companies within 24 h of the event, and every injury should be investigated by OSHA. Health care providers should recognise amputation as a public health emergency and should be compelled to report. There should be a more comprehensive occupational injury surveillance system in the US that enhances the BLS-SOII through linkage with state databases. Addition of industry, occupation, and work-relatedness fields to the Electronic Health Record, the Uniform Billing form, and national health surveys would allow better capture of occupational cases for prevention and for assigning bills to the right payer source.

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Introduction

Workplace amputation is a widespread, disabling, costly, and preventable public health problem. Thousands of occupational amputations occur each year, clustering in particular economic sectors, workplaces, and demographic groups such as young workers, Hispanics, and immigrants.^{1–10} Traumatic amputations are particularly catastrophic for these groups – because of their often limited educational attainment and the challenges of language and literacy, manual labour may be their only employment option.^{11,12} Amputation injuries affect not only physical functioning and economic viability, but also psychological and

social well being.^{13,14} Studies estimate the total cost of workplace amputations to be in the billions of dollars annually.¹⁵ But what is perhaps most disturbing and tragic about workplace amputations is that these injuries are preventable if legally mandated protections are in place.¹⁶

The Bureau of Labor Statistics (BLS) is the primary source of fatal and non-fatal occupational injury and illness surveillance in the US.¹¹ The BLS Survey of Occupational Injuries and Illnesses (SOII) has been shown to significantly undercount the number of work-related injuries, illnesses, and fatalities.^{17–20} Furthermore, although detailed information about the employer of workers suffering an amputation is available in SOII, there is little information on risk factors and no information regarding the severity of injury and outcomes relating to future employment prospects – disability and impairment. An accurate count and information about risk factors and disability are critical to

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targeting and evaluating interventions to prevent occupational amputation injuries.

The Occupational Safety and Health Administration (OSHA), charged with preventing injury and illness in the workplace, developed a National Emphasis Program to prevent amputations. Ongoing since 1997, OSHA area offices are supposed to systematically investigate at-risk workplaces, looking for violations that could lead to amputation injuries. Citations issued as part of the investigations are posted on OSHA’s website.²¹ Examination of OSHA investigations relating to occupational amputations has not been published.

The goal of this project was to identify and describe work related amputations amongst Illinois residents that occur within Illinois as reported in three legally mandated State databases for the years 2000–2007; to compare these cases with those identified through the BLS-SOII; and to determine the extent of direct intervention by OSHA for these injuries in the State.

Materials and methods

Data sources

The Illinois Trauma Registry (TR) captures the records of patients treated in a level I or II trauma centre for 12 or more hours. The TR does not include patients admitted to a hospital that is not designated as a trauma centre, those who die at the scene of the traumatic injury but are not transported to a trauma centre, or patients that are cared for at a trauma centre for less than 12 h. The variables in the TR that we used for this investigation are: age; birth date; sex; race/ethnicity; injury date and time; county code (Federal Information Processing System code) for home and scene of the event; ICD9 External Injury (E)-codes for mechanism and place of injury; ICD9 Diagnosis (N)-codes for type of amputation injury; discharge criteria; time of admission; and home postal zip code.

Hospital discharge (HD) data are collected by the Illinois Hospital Association. This database provides information from all inpatient hospitalisations within the State. Inpatients have a hospitalisation length of stay of 24 or more hours; anyone that stays in the hospital for less than 24 h is considered an outpatient and is not entered into the database. The variables used in the HD database are: demographic characteristics (birth date, sex); hospital ID number; hospital name; zip-code of residence; ICD9

codes for diagnosis, procedure and external cause of injury (N-codes, P-codes, E-codes); hospital outcomes; payer source; and hospital billing charges.

The Illinois Workers Compensation Claims (WC) database captures reports from injured workers who are not satisfied or anticipate a dispute regarding compensation for medical costs, wage replacement, or permanent partial/total disability; a claim is a request for arbitration through the State of Illinois Workers’ Compensation system. These claims are filed and entered into a separate database. In Illinois, there is not a statewide fund that manages all workers compensation claims. “Claims” are to be distinguished from “First Reports of Injury,” which are filed immediately after injury for those injuries that result in three days of lost work time according to Illinois statute. There are approximately 60,000 claims filed for arbitration each year, although this number has been declining in recent years. To put this in context, the BLS estimated that a total of 137,900 work related injuries and illnesses occurred in Illinois in 2009, of which 42,700 resulted in days away from work. Data elements included in the Workers Compensation Claims database (WC) are demographic variables (age, sex, marital status, number of dependents); nature of injury; part of body; date of injury; pro-se (advocating for oneself rather than hiring an attorney); date of claim filing; employer name; total medical costs; weekly wages; total weeks of temporary total disability; percent permanent partial disability awarded to the employee; and the monetary compensation disbursed.

A description of these databases, criteria for inclusion of cases, and data elements by category for each of the Illinois databases used in this study are shown in Table 1.

Illinois population

According to the 2010 census, there were 12.9 million people in the State of Illinois, with 71.5% of them white, 14.5% black and 15.8% Hispanic.²² Some 6.0 million people were employed, with ~200,000 in temporary jobs.²³

Case definition – work related amputations

The injured workers that were included in the study were employed in both public and private sectors suffering amputations

Table 1
Data elements showing the complementary nature of Illinois workers compensation and health outcomes databases that can be used to describe frequencies, calculate prevalence, and be used for multivariate analyses.

Database	Inclusion criteria	Data elements			
		Demographics	Exposure data	Health data	Economic variables
Trauma registry (ITR)	Persons treated in level 1 or 2 trauma unit for ≥ 12 h (~45,000/yr)	Name SSN Gender Age Race/ethnicity	ICD9 E-codes E849*, showing location where injury occurred Time, day, date of injury	ICD9N & E-codes Body site Severity Hospital procedures Treatment Disability status on discharge Blood alcohol	Cost of hospitalisation Hospital procedures Hospital days
Hospital discharge (HD)	All individuals hospitalised in Illinois	Gender Age Race/ethnicity	ICD-9N and E-codes	ICD9 codes Hospital procedures Hospital cost Discharge status	Cost of hospitalisation Hospital days Payer source
Workers compensation claims (IWCC)	Persons filing workers compensation claims for arbitration through IWCC (~70,000/yr)	Name SSN Gender Age	Employer Name Nature of injury Narrative of injury circumstances	ICD9 codes Hospital procedures Level of disability	Total medical costs Lost wages Cost of compensation Payer source

* ICD9 External Injury Code E 849 has decimal points that give the place injury occurred, e.g., E849.1 is Farm.

at work between 2000 and 2007. Individuals with a reported place of residence outside of Illinois were excluded.

For this study, an amputation is defined as a total avulsion of a part of a limb with bone loss. Amputations were identified in both the Illinois hospital discharge dataset and the Illinois trauma registry through the International Classification of Diseases coding system (ICD-9-CM): N-codes 885-traumatic amputation of thumb, 886-traumatic amputation of other finger(s), 887-traumatic amputation of the arm and hand, 895-traumatic amputation of toe(s), 896-traumatic amputation of foot, and 897-traumatic amputation of leg(s). This ICD9-based definition excludes fingertip amputations without bone loss. The WC claims dataset used an internal coding system for describing injury type and body part affected. Workers compensation codes for amputations that did not involve bone loss were excluded from the analysis.

Different work-relatedness criteria were used for each dataset because of differences in defined data elements. In the trauma registry, the trained record-keepers are required to ascertain if an injury occurred on the job and “work-related = yes or no” is a mandatory field on the database form. In the trauma registry, we also included patients whose hospital charges were paid by workers compensation. In the hospital discharge dataset, we identified all patients with a listed workers compensation insurance carrier. Since the companies that provide individual workers compensation may also cover general health insurance, we only considered those persons with a “comp” carrier who also had External Injury codes (E-codes) for place of injury in an industrial facility (E 849.3) and/or injuries caused by machinery likely to be associated with occupational injuries (E-codes: E918, E919, E920). In the WC dataset, all amputations were classified as work related.

Data linkage

Amputation cases were linked across the three databases using probabilistic methods based on the following common variables: treating hospital, date of birth, date of injury, date of admission, date of discharge, sex, residential zip code, cause of injury, and type of injury. The merged datasets (cases overlapping in all three and cases overlapping in any two datasets) were validated by comparing the part of body affected. Fig. 1 shows the distribution of cases by dataset, prior to and after the linkage process. We used SAS software for the data linkage process and all statistical analyses (v.9.2; Cary, NC).

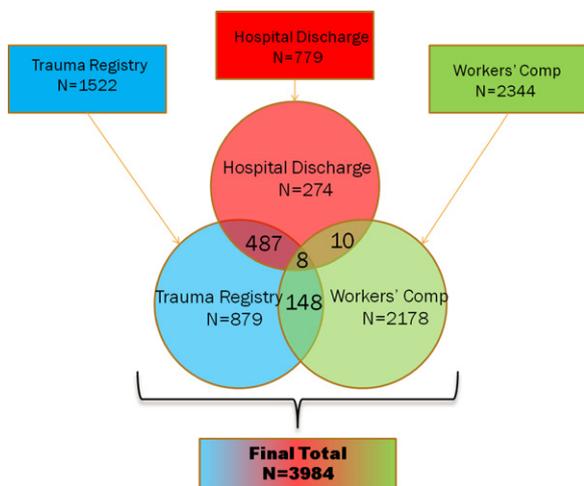


Fig. 1. Number of amputation cases in Illinois by source of data, 2000–2007.

Comparison to Bureau of Labor Statistics estimates

The BLS Survey of Occupational Illnesses and Injuries (SOII) is a national survey of private sector employers. The Survey also provides state estimates. In Illinois, approximately 6000 employers – sampled to represent employment in the State – are requested to carefully maintain their OSHA 300 injury reporting logs and deliver them at the end of the year. The OSHA 300 log is a federally mandated record of workplace illnesses and injuries that require more than first aid, or for which workers are off of work for more than one day. Data is extrapolated to approximate the frequencies of different types of injuries over the year. Certain public sector employers, the agricultural sector, and the military are excluded from SOII, however, state and local government agencies in Illinois are included in the Survey. There were no amputations reported by state and local government agencies in Illinois in the annual SOII reports, although other injuries and illnesses were reported from these employers. Therefore, we used a correction factor to estimate total private sector employees in our linked dataset (2.2% of employees were employed in the public sector) to account for the State SOII estimates having counts exclusively for private sector employers. Observed counts from the three Illinois datasets were compared to amputation estimates from the BLS Survey of Occupational Illnesses and Injuries in Illinois for the same time period.

OSHA investigation reports

The Occupational Safety and Health Administration conducts inspections and investigates public sector workplaces when there is either a death, a catastrophic event that causes hospitalisation of three employees, a referral from medical personnel, or a complaint from a worker representative or three employees. A National Emphasis Program on amputations has been in place since 1997 whereby OSHA conducts inspections of workplaces that pose a high risk for amputation injuries (OSHA, 2006). OSHA posts information about all investigations it executes on its website (OSHA, 2011). We identified companies with the highest numbers of amputations through the WC dataset and searched the OSHA website to determine whether they had an OSHA investigation; we describe citations that may have been issued following the investigation.

Results

From 2000 to 2007 there were 3984 unique cases of work-related amputations identified in Illinois using the three databases, with 653 cases overlapping between these datasets, and only eight of those cases common to all three (Fig. 1). The number and percent of amputations by body part are shown in Fig. 2. There were two fatal amputations, which also involved electrocution and cardiac arrest.

The majority of amputation injuries occurred in males (88.8%) and individuals between the ages of 25 and 54 (70.4%). Amongst those with WC claims, 54.7% were married, 63.1% lived with no dependents, 13.6% lived with one dependent, 12.1% with two dependents, and 11.2% with three or more. The median weekly wage amongst claimants was \$500, with an interquartile range of \$347–\$736 (25–75% tile). WC data shows that of these cases 52.6% represented themselves in arbitration rather than hiring legal representation. Amongst claims for all injuries and illnesses, only 18% of injured workers represent themselves.

The distribution of injuries for each month of the year showed a steady trend across the months with a small decrease between September and December. Cases were evenly distributed on Monday through Friday and much lower on the weekends. The

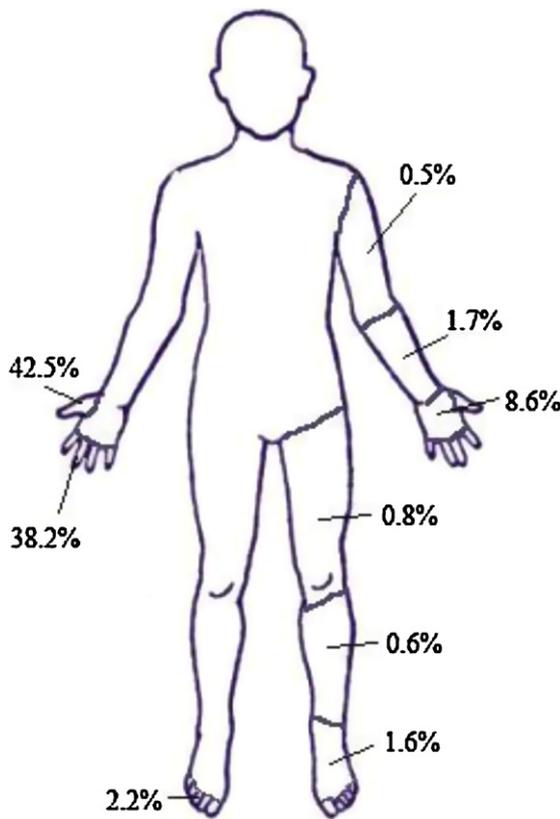


Fig. 2. Amputation Injuries (n = 3984) by part of body based on linkage of trauma registry, hospital discharge and workers compensation claims, Illinois 2000–2007.

causes of the amputations were most commonly machinery, such as power hand tools (63.8%), or “caught in or between objects” (11.6%).

Amongst the ten employers with the most amputations, five were employment service companies or temporary employment agencies, and the others included food manufacturers, the State of Illinois, heavy manufacturing, and a large grocery store chain. These ten employers had between 6 and 12 amputation injuries, each, between 2000 and 2007. In contrast, only 11.5% of the employers with a recorded work-related amputation in Illinois had two or more amputations during these years.

The employers with the highest number of major amputations (i.e., excluding digits), were the State (n = 8; 5 arm or hand and 3 leg), one temporary employment agency (n = 6; 4 arm or hand and 2 legs), two heavy manufacturers (n = 9; 6 arm or hand, 2 leg, one foot), one food manufacturer (n = 4; arm or hand), and one waste disposal company (n = 3; arm or hand).

Table 2
Comparison of amputation injuries of residents in Illinois from state data sources to SOII estimates from 2000 to 2007.

Year of amputation	Total cases	Private sector ^a	SOII estimated CASES	Percent error ^b total cases	Percent error ^b private sector only
2000	689	674	696	-1.0%	-3.2%
2001	576	563	658	-12.5%	-14.4%
2002	507	496	453	11.9%	9.5%
2003	481	470	540	-10.9%	-12.9%
2004	467	457	280	66.8%	63.1%
2005	471	461	450	4.7%	2.4%
2006	437	427	230	90.0%	85.8%
2007	356	348	330	7.9%	5.5%
Total	3984	3896	3637	9.5%	7.1%

^a Private sector cases is estimated based on subset of cases with employer information (n = 2344), of which 2.2% were employed in the public sector.

^b Percent error formula: Linked dataset (experimental) minus Survey of Occupational Injuries and Illnesses estimate (accepted value) divided by the accepted value.

OSHA citations

There were 2712 OSHA investigations resulting in citations in Illinois between 2000 and 2007 where “amputation” was the designated reason for the visit (OSHA). Amongst the top five employers with 30 cases of major amputations, there were 12 inspections for amputations between 2000 and 2008. Only one inspection occurred within 60 days of a major amputation event; 60 days is the statute of limitations for inspecting a workplace after a referral or complaint. Three of the five employers were cited for known amputation hazards (machine guarding, lockout-tagout training and communication, open hole guarding, no railing for a spiral staircase, outdoor exit, personal protective equipment, oxygen storage, no emergency plan). Advance notice was not given to any of these employers, and violations were typically abated within 30 days.

Comparison to national data

Between 2000 and 2007, the BLS SOII estimated that 3637 private-sector, work-related amputations occurred in Illinois. Our analysis identified 3984 cases (Table 2) of amputation during the same period of which 2.2% were public sector employees. Table 2 compares amputation injuries from our linked dataset to SOII cases. Overall, the two data sources (linked dataset vs. BLS State estimates) identified nearly the same number of total cases of amputations, with the linked dataset identifying 7.1% more cases. Table 2 shows the comparison of actual amputation cases to the SOII estimates for each year from 2000 to 2007. During most years, the number of identified cases in the linked dataset and the SOII estimates differed by no more than 15%. The biggest differences are seen in 2004 and 2006 with percent differences of 63.1% and 85.8%, respectively.

Table 3 shows qualitative differences between the cases captured in SOII vs. State databases and suggests reasons for these differences. There are more fingertip injuries in the SOII data, as expected: the State datasets tend to contain more serious cases because they come from trauma units and hospitalisations, whereas SOII captures outpatients and has a higher frequency of less severe amputations.

Discussion

Data linkage

Systems designed to capture occupational illnesses and injuries primarily include targeted surveys (e.g., the BLS Survey of Occupational Illnesses and Injuries, and the National Agricultural Workers Survey), state-based workers compensation reports (First Reports of Injury/Illness, and Claims), and rare physician reporting systems. Each of these sources significantly undercounts the

Table 3

Characteristics of state-based data sources vs. BLS-SOII and solutions for identifying missed occupational injury cases in each.

	Illinois linkage data (TR, HD, WC)	BLS-SOII data
Body part injured	80% fingers	94% fingers
Which cases are missing?	<ul style="list-style-type: none"> • Minor amputations <ul style="list-style-type: none"> - e.g., fingertips, those treated as outpatient • Injuries that led to amputation after hospitalisation or acute period • Those not filing WC claim • Those whose filing is in progress <ul style="list-style-type: none"> - Lag time to filing and establishing case 	<ul style="list-style-type: none"> • Small farms <10 employees • Public sector • Self-employed, independent contractor • Case not reported by employer • Non-representative sampling
Solution for identifying missed cases	<ul style="list-style-type: none"> • Obtain ED records • Obtain outpatient records • Get insurance data from work comp carriers • Conduct chart reviews of suspected cases • Review all amputation cases for possible work-relatedness • Link state-based data sources with BLS 	<ul style="list-style-type: none"> • Improve record keeping <ul style="list-style-type: none"> - Audit • Change weighting system—use more accurate correction factor • Require universal, web-based reporting • Expand system to cover more segments of the workforce • Link with state-based data sources

number of work-related injuries, illnesses, and fatalities owing to a variety of barriers: on the part of workers, there is underreporting of injuries to supervisors, inability to afford lost work time, inability to easily access workers compensation insurance, and reluctance to jeopardise cash-economy jobs or come to the attention of immigration officials²¹; on the part of employers there may be a disinclination to record incidents in OSHA 300 logs, to report to workers compensation insurers, or to call attention to informal employment arrangements²⁰; and physician reporting systems result in limited and poor capture rates.²⁴

Data linkage allows for capture of the maximum number of cases, since it identifies cases present in databases that have different inclusion criteria. Of the 3984 amputations identified through data linkage of the three state databases, only 653 cases linked across at least two, and only eight cases across all three. Trauma registry and hospital discharge records do not rely on reporting, but rather, automatically capture any case admitted to a level one or level two trauma centre (TR) and any case admitted to the hospital (HD). These two data sources are more likely to capture severe injury cases, and this is seen in the higher proportion and number of more severe cases and less fingertip injuries than the estimates reported in the BLS survey (Table 2). Workers Compensation Claims (WC) are conceivably more likely to be filed in cases where costs and lost work time are high – i.e., the more severe amputation injuries. However, there may be other factors that influence filing a request for arbitration by the Illinois Workers' Compensation Commission, such as type of injury, specific employers or types of employers, or labour-management relations. Table 3 lists the types of cases that would potentially be missing from these datasets and suggests solutions for making them more complete.

Data linkage also makes it possible to fill in missing variables – if there is a case match between two different data sources, missing data entries in one data source may be found in the other source to complete all data fields. Also, inaccurate or non-sense entries can be corrected by comparing individual cases across data sources. Finally, data linkage can assist in determining the integrity of a multiple imputation process, where empty fields are filled in with imputed entries that are likely to be accurate.

In addition to improving case identification and “cleaning” datasets, data linkage can expand the number and range of variables that may be used to describe, in this case, workplace amputations, giving a bigger picture of demographics, workplace hazards, risk factors, circumstances of injury/illness, adverse occupational health outcomes, and cost. For example, there are no data elements for race/ethnicity within workers compensation

claims in Illinois. Linkage of work comp claims to trauma registry or hospital discharge allows identification of race/ethnicity in a database that can provide information about the workplace and time lost or permanent partial impairment payouts for a given injury; conversely, information about the workplace and workers compensation insurance parameters are linked with medical records that can provide more detailed information about injury severity and medical procedures in the acute phase.

Although the number of amputation cases that linked across three datasets was small ($n = 8$), with a larger dataset it would be possible to conduct multivariable analyses to assess the impact of independent factors (e.g., diagnosis and injury severity, medical procedures) on outcomes (e.g., functional capacity, return to work, cost). This would make it possible to find intervention points to limit adverse health outcomes and lower costs. For example, the identification of employers (from workers compensation claims) with the most severe amputation injuries (from the trauma registry) should lead to an investigation of those specific workplaces and further research into conditions in similar workplaces with the goal of prevention.

Comparisons with national data sources

The Bureau of Labor Statistics is the primary source of fatal and non-fatal occupational injury and illness surveillance in the US.²⁵ The Survey of Occupational Illnesses and Injuries relies on a weighted sample and specifically excludes certain segments of the workforce, including federal government employers, workplaces with less than 11 employees (independent contractors), and the agriculture sector.

It is interesting to note that in most years there is little difference between the total amputation estimates in the BLS vs. the linked databases (Table 2). However, the counts based on the state-based data are far more stable across the years than the estimates provided by BLS-SOII, which showed major fluctuations in their estimates in two years – the BLS estimate was lower by 66.8% in 2004 and 90% in 2006. The BLS predictably undercounts occupational illnesses with a long latency, cases that occur in sectors that are outside the scope of the survey (certain public sector employees, independent contractors within and outside the formal economy, domestic workers, those working on small farms), cases that might be found in the workers' compensation system or health care records but did not get recorded by employers, and cases that do not get recorded anywhere.¹⁹ A clearer understanding of the ways in which SOII does or does not approximate true frequencies of non-fatal, occupational injuries

and illnesses – which may differ by specific injury or illness – would assist in refining how weighting of the sample is handled.

As expected, the BLS-SOII captures more minor injuries – fingertips – than the cases coming from trauma centres, hospitalised workers, and those requesting arbitration on workers compensation claims in Illinois. This finding suggests that a multi-source system, in which the BLS-SOII survey plays a central role, would yield a more accurate count and one that would span levels of severity and types of injuries and illnesses.

Other possible solutions are to require all employers to report – perhaps requiring the completion and upload of an electronic OSHA 300 log; or to develop a dedicated survey of workers instead of competing to insert questions on other national surveys (e.g., BRFSS, CPS).

Wolfe and Fairchild detail the history of occupational surveillance in the US and point out that the problems in determining numbers, rates, and trends are due to a lack of will on the part of policy makers rather than on the BLS.²⁶ This lack of will affects our ability to protect all workers, to hold employers accountable, to carefully examine the breaches in protection/prevention, or to evaluate policy and enforcement efforts. This investigation shows that data linkages can be an affordable alternative to augment BLS SOII, and can provide details regarding occupational injuries that are not captured in the employer survey.

OSHA citations

There were many severe, acute amputations in Illinois from 2000 through 2007: whole hand = 343; forearm = 68; upper arm = 20, whole foot = 64; lower leg = 24; upper leg = 32. These injuries undoubtedly led to high medical expenditures, extensive rehabilitation, and considerable lost work time in the acute phase. Given that the hand injuries generally occur during manual tasks required by the job, it is unlikely that any of the workers suffering severe upper extremity amputations returned to their usual work or manual labour of any kind. A study by Matsuzaki et al. and others have found that increased injury severity and self-reported hand dysfunction correlated negatively with return to work and functional ability.^{27,28} Amputation injuries, alone, lead to significant psychological trauma and lower quality of life^{29,30}; for labourers whose hands are essential to their livelihoods, this is the penultimate devastation for them and their families.³¹ Yet current Federal law, which requires reporting of fatalities or events that send three workers to the hospital, does not require reporting of amputations to the main occupational health and safety enforcement agency in the US. A new rule is being proposed to require reporting of all amputation injuries to OSHA.³² This change should not only go into effect, but efforts should be made to require reporting from health care providers to OSHA in order to assure that this public health emergency be addressed.

Limitations

There are several limitations to this study. First, identifiers in the datasets were not available for this research; a combination of deterministic and probabilistic linkage techniques may have led to a greater number of linked cases than with probabilistic linkage, alone. Deterministic linkage of cases with emergency department, outpatient records, and BLS-SOII data is being done in three other states currently to assess the ways in which underreporting is occurring and to define a scheme for strengthening and expanding occupational surveillance capabilities in the US [personal communication]. An emergency department database has just come available in Illinois (starting 2009); however, outpatient records from private practices and clinics are not available. Data from these sources would identify many more cases, since less severe injuries,

like fingertip and toe amputations, are frequently managed on an outpatient basis.

We have no way of knowing the validity of the case definition requiring loss of bone, nor can we know the accuracy of the coding without conducting a review of medical records. There could be misclassification of avulsions without bone loss due to lack or misreading of diagnostic criteria for amputation – those assigning diagnosis codes in the workers compensation claims, and even those assigning ICD9 codes in the medical settings may not have requisite data (e.g., X-ray results for fingertips); even physician coding has been shown to be inaccurate.^{33–35} Also, some injuries, like crush injuries, could result in amputations days or weeks after the acute injury, and would not be captured through TR or HD sources.

“Work-related = yes/no” also could have been miscoded. Workers compensation carrier as payer could be inaccurate for TR and HD records, given that the causality of these injuries by work may be disputed later on. For injury sentinels of a chronic nature, or those with a long latency between exposure and health effect, the relationship with work may be unrecognised, and coding for “work related” is more likely to be inaccurate. However, because of the dramatic nature of amputations and their proximate relationship with work tasks, miscoding is less likely. Our other mode of ascertainment of “work related” in the HD and TR databases to address the problem of listed workers compensation carriers possibly paying out via general health insurance – i.e., these cases had to also have E-codes for place of injury in an industrial facility and/or injuries caused by machinery more commonly found at work than at home – could underestimate work-related cases.

Conclusions and recommendations

Increased detection of workplace amputations is essential to targeting interventions and to evaluating program effectiveness, and could be accomplished in the following ways:

There should be mandatory reporting of amputation injuries by employers within 24 h of the event, and every injury should be investigated by OSHA. In order to identify cases, health care providers – including EMS first responders, emergency department and trauma centre personnel, and outpatient clinicians – as well as insurance providers should also be required to report to OSHA. An amputation injury should serve as a sentinel event that identifies a failure of prevention; the affected worker’s co-workers remain at risk unless the cause is remediated. Whilst HIPAA law induces extreme caution in reporting by health care providers, a legal requirement would supersede the HIPAA law (45 CFR 164.512). Even if the proposed OSHA reporting rule does not take effect, there is precedent of public health emergencies superseding protection of privacy in the health care setting, as is the case for gunshot injuries and child abuse cases. There should be a requirement of submission of OSHA 300 logs to BLS or to OSHA from every at-risk company; workers compensation systems should be mandated to submit amputation claims to OSHA as well.

More intensive investigation of workplaces that are at-risk for amputation should occur. The OSHA National Emphasis Program on amputations clearly did not prevent the injuries described here, and its overall effectiveness has not been studied. Greater resources should be allocated to OSHA to better address these and other devastating workplace injuries.

Research should be designed, funded, and used to better inform policymakers in the realm of occupational health and safety. The three funded studies of underreporting of occupational amputations, described above, will hopefully be the starting point to laying out a mechanism for expanded occupational injury and illness surveillance in the US. Although much research indicates problems

with the current occupational health surveillance system, larger, longer term, and more directed studies would better provide the necessary evidence on which to make policy decisions.

Although the BLS SOII provides a picture of occupational health in the US, it is limited by exclusion of a large segment of the working population, its estimates for specific work-related injuries can vary widely from year to year, and the size of its sample frame (the result of resource constraints) limits the potential for regional and local analysis and intervention. The move towards uniformity and sharing of health care data in the US provides opportunities to use medical records and billing forms for occupational surveillance at minimal cost. Codes for “industry” and occupation” could be added to the Uniform Billing form, which has been widely adopted for decades, to enter information to medical bills.^{36–38} A field for “work-relatedness” could be added to the Electronic Health Record, as could “industry” and “occupation” codes. These two changes would have not only immediate benefits for correct cost allocation and patient care, but would also generalise occupational health surveillance and injury/illness prevention in workplaces.

Conflict of interest

None of the authors have any financial or personal relationships with people or organizations that could inappropriately influence our work.

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