# Analysis of Workers' Compensation Claims Data for Machine-Related Injuries in Metal Fabrication Businesses

**Samuel C. Yamin, MPH,[1*] Anca Bejan, MS,[1] David L. Parker, MD, MPH,[1] Min Xi, PhD, MS,[1] and Lisa M. Brosseau, ScD[2]**

**Background** *Metal fabrication workers are at high risk for machine-related injury. Apart from amputations, data on factors contributing to this problem are generally absent.*
**Methods** *Narrative text analysis was performed on workers' compensation claims in order to identify machine-related injuries and determine work tasks involved. Data were further evaluated on the basis of cost per claim, nature of injury, and part of body.*
**Results** *From an initial set of 4,268 claims, 1,053 were classified as machine-related. Frequently identified tasks included machine operation (31%), workpiece handling (20%), setup/adjustment (15%), and removing chips (12%). Lacerations to finger(s), hand, or thumb comprised 38% of machine-related injuries; foreign body in the eye accounted for 20%. Amputations were relatively rare but had highest costs per claim (mean $21,059; median $11,998).*
**Conclusions** *Despite limitations, workers' compensation data were useful in characterizing machine-related injuries. Improving the quality of data collected by insurers would enhance occupational injury surveillance and prevention efforts.* Am. J. Ind. Med. © 2016 Wiley Periodicals, Inc.

***KEY WORDS: occupational safety; machine safeguarding; workers' compensation; injury prevention; safety management***

## INTRODUCTION

Over one million U.S. workers are employed in fabricated metal products manufacturing (North American Industry Classification System [NAICS] code 332), with several hundred thousand more employed in closely related metal manufacturing sub-sectors (NAICS 331, 333) [U.S. Census Bureau, 2013]. In 2014, the rate of injuries involving lost workdays (125.1 per 10,000 workers) in metal fabrication was considerably higher than the overall rate for private manufacturing (97.8 per 10,000) as were the rates for amputations (2.7 vs. 0.5 for private manufacturing overall), injuries to the eye (9.1 vs. 2.2), and hand (34.5 vs. 12.8) [BLS, 2016].

Metal-working machines such as power presses, press brakes, and lathes are frequently noted in U.S. Occupational Safety and Health Administration (OSHA) investigation reports of fatalities and catastrophic injuries [OSHA, 2015]. A Michigan surveillance program reported that metal fabrication was the industrial sub-sector with the highest average annual number of amputations for the period 2006–2012, and the third highest average incidence rate behind wood products and paper manufacturing [Largo and Rosenman, 2015]. State-level surveillance in Minnesota found that lack of machine guards was a contributing factor in a high proportion (61%) of amputation cases during

[1]HealthPartners Institute, Bloomington, Minnesota
[2]Division of Environmental and Occupational Health Sciences, School of Public Health, University of Illinois, Chicago, Chicago, Illinios
*Correspondence to: Samuel C. Yamin, MPH, HealthPartners Institute, 8170 33rd Avenue South, Mail stop 23301A, Bloomington, MN 55440–1524. E-mail: samuel.c.yamin@healthpartners.com

Accepted 21 April 2016
DOI 10.1002/ajim.22603. Published online in Wiley Online Library (wileyonlinelibrary.com).

1994–1995 [Boyle et al., 2000]. Aside from amputations, data are generally absent on contributing factors for injuries involving metal fabrication machinery.

Workers' compensation (WC) insurance claims data are a potentially useful source of information for occupational health and safety surveillance, albeit with limitations because WC data are collected for legal and business rather than research purposes and reporting requirements differ between states [Goldsmith, 1998; Dembe, 2010; Silverstein et al., 2010; Utterback et al., 2012]. WC data have been used to assess eye and amputation injury incidence across a variety of occupations [Islam et al., 2000; McCall and Horwitz, 2006; McCall et al., 2009; Largo and Rosenman, 2015] and to characterize injuries within occupational groups such as healthcare workers [Horwitz et al., 2002; Bell et al., 2013], carpenters [Lipscomb et al., 2013], and welders [Lombardi et al., 2005]. The purpose of this paper is to examine the strengths and limitations of workers' compensation claims data as a surveillance tool in understanding the etiology and cost of machine-related injuries occurring in metal fabrication businesses.

# METHODS

## Data Source

Workers' compensation claims data were compiled as part of the National Machine Guarding Program (NMGP), a machine safety intervention carried out in metal fabrication firms (NAICS 331, 332, 333) with between three and 150 employees. NMGP activities were conducted in partnership with two workers' compensation insurers [Yamin et al., 2014; Parker et al., 2015a,b]. One insurer provided de-identified claims data from all metal fabrication businesses holding WC policies and having a loss between January 1, 2010 and February 28, 2014.

The WC dataset contained 4,268 claims from 576 metal fabrication businesses. Cost data were included for 3,351 claims that were closed as of August 1, 2014. The number of employees was provided for 87% of businesses that had at least one claim during the referent period. Of those, 98% had fewer than 150 employees (range 3–252; mean = 19). The dataset included no information on an additional 439 insured metal fabrication businesses that experienced no workers' compensation claims during the study period.

The insurer applied a coding scheme built for National Council on Compensation Insurance (NCCI) reporting [NCCI, 2016]. Information on each claim was obtained from the first report of injury and included codes for part of body (POB), nature of injury (NOI), and cause of injury (COI), and a one- to two-sentence narrative description of the event. Medical and indemnity (replacement of lost wages) costs were provided for claims that were closed as of August 1, 2014. The number of lost or restricted workdays was not provided, nor was diagnostic information such as ICD-9 code. Although eligibility in the NMGP intervention was limited to businesses with three to 150 employees, no size limits were applied to the WC dataset.

## Narrative Text Analysis

A multi-level classification scheme was developed to systematically characterize each claim (Fig. 1). First, a keyword auto-coding program [Bertke et al., 2012] was used to assign all injury claims to one of three mutually exclusive categories: musculoskeletal disorders (MSDs), slips/trips/falls (STFs), or all other injuries. Two reviewers—an industrial hygienist and a machine safety specialist—then independently classified all claims in the latter category into one of three groups:

- Machine-related: the injury was attributable to operating or otherwise working with a stationary metal fabrication machine. Example: *Employee operating metal lathe and cut his thumb on sharp metal*. Injuries involving hand-held tools or mobile machinery such as forklifts were excluded.
- Non-machine: the injury was attributable to a cause other than operating or working with a machine. Example: *Employee struck finger with a hammer*.
- Possible machine-related: the narrative indicated that the injury may have been attributable to working with a machine. However, there was insufficient information to attribute the injury to work with a machine or to conclude that the injury was not machine-related. Example: *Piece of metal went under safety glasses*.

There was 83% concordance between the two reviewers on classification of claims across the three categories. The remaining 17% of claims were jointly re-evaluated by the two reviewers and placed into one of the three categories.

Each machine-related claim was subsequently reviewed to determine the work task most directly involved in the injury. Based on prior job hazard analyses, eight task categories were defined. If more than one category was applicable, the one that fit best was selected. The eight work task categories were:

- Cleaning machine: cleaning a machine or machine workstation. Removing chips was classified separately; cleaning or washing parts was excluded.
- Clearing jam: freeing a workpiece or other material stuck within a machine.
- Machine operation: operating a machine or being in the vicinity of a machine that was in operation.
- Removing chips: removing chips or scrap from a machine or workpiece.

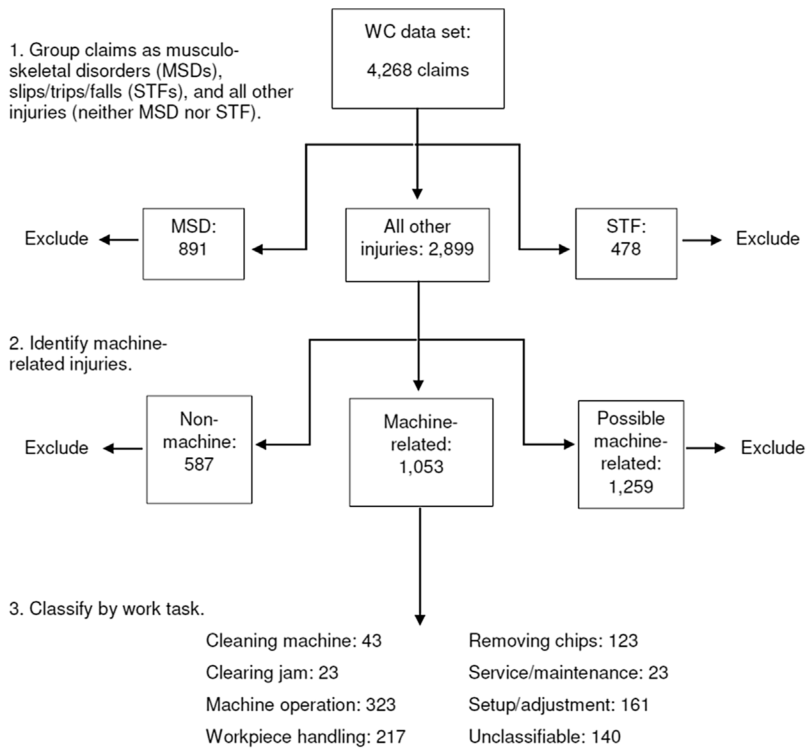


**FIGURE 1.** Classification of workers' compensation (WC) claims using narrative text.

- Service/maintenance: performing service, maintenance, or repair on a machine.
- Setup/adjustment: setting up a machine for operation, or adjusting machine parts or safeguards. Maintenance work and loading/unloading were excluded.
- Workpiece handling: handling of workpiece(s), feed-stock, or material (e.g., sheet metal) in the machine work area. Loading or feeding stock along with failure to properly clamp or secure a workpiece into a machine were included in this category, as was removing a workpiece from a machine, except when due to a jam. Material transport and handling in a warehouse or storage area were excluded.
- Unclassifiable: the injury was machine-related but the narrative did not contain enough information to specify an activity or task.

Two reviewers separately determined work task in a practice set of 100 sequentially selected claims, with a target threshold of 85% agreement. Agreement between reviewers was 90%. Thereafter, classification of work tasks for the remaining claims was performed by one reviewer.

## Quantitative Analysis

Basic descriptive statistics including frequency distributions, percentages, and means were used to describe work tasks and nature of injury. Data were further evaluated using cost per claim. Dollar amounts were not adjusted for inflation. Because costs were low for most claims, the figure of $100,000 was assigned to claims in excess of that amount when computing mean cost per claim. Severity was examined in terms of total cost per claim and indemnity cost where applicable.

Incidence rates could not be calculated for the full dataset, due to the lack of a denominator, as noted above. However, it was possible to calculate incidence rates for a subset of businesses. The number of employees was collected on-site during a machine guarding audit conducted at 198 shops [Parker et al., 2015a] insured by the study partner who provided the WC dataset used in the current paper. A denominator could thereby be formed for these 198 shops, even though many had zero claims during the referent period. Full-time equivalents per year (FTE/year) were estimated using the total number of employees at each business and the years of workers' compensation policy coverage between January 2010 and February 2014. Each employee was assumed to have worked full-time throughout the period of policy coverage.

## RESULTS

Using the auto-coding program [Bertke et al., 2012], 2,899 claims were classified into the "all other injuries" group (Fig. 1). Of those, 1,053 (36%) were manually classified as machine-related. The machine-related claims came from 495 businesses, of which 55% had one, 40% had between two and five, and 5% had between 6 and 20. The work tasks most commonly associated with machine-related injuries were machine operation (31%), workpiece handling (20%), setup/adjustment (15%), and removing chips (12%); 13% could not be classified.

Eye(s), finger(s) other than thumb, thumb, and hand were the most commonly injured body parts and accounted for 81% of machine-related injuries. As seen in Table I, eye(s) were the most frequently injured body part during both removing chips (57% of total) and machine operation (39%). Finger(s) were the part most often injured during setup/adjustment and workpiece handling (47% and 48%, respectively). Claims assigned various other part of body (POB) codes each accounted for fewer than 5% of the total, and were grouped as "all other POB." Distribution within "all other POB" was widest for workpiece handling (56 injuries across 22 different body parts) and setup/adjustment (42 injuries across 16 body parts).

Finger, hand, and thumb injuries combined accounted for 61% of all machine-related events (Table I). Lacerations were the most common type of finger, hand, and thumb injury, comprising 62% overall and between 62% and 82% within each work task shown in Table II. The greatest number of both amputations (n = 10) and fractures (n = 13) occurred during machine operation while the most contusions (n = 20) and crushes (n = 10) took place during workpiece handling.

As seen in Table III, the category "all other injuries" comprised 68% (2,899/4,268) of all claims. In all categories, mean medical cost per claim was much higher for claims with lost time (indemnity) payments than for those without. For claims with lost time payments, mean indemnity and medical costs per claim were similar across categories. Mean total cost per claim ($6,887) was highest for MSDs, followed by STFs ($4,363). The proportion of claims with indemnity costs was much higher for MSDs (180/627; 29%) and STFs (80/338; 24%) than for "all other injuries" (236/2,386; 10%).

Cost data were available for 86% of machine-related claims. These claims had a cumulative cost just over $2.3 million (Table IV). The $100,000 cap was applied to one amputation (actual cost = $142,794), one crush ($111,787) and one fracture ($112,481). Amputations were the most costly events with a median total cost per claim of almost $12,000 and the lowest percentage of claims with medical-only expenses (14%).

Foreign body was the nature of injury (NOI) for 98% (207/211) of machine-related eye injuries. Foreign body in the eye(s) accounted for 20% of machine-related injuries, but only 4% of cumulative costs, as only one claim resulted in indemnity costs, and median total cost per claim was lower than for any other NOI group (Table IV). Among four machine-related eye injuries assigned other NOI codes (two burns and two lacerations) none had indemnity costs.

Claims with total costs of at least $10,000 accounted for 6% (53/902) of machine-related injuries, including 14 lacerations, 13 amputations, and 10 fractures (Table IV). Work tasks most commonly associated with these high-cost injuries were machine operation (18), setup/adjustment (10), and workpiece handling (10), with 11 unclassifiable and four during other work tasks (data not shown in table).

Incidence rates in a subset of 198 businesses are shown in Table V. Rate data compiled by the U.S. Department of Labor, Bureau of Labor Statistics (BLS) [2016] are included in the table for comparison. Rates were generally higher in the WC dataset, although comparisons are inexact because the BLS data include only injuries involving lost workdays, whereas the WC rate data reflect all claims regardless of whether or not there was lost work time.

## DISCUSSION

Findings from this study are twofold in nature. First is the extent to which analysis of workers' compensation (WC)

**TABLE I.** Machine-Related Injuries: Common Work Tasks and Body Parts Injured

| | Work task | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Removing chips | | Machine operation | | Setup/adjustment | | Workpiece handling | | Total, all machine-related | |
| **Part of body (POB)** | **n** | **(%)** | **n** | **(%)** | **n** | **(%)** | **n** | **(%)** | **n** | **(%)** |
| Eye(s) | 70 | (57) | 125 | (39) | 3 | (2) | 2 | (1) | 211 | (20) |
| Finger(s) | 25 | (20) | 101 | (31) | 75 | (47) | 104 | (48) | 422 | (40) |
| Hand | 10 | (8) | 33 | (10) | 26 | (16) | 31 | (14) | 127 | (12) |
| Thumb | 10 | (8) | 26 | (8) | 15 | (9) | 24 | (11) | 92 | (9) |
| All other POB | 8 | (7) | 38 | (12) | 42 | (26) | 56 | (26) | 201 | (19) |
| Total | 123 | (100) | 323 | (100) | 161 | (100) | 217 | (100) | 1,053 | (100) |

Percentages are subject to rounding error.

**TABLE II.** Machine-Related Finger, Hand, and Thumb Injuries: Nature of Injury and Percentage by Work Task

| | Work task | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Removing chips | | Machine operation | | Setup/adjustment | | Workpiece handling | | Total, all machine-related | |
| **Nature of injury (NOI)** | **n** | **(%)** | **n** | **(%)** | **n** | **n** | **n** | **(%)** | **n** | **(%)** |
| Amputation | 2 | (4) | 10 | (6) | 2 | (2) | 4 | (3) | 30 | (5) |
| Contusion | 2 | (4) | 10 | (6) | 8 | (7) | 20 | (13) | 50 | (8) |
| Crush | 0 | (0) | 3 | (2) | 5 | (4) | 10 | (6) | 27 | (4) |
| Fracture | 0 | (0) | 13 | (8) | 12 | (10) | 9 | (6) | 49 | (8) |
| Laceration | 37 | (82) | 104 | (65) | 72 | (62) | 100 | (63) | 400 | (62) |
| Puncture | 1 | (2) | 4 | (3) | 5 | (4) | 2 | (1) | 13 | (2) |
| Multiple injuries | 1 | (2) | 8 | (5) | 3 | (3) | 8 | (5) | 33 | (5) |
| All other NOI | 2 | (40) | 8 | (5) | 9 | (8) | 6 | (4) | 39 | (6) |
| Total | 45 | (100) | 160 | (100) | 116 | (100) | 159 | (100) | 641 | (100) |

Percentages are subject to rounding error.

insurance claims data provides a better understanding of machine-related injuries and thereby aids in future prevention efforts. Second are insights into the strengths and limitations of WC data as a means of enhancing occupational injury surveillance.

This study evaluated a cross-section of machine-related injuries in metal fabrication businesses. Slightly over 30% of injuries occurred while the worker was operating a machine to produce or finish a part, with the remainder taking place during tasks such as removing chips, setup/adjustment, and

**TABLE III.** Narrative Text Analysis Categories and Claims Costs

| | | | Total costs (medical + indemnity) | | Claims with indemnity costs | | | | | Claims with medical costs only | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Category** | **N, all claims** | **N, claims with cost data** | **Cumulative costs** | **Mean total cost per claim** | **N** | **Mean indemnity cost per claim** | **Median indemnity cost per claim** | **Mean medical cost per claim** | **Median medical cost per claim** | **N** | **Mean cost per claim** | **Median cost per claim** |
| I. Musculoskeletal disorders (MSDs) | 891 | 627 | $4,318,183 | $6,887 | 180 | $7,981 | $2,312 | $13,058 | $9,980 | 447 | $1,585 | $518 |
| II. Slips/trip/falls (STFs) | 478 | 338 | $1,474,832 | $4,363 | 80 | $5,100 | $2,160 | $9,460 | $5,239 | 258 | $1,393 | $633 |
| III. All other injuries (neither MSD nor STF) | 2,899 | 2386 | $6,115,193 | $2,563 | 236 | $6,507 | $2,231 | $12,206 | $7,319 | 2150 | $903 | $488 |
| Machine-related | 1,053 | 902 | $2,364,576 | $2,621 | 93 | $6,077 | $2,198 | $11,992 | $7,005 | 809 | $939 | $517 |
| Possible machine-related | 1,259 | 1,012 | $2,743,728 | $2,711 | 98 | $7,968 | $2,476 | $12,888 | $8,533 | 914 | $936 | $479 |
| Non-machine | 587 | 472 | $1,006,889 | $2,133 | 45 | $4,212 | $2,169 | $11,152 | $7,203 | 427 | $764 | $471 |
| Total (I, II, and III) | 4,268 | 3,351 | $11,908,208 | $3,554 | 496 | $6,815 | $2,251 | $12,075 | $7,332 | 2855 | $1,054 | $502 |

(i) Cost data were only available for claims that were closed; (ii) 11 claims that exceeded $100,000 were assigned that amount: three MSDs, one STF, three machine-related, and four non-machine.

**TABLE IV.** Machine-Related Injuries: Nature of Injury and Claim Costs

| | | | Total costs (medical + indemnity) | | | | Claims with indemnity costs | | | | | Claims with medical costs only | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Nature of injury (NOI)** | **N, all claims** | **N, claims with cost data** | **Cumulative costs** | **Mean cost per claim** | **Median cost per claim** | **Number of claims ≥$10,000** | **N** | **Mean indemnity cost per claim** | **Median indemnity cost per claim** | **Mean medical cost per claim** | **Median medical cost per claim** | **N** | **Mean cost per claim** | **Median cost per claim** |
| Amputation | 32 | 22 | $463,307 | $21,059 | $11,998 | 13 | 19 | $11,281 | $5,570 | $15,085 | $7,408 | 3 | $1,356 | $543 |
| Contusion | 86 | 66 | $56,889 | $862 | $423 | 0 | 2 | $188 | $188 | $1,861 | $1,861 | 64 | $824 | $403 |
| Crush | 34 | 25 | $236,245 | $9,450 | $1,551 | 6 | 8 | $10,290 | $3,043 | $18,542 | $11,704 | 17 | $1,021 | $965 |
| Foreign body [eye] | 207 | 188 | $97,646 | $519 | $295 | 1 | 1 | $7,400 | $7,400 | $11,600 | $11,600 | 187 | $420 | $295 |
| Fracture | 64 | 56 | $338,289 | $6,041 | $1,880 | 10 | 17 | $6,243 | $2,267 | $9,386 | $4,852 | 39 | $2,437 | $1,210 |
| Laceration | 487 | 431 | $723,517 | $1,679 | $580 | 14 | 29 | $3,755 | $1,362 | $9,611 | $7,332 | 402 | $835 | $553 |
| Puncture | 19 | 17 | $63,374 | $3,728 | $918 | 1 | 2 | $606 | $606 | $17,308 | $17,308 | 15 | $1,836 | $684 |
| Multiple injuries | 44 | 35 | $259,753 | $7,422 | $2,034 | 6 | 10 | $3,154 | $1,633 | $17,260 | $22,832 | 25 | $2,224 | $1,498 |
| All other NOI | 80 | 62 | $125,556 | $2,025 | $739 | 2 | 5 | $2,597 | $1,128 | $3,903 | $4,534 | 57 | $1,632 | $629 |
| Total | 1,053 | 902 | $2,364,576 | $2,621 | $565 | 53 | 93 | $6,077 | $2,198 | $11,992 | $7,005 | 809 | $939 | $517 |

(i) Cost data were only available for claims that were closed; (ii) three claims costing in excess of $100,000 were assigned that amount: one amputation, one crush, and one fracture.

**TABLE V.** Injury Incidence in a Subset of Metal Fabrication Firms (n = 198) with BLS National Data for Comparison

| **Circumstances of injury** | **Incidence rate[a] [injuries/100 FTE/year]** | **95%CI** | **BLS rates[b] for injuries involving lost workdays in metal fabrication, converted to [injuries/100 FTE/year]** |
|---|---|---|---|
| All injuries[c] | 6.74 | 5.57–7.92 | 1.25 |
| Machine-related[d] | 1.65 | 1.30–2.00 | 0.16 |
| Part of body[e] | | | |
| Eye | 0.77 | 0.45–1.08 | 0.09 |
| Hand | 0.61 | 0.39–0.83 | 0.35 |
| Finger(s) | 1.56 | 1.05–2.08 | Not available |
| Thumb | 0.37 | 0.21–0.53 | Not available |
| Nature of injury[f] | | | |
| Amputation | 0.07 | 0.00–0.17 | 0.03 |
| Laceration | 2.16 | 1.55–2.76 | 0.18 |

[a]Full-time equivalents per year (FTE/year) were estimated using the total number of employees at each business and the years of workers' compensation policy coverage between January 2010 and February 2014. Each employee was assumed to have worked full-time throughout the period of policy coverage.
[b]Rates for injuries with lost workdays in all U.S. private fabricated metal product manufacturing (NAICS 332) for 2014. Rates presented and categories defined in: U.S. Department of Labor, Bureau of Labor Statistics. *Occupational Injuries/Illnesses and Fatal Injuries Profiles*. Available at: http://data.bls.gov/gqt, Accessed April 13, 2016 [BLS, 2016].
[c]In the current study, this includes all claims (with and without lost workdays) between January 2010 and February 2014.
[d]In the current study, machine-related injuries were identified through narrative text analysis of workers' compensation claims, and therefore may differ from BLS definitions [BLS, 2016].
[e]In the current study, part of body was coded by the insurer, and therefore may differ from BLS definitions [BLS, 2016].
[f]In the current study, nature of injury was coded by the insurer, and therefore may differ from BLS definitions [BLS, 2016].

workpiece handling. In comparison, an early study of metal-cutting lathe operators found that 17% of injuries occurred during machine operation, while the rest involved a variety of manual secondary tasks described as loading/unloading, deburring, and cleaning/clearing [Etherton et al., 1981].

From an occupational health surveillance perspective, several studies have investigated amputations within the metal fabrication trades [Olson and Gerberich, 1986; Boyle et al., 2000; Stanbury et al., 2003; Largo and Rosenman, 2015]. This study provides a broader perspective on the number and scope of injuries in metal fabrication, including many relatively minor (as indicated by low costs) but frequently occurring events such as lacerations and eye injuries. Although preventing amputations through point of operation guarding is critical, the finding that amputations and other serious, costly traumatic injuries such as fractures, crushes, and severe lacerations occurred during a variety of work tasks underscores a need to extend prevention efforts beyond the point of operation.

Finger, hand, and thumb injuries together comprised 61% of machine-related injuries in this analysis, with 62% of those being lacerations. The high proportion of lacerations is consistent with results of a clinical study finding that 63% of hand injuries in a wide variety of occupations were lacerations [Sorock et al., 2002]. Additionally, the most common source of injury was contact with "small metal items such as nails, metal stock, and burrs on metal pieces" [Sorock et al., 2002]. This likely indicates circumstances similar to those described in many of the claims narratives reviewed for this study, such as handling metal stock, grinding burrs, or removing metal chips from parts or machinery.

Eye injuries resulting from an airborne chip or particle were the second-most common type of machine-related injury in this analysis. Several other WC studies have also reported that occupational eye injuries are commonplace and frequently involve a foreign body in the eye [Islam et al., 2000; Lombardi et al., 2005; McCall et al., 2009]. Low claims costs indicate that most eye injuries in the current study were relatively minor, yet they are also largely preventable [Bull, 2007], and may result in rare but serious injury.

The nature of metal machining operations limits the ability to generalize findings to other industries. For example, while 98% of eye injuries in this analysis involved a foreign body, in a study of WC claims for welding-related eye injuries 63% were due to a foreign body and 30% were secondary to burns [Lombardi et al., 2005]. Similarly, finger, hand, and thumb injuries accounted for a high percentage of injuries in metal fabrication, whereas these body parts comprised just 21% of injuries in a study of carpenters [Lipscomb et al., 2013]. These differences between trades are not surprising, and point toward the importance of analyzing WC data on an industry-specific basis.

### Limitations

There are a number of limitations in using WC data to inform occupational health and safety practice. As noted by Bell et al. [2013], claims narratives lacking information on causal factors hinder the usefulness of WC data in development of preventive strategies. In the current study, most claims narratives contained a description of the task in which the injured worker was engaged at the time of the injury. However, the narratives were often insufficient with regard to identification of underlying factors that may have led to the injury event. For example, information was rarely included on specific hazards or on controls such as machine guards or the use of personal protective equipment.

An additional limitation was that lost workdays were not included in the dataset, so the severity of injuries could only be approximated with the dollar amount of claims. Lastly, it was not possible to calculate incidence rates for the full WC dataset because the number of employees was not provided for insured businesses that did not experience a claim during the study period. Incidence was calculated for a subset of businesses, yet comparability to national rate data [BLS, 2016] was limited due to differences in case definitions and reporting criteria.

## CONCLUSIONS

Based on narrative text analysis, there appear to be a large number of preventable injuries among metal fabrication workers. For example, the large number of eye injuries related to a foreign body may reflect a need for businesses to provide all workers with properly fitted, OSHA-compliant safety eyewear [OSHA, 2016] and enact other preventive measures such as strictly limiting the use of compressed air for removing chips from machines or parts. Similarly, the large number of finger, hand, and thumb lacerations may indicate the need for better machine guards during machine operation and use of tools rather than hands for tasks such as removing scrap or jammed parts from machines.

Workers' compensation (WC) insurers collect data on occupational injuries in manufacturing and are well positioned to assist businesses with implementation of safety management programs [Barbeau et al., 2004; Morse et al., 2013; Parker et al., 2016]. As such, data collection for purely administrative purposes represents a missed opportunity with regard to occupational injury surveillance. WC claims narratives often have insufficient detail to identify causal factors or to allow for precise coding of the nature of injury. Improving the quality of these narratives and integrating claims data with diagnostic coding would enhance the usefulness of WC data for occupational injury surveillance and prevention research.

## AUTHOR'S CONTRIBUTIONS

All of the authors listed here have made the following contributions: Substantial contributions to the conception or design of the work; or the acquisition, analysis, or interpretation of data for the work; and drafting the work or revising it critically for important intellectual content; and final approval of the version to be published; and agreement to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. Mr. Yamin was responsible for the overall management of the research study, data analysis, and drafting the manuscript. Ms. Bejan contributed to data analysis and drafting the manuscript. Dr. Parker served as the principal investigator was responsible for the overall integrity of the research and drafting the manuscript. Dr. Xi was lead statistician and data analyst. Dr. Brosseau served as the co-principal investigator and was responsible for the overall integrity of the research and drafting the manuscript.

## ACKNOWLEDGMENTS

The authors thank Steve Wurzelbacher, Stephen J. Bertke, Alysha R. Meyers, and Steve Allee from the NIOSH Center for Workers' Compensation Studies for use of the auto-coder and training set of keyword probabilities. The authors thank Jeanne Mettner of Park Nicollet Institute for editorial assistance.

## FUNDING

Authors received funding from U.S. Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health (NIOSH); Grant number: 5R01 OH003884-10.

## CONFLICT OF INTEREST

The authors do not have any competing interests/ conflicts of interest.

## DISCLOSURE BY AJIM EDITOR OF RECORD

Paul Landsbergis declares that he has no competing or conflicts of interest in the review and publication decision regarding this article.

## REFERENCES

Barbeau E, Roelofs C, Youngstrom R, Sorensen G, Stoddard A, LaMontagne AD. 2004. Assessment of occupational safety and health programs in small businesses. Am J Ind Med 45(4):371–379.

Bell JL, Collins JW, Tiesman HM, Ridenour M, Konda S, Wolf L, Evanoff B. 2013. Slip, trip, and fall injuries among nursing care facility workers. Workplace Health Saf 61(4):147–152.

Bertke SJ, Meyers AR, Wurzelbacher SJ, Bell J, Lampl ML, Robins D. 2012. Development and evaluation of a Naïve Bayesian model for coding causation of workers' compensation claims. J Safety Res 43(5–6):327–332.

Boyle D, Parker D, Larson C, Pessoa-Brandao L. 2000. Nature, incidence, and cause of work-related amputations in Minnesota. Am J Ind Med 37(5):542–550.

Bull N. 2007. Mandatory use of eye protection prevents eye injuries in the metal industry. Occup Med (Lond) 57(8):605–606.

Dembe AE. 2010. How historical factors have affected the application of workers' compensation data to public health. J Public Health Policy 31(2):227–243.

Etherton JR, Trump TR, Jensen RC. 1981. The determination of effective injury controls for metal-cutting lathe operators. Scand J Work Environ Health 7(Suppl 4):115–119.

Goldsmith DF. 1998. Uses of workers' compensation data in epidemiology research. Occup Med 13(2):389–415.

Horwitz IB, Kammeyer-Mueller J, McCall BP. 2002. Workers' compensation claims related to natural rubber latex gloves among Oregon healthcare employees from 1987–1998. BMC Public Health 18(2):21.

Islam SS, Doyle EJ, Velilla A, Martin CJ, Ducatman AM. 2000. Epidemiology of compensable work-related ocular injuries and illnesses: Incidence and risk factors. J Occup Environ Med 42(6):575–581.

Largo TW, Rosenman KD. 2015. Surveillance of work-related amputations in Michigan using multiple data sources: Results for 2006–2012. Occup Environ Med 72(3):171–176.

Lipscomb HJ, Schoenfisch A, Cameron W. 2013. Work-related injuries involving a hand or fingers among union carpenters in Washington State, 1989 to 2008. J Occup Environ Med 55(7):832–838.

Lombardi DA, Pannala R, Sorock GS, Wellman H, Courtney TK, Verma S, Smith GS. 2005. Welding related occupational eye injuries: A narrative analysis. Inj Prev 11(3):174–179.

McCall BP, Horwitz IB. 2006. An assessment and quantification of the rates, costs, and risk factors of occupational amputations: Analysis of Kentucky workers' compensation claims, 1994–2003. Am J Ind Med 49(12):1031–1038.

McCall BP, Horwitz IB, Taylor OA. 2009. Occupational eye injury and risk reduction: Kentucky workers' compensation claim analysis 1994–2003. Inj Prev 15(3):176–182.

Morse T, Bracker A, Warren N, Goyzueta J, Cook M. 2013. Characteristics of effective health and safety committees: Survey results. Am J Ind Med 56(2):163–179.

National Council on Compensation Insurance (NCCI). Data reporting. https://www.ncci.com/pages/data_reporting.aspx (accessed January 13th, 2016).

Olson DK, Gerberich SG. 1986. Traumatic amputations in the workplace. J Occup Med 28(7):480–485.

Parker DL, Yamin SC, Brosseau LM, Xi M, Gordon R, Most IG, Stanley R. 2015a. National machine guarding program: Part 1. Machine safeguarding practices in small metal fabrication businesses. Am J Ind Med 58(11):1174–1183.

Parker DL, Yamin SC, Brosseau LM, Xi M, Gordon R, Most IG, Stanley R. 2015b. National machine guarding program: Part 2. Safety management in small metal fabrication enterprises. Am J Ind Med 58(11):1184–1193.

Parker DL, Yamin SC, Xi M, Brosseau LM, Gordon R, Most IG, Stanley R. 2016. Findings from the National Machine Guarding Program—A small business intervention: Lockout/Tagout. J Occup Environ Med 58(1):61–68.

Silverstein B, Spieler E, Utterback D, Schnorr T, Leamon T, Davis L. 2010. Summary of workshop discussion: Occupational health and safety surveillance using workers' compensation data. In: Utterback DF Schnorr TM, editors. Use of workers' compensation data for occupational in jury & illness prevention. Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health (NIOSH) and United States Department of Labor, Bureau of Labor Statistics. pp. May 2010; Revised August 2010 173–178.

Sorock GS, Lombardi DA, Hauser RB, Eisen EA, Herrick RF, Mittleman MA. 2002. Acute traumatic occupational hand injuries: Type, location, and severity. J Occup Environ Med 44(4):345–351.

Stanbury M, Reilly MJ, Rosenman KD. 2003. Work-related amputations in michigan, 1997. Am J Ind Med 44(4):359–367.

United States Census Bureau. 2013. Economic census: Industry snapshots: 2013. http://www.census.gov/econ/snapshots/index.php (accessed June 11th, 2015).

United States Department of Labor, Occupational Safety and Health Administration (OSHA). 2015. Fatality and catastrophe investigation summaries. https://www.osha.gov/pls/imis/accidentsearch.html (accessed July 10, 2015).

United States Department of Labor, Occupational Safety and Health Administration (OSHA). 2016. Occupational safety and health standards; personal protective equipment: Eye and face protection. 29 CFR 1910.133 https://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table = STANDARDS&p_id = 9778 (accessed February 3, 2016).

United States Department of Labor, Bureau of Labor Statistics (BLS). 2016. Occupational injuries and illnesses and fatal injuries profiles. http://data.bls.gov/gqt/InitialPage (accessed April 13, 2016).

Utterback DF, Schnorr TM, Silverstein BA, Spieler EA, Leamon TB, Amick BC 3rd. 2012. Occupational health and safety surveillance and research using workers' compensation data. J Occup Environ Med 54(2):171–176.

Yamin S, Parker D, Brosseau L, Gordon B, Xi M. 2014. National Machine Guarding Program: Design of a machine safety intervention. Saf Sci Monit (Sweden) 18(1): http://ssmon.chb.kth.se/index.php/volume-18/issue-1 (accessed November 17, 2015).