Work-related Amputations in Michigan, 2008

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A Joint Report

of the

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EXECUTIVE SUMMARY

The Division of Occupational and Environmental Medicine at Michigan State University has developed a system for collecting data on work-related amputations in Michigan. This report characterizes these injuries for 2008. The salient findings are as follows:

- The system identified a total of 609 Michigan resident work-related amputations. This corresponds to a rate of 13.5 per 100,000 workers. In comparison, the official U.S. Department of Labor estimate (250)[1] was 59% lower.
- Hospital/emergency department medical records identified 528 cases. Workers' compensation lost work time claims data identified 233 amputation cases of which 80 were not found using medical records alone. In combination, hospital/emergency department medical records and workers' compensation claims identified one additional case.
- The amputation rate for males was nearly seven times that for females. Among males, rates were highest for those aged 20-24.
- Forty-five percent of the incidents occurred among those working in the manufacturing industry. The specific manufacturing groups with the highest rates were Paper Manufacturing, Wood Product Manufacturing, and Fabricated Metal Product Manufacturing.
- Power saws were the leading cause of amputations, accounting for 18% of cases for which injury cause was specified.
- Ninety-six percent of amputations involved fingers. One in nine of these finger injuries were to multiple fingers.
- Upper extremity amputations occurred most often (59%) on the left side.
- Workers' compensation was the expected source of payment of hospitalization or emergency department care for 79% of the cases for which payment source was identified. Payer source could not be determined for 5.5% of medical records reviewed.
- To date, the Michigan Occupational Safety and Health Administration (MIOSHA) inspected 35 of the worksites identified through medical records and assessed an average of nine violations and $1,350 in fines per inspection.

All of Michigan's acute care hospitals are required to participate in this surveillance system and were the primary source of data for most (87%) of the identified cases for 2008. Data provided by the Michigan Workers' Compensation Agency identified an additional 13% of cases that were not identified by hospital-based surveillance alone. The workers' compensation data were limited to individuals who requested wage replacement and did not include individuals who had claims for medical care cost reimbursement alone. Therefore, the surveillance system missed those cases in which injured workers were treated in non-hospital/emergency department settings or at out-of-state hospitals and did not request wage replacement.

The Michigan work-related amputation surveillance system produces valuable information. It identifies hazardous worksites that otherwise might go undetected and facilitates remediation at these worksites. It provides information that can be used to characterize workers and industries with high amputation rates. Finally, by combining data from two separate systems, medical records and workers' compensation claims, it provides the best estimate of the true number of amputations that occur in Michigan. The 609 amputations identified are appreciably larger than the official employer based estimate of 250.

This report will be updated annually and made available on the websites of the Michigan Department of Community Health, Division of Environmental Health, and the Michigan State University Division of Occupational and Environmental Medicine.

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INTRODUCTION

An amputation is one of the most debilitating injuries that can occur in the workplace. Unlike many other types of injuries, amputations often cannot be fully mended through medical or surgical treatment. Thus, workers sustaining amputations may be forced to make significant physical and psychological adjustments both in the workplace and their personal lives.

The Bureau of Labor Statistics estimates that 6,230 amputations resulting in days away from work occurred nationally in the private sector in 2008. The median number of lost workdays was 26 for amputation cases compared to seven days for all work-related injuries.[1] Reducing the incidence of work-related amputations is a federal priority. Between 2001 and 2004, the National Institute for Occupational Safety and Health (NIOSH) collaborated with the Council of State and Territorial Epidemiologists (CSTE) and staff from NIOSH-funded states to develop a set of nineteen occupational health indicators.[2] Two of the indicators were measures of work-related amputations.

The Michigan Occupational Safety and Health Administration (MIOSHA) was established in 1974. MIOSHA is part of the Michigan Department of Energy, Labor and Economic Growth (MDELEG). Its mission is to help assure the safety and health of Michigan workers through education and training, consultation, and enforcement. MIOSHA developed a strategic plan for 2004-2008 that included an objective to reduce amputations by 20%[3]. One general strategy listed is to develop cooperative efforts with the occupational safety and health community to identify and address workplace hazards.

In May 2004, staff in the Occupational and Environment Medicine (OEM) Division within Michigan State University's College of Human Medicine began reviewing hospital records for patients treated for amputations and referring cases meeting designated criteria to MIOSHA. MIOSHA referrals were tracked through 2005. Beginning with 2006 data, a surveillance system to track all work-related amputations treated at Michigan hospitals/emergency departments was established.[4] In addition, data were obtained from the Michigan Workers' Compensation Agency to supplement the hospital-based data and

provide a more complete count of work-related amputations. This report summarizes work-related amputations identified by this surveillance system for the third full year of data, 2008.

DATA SOURCES and METHODS

Data Sources

Medical records were used to identify work-related amputation cases treated at hospitals/emergency departments. Under the Michigan Public Health Code, Michigan hospitals are required to report these conditions.[5] MSU administers this law for both MDELEG and MDCH and medical records are sent directly to MSU's OEM Division.

The MDELEG Workers' Compensation Agency provided access to a database of claims for wage replacement due to lost work time. To be eligible for wage replacement, an individual must have been out of work seven consecutive days (i.e. five weekdays and two weekend days) or have sustained "specific losses." These specific losses include amputations in which at least a full phalanx is lost.

MIOSHA inspection reports were the source of information on the number of violations cited and the total penalties assessed for worksites referred to MIOSHA by the surveillance system for inspection.

The Current Population Survey (CPS), conducted by the U.S. Census Bureau for the Bureau of Labor Statistics, was the source of the estimated number of employed Michigan residents by defined age groups, gender, and industry groups for 2008. The BLS Local Area Unemployment Statistics (LAUS) system, which utilizes CPS data in combination with data from the BLS Current Employment Statistics program and state unemployment insurance systems, was the source of the number of Michigan residents employed by county of residence. The CPS and LAUS employment data were used to calculate worker-based amputation rates.

Methods

A case identified using hospital medical records was defined as an individual aged 16 years or older receiving medical treatment at a Michigan hospital/emergency department for whom: a) an amputation diagnosis was assigned (ICD-9-CM[6] codes 885.0-.1, 886.0-.1, 887.0-.7, 895.0-.1, 896.0-.3, and 897.0-.7); and b) the incident was documented as having occurred at work in 2008. The level of hospital care included outpatient surgery, emergency department visit, and hospital admission. A case identified using the workers' compensation system was defined as an individual aged 16 years or older who was in their lost work time wage replacement database with an accepted work-related amputation occurring in 2008. Cases that listed body parts that were inconsistent with upper or lower extremity amputation (e.g., "eye", "back") were excluded.

Worksites of hospital/emergency department-treated cases[*] that met the following additional criteria were referred to MIOSHA: a) the worksite was located in Michigan; and either b) the company was within an industry identified by MIOSHA as having a high injury rate or c) the amputation potentially was caused by a mechanical power press.[Δ] The MIOSHA high injury rate industries were those within North American Industry Classification System (NAICS)[7] three-digit codes 312, 321, 326, 327, 331, 332, 333, 336 and specific industry six-digit codes 423930 and 561730.[†]

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[*] Cases identified solely through workers' compensation records were not referred to MIOSHA. Data provided by the Michigan Workers' Compensation Agency can be used only for research and not for enforcement purposes.

[Δ] Employers are required to report injuries caused by mechanical power presses directly to MIOSHA within 30 days of the incident. MIOSHA uses referrals for amputations caused by power presses to identify companies that fail to comply with this reporting regulation. Worker's names are used in this process. Often medical records fail to specify the type of press (e.g., mechanical, hydraulic). Thus, cases where the medical record notes only that the injury was cause by a "press" were considered potential mechanical power press cases and were referred.

[†]

NAICS Code	Industry
312	Beverage and Tobacco Product Manufacturing
321	Wood Product Manufacturing
326	Plastics and Rubber Products Manufacturing
327	Nonmetallic Mineral Product Manufacturing
331	Primary Metal Manufacturing
332	Fabricated Metal Product Manufacturing
333	Machinery Manufacturing
336	Transportation Equipment Manufacturing
423930	Recyclable Material Merchant Wholesalers
561730	Landscaping Services

An MSU referral to MIOSHA consisted of copies of medical records that documented the injury, its cause, and the employer (workers' names were suppressed except for cases potentially involving power presses). MIOSHA staff reviewed referred cases to determine if they would conduct a worksite inspection. Referrals were made to MIOSHA between April 2009 and January 2010.

Some medical records lacked information as to whether an amputation occurred at work. In addition, for some work-related cases, the employer was not identified, information necessary to determine if an amputation met the criteria for a MIOSHA referral. In either of these instances, MSU staff attempted to interview the patient by phone to ascertain the missing information.

For all work-related amputation incidents identified from hospital/emergency department medical records, data collected included: hospital name, date of admission, patient demographics, city and county of residence, primary source of payment, company name, address, NAICS code, injury date and time, nature of injury (i.e., body part and amount amputated), dominant hand, and cause of injury. For cases referred to MIOSHA, additional information was obtained, including: date of referral, whether an inspection was performed, inspection date, number of violations, power press violations, total fines assessed, and whether the company had been on MIOSHA's "priority list[*]."

Once case ascertainment from medical record review and patient interviews was completed, records in the work-related amputation database were linked to records in the workers' compensation claims database using SAS software, version 9.1 of the SAS System for Windows (copyright 2002-2003 by SAS Institute Inc.). There were several steps in the record-linkage process. First, matches were identified using various combinations of social security number (either all nine digits or the last four digits which

[*] Each year, MIOSHA develops a priority list of establishments to inspect. These companies are selected because, as identified using workers' compensation records, they have a higher number of injuries or illnesses resulting in seven or more lost workdays than other companies performing similar work. In addition, MIOSHA inspects a random sample of employers each year. To evaluate if safeguards are maintained, MIOSHA also performs some re-inspections at establishments previously inspected who were found to have five or more serious violations.

often were all that medical records provided), date of injury (or date of hospital admission), first three letters of last name, date of birth, and company name. For cases that matched, the linked record was visually assessed to verify the match. Once this set of matched cases was created, additional matches were sought using less unique information (e.g., patient zip code of residence, date of injury plus/minus thirty days). The matching process was performed on the entire 2008 workers' compensation claims database to allow for links to cases not categorized as amputations by that system.

Upon completion of record linkage, cases were assigned to one of the following categories: 1) workers' compensation case where injury was an amputation matched with a work-related amputation per medical record; 2) workers' compensation case where injury was an amputation matched with a non-work-related amputation per medical record; 3) workers' compensation case where injury was an amputation matched with a case in which work-relatedness could not be determined from the medical record; 4) workers' compensation case where injury was an amputation not matched with an amputation per medical records; 5) workers' compensation case where injury was not an amputation matched with a work-related amputation per medical record; 6) workers' compensation case where injury was not an amputation matched with a non-work-related amputation per medical record; 7) workers' compensation case where injury was not an amputation matched with a case in which work-relatedness could not be determined from the medical record; 8) workers' compensation case where injury was not an amputation not matched with an amputation per medical records; 9) work-related amputation per medical record with no match to workers' compensation; 10) non-work-related amputation per medical record with no match to workers' compensation; 11) unknown if work-related amputation per medical record with no match to workers' compensation.

Work-related amputation rates were calculated by gender, age group, county of residence and type of industry by dividing the number of Michigan resident workers sustaining an amputation by the number employed and multiplying the result by 100,000. Rates were

not calculated for groups with fewer than six cases because these were considered statistically unreliable. Asterisks identify these cases in the tables.

SYMBOLS USED IN TABLES	
No cases occurred within category	–
Rate is considered statistically unreliable	*

Database management was conducted using Microsoft Access. Data analysis was performed using SAS software.

RESULTS

One hundred nineteen (119) of Michigan's 127 acute care hospitals submitted medical records to MSU. Six hospitals submitted no records but reported that they had no work-related amputation cases in 2008. One small rural hospital was unable to provide records due to technical issues and one mid-sized suburban hospital provided a computer printout of its amputations but has not yet provided individual medical records. This printout indicated they had treated 18 patients with amputations, five of whom had workers' compensation listed as the payer. The total number of records received and reviewed was 1,685. Project staff attempted to interview 188 patients to ascertain work-relatedness and/or employer information and completed 119 of these interviews (a 63% success rate).

In 2008, 541 individuals were treated at a Michigan acute care hospital/emergency department (ED) following a work-related amputation[*]. These include 537 originally identified through medical records and another four that were treated at a Michigan hospital, but could not be identified as work-related until linked to workers' compensation records.

These workers made a total of 660 hospital visits for care (116 of the 541 workers made multiple hospital visits). Nearly all workers (98.3%) were Michigan residents (N=532)

[*] Some of the cases identified solely through workers' compensation records may also have been treated at a Michigan acute care hospital/ED, but this could not be determined via analysis of that dataset.

(Table 1). The work-related amputation rate for these hospital-treated amputations among Michigan residents was 11.8 per 100,000 workers.

TABLE 1
Workers treated for an amputation at a
Michigan acute care hospital/ED, 2008

Characteristics of Workers and Healthcare Utilization	Number of Workers	%
Received treatment at a Michigan acute care hospital/ED	541	100.0
Michigan resident	*532*	*98.3*
One hospital visit	*418*	*77.3*
Multiple hospital visits (followup care or transfer to another hospital)	*114*	*21.1*
Out-of-state resident	*9*	*1.7*
One hospital visit	*7*	*1.3*
Multiple hospital visits (followup care or transfer to another hospital)	*2*	*0.4*

Data Source: Michigan hospital/ED medical records

Table 2 illustrates the number of cases ascertained by the two data sources and the results of the matching process. The workers' compensation database contained 233 accepted lost work time claims from Michigan residents with amputations. Two hundred twenty five (225) were paid for lost work time. For the remaining eight cases the amputation was not contested as being work-related but there was no indication that the individuals were paid for lost work time. Some of the 225 individuals paid for lost work time may not have been out of work seven consecutive days. As described previously (page 2), workers are eligible for wage replacement if they sustain "specific losses," such as the loss of a phalanx.

One hundred fifty six (156) of the 233 workers' compensation claims (67%) matched an amputation case identified from medical record review. For 77 cases, hospitals/EDs did not submit a medical record of an amputation (first row of Table 2). One hundred twenty

five (125) of the 528 hospital-record-based amputation cases (24%) matched workers' compensation claims records for which the type of injury listed in the claims data was something other than an amputation (e.g., crush, fracture, laceration). In one case, the medical record indicated the amputation was not work-related, however, the case was matched to a workers' compensation file. Finally, of 77 cases for which work-relatedness could not be determined via medical records, 3 matched workers' compensation files (two with an amputation, one with a non-amputation injury) (third column of Table 2).

TABLE 2
Results of matching Michigan resident work-related amputation cases ascertained from hospital/ED medical records and workers' compensation lost work time claims, 2008

Was Michigan Resident in Workers' Compensation Database?	Was Michigan Resident Amputation Work-related per Hospital/ED Medical Record?			No Match to Medical Record	Total
	Yes	No	Unknown		
Yes, with amputation injury	153	1	2	77	233
Yes, with a non-amputation condition	125	0	1	28,571	28,697
No	250	874	74	NA	1,198
Total	528	875	77	28,648	30,128

Shaded cells illustrate work-related amputation cases.

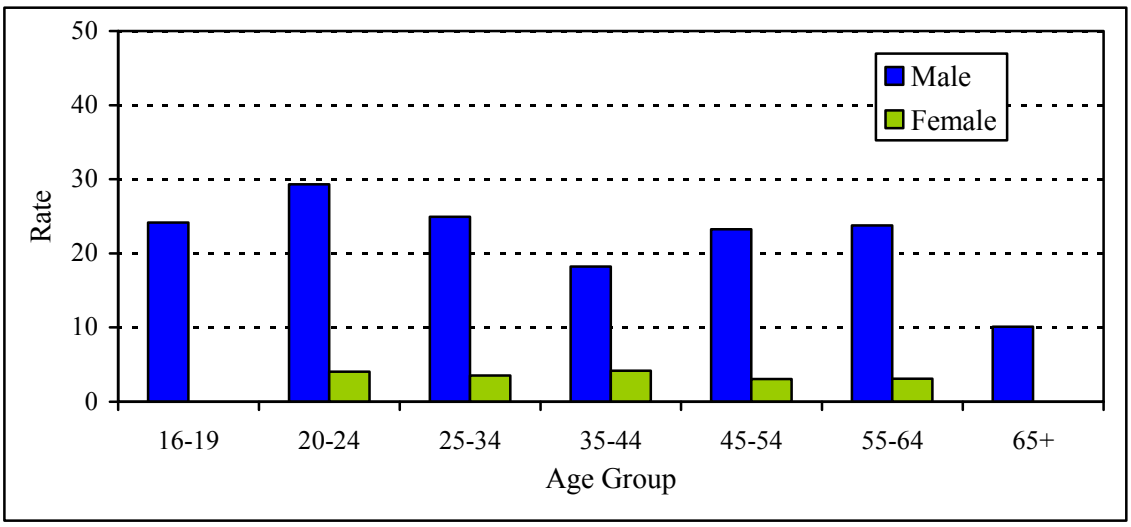
Adding the 81 cases that were identified using workers' compensation records to the 528 hospital-based cases yields a total of 609 Michigan resident workers. This corresponds to a rate of 13.5 amputations per 100,000 workers. The following analyses examine these 609 cases.

Characteristics of Injured Workers

Age and Gender

Males comprised 88% of workers who sustained an amputation. Among males, rates were highest for workers aged 20-24. Figure 1 displays amputation rates by age group and gender.

FIGURE 1
Work-related amputation rates
by age group and gender
Michigan residents, 2008



Rates are the number of workers sustaining an amputation per 100,000 workers.
Statistically valid rates could not be calculated for females aged 16-19 and 65+ due to insufficient numbers of cases.
Data Sources: Number of amputations – Michigan hospital/ED medical records and Michigan Department of Energy, Labor and Economic Growth Workers' Compensation Agency; Number of workers employed by age group used to calculate rates - Bureau of Labor Statistics' Current Population Survey

Race and Hispanic Ethnicity

Information on patient race and Hispanic ethnicity was missing in 44% and 94% of medical records, respectively, and is not collected in workers' compensation claims (see Table A-2 in Appendix A). Due to these levels of missing information, rates for racial/ethnic groups were not calculated. Of the workers for whom race was specified

(N=296), whites comprised 86% and African Americans 10%, very similar to the racial composition of Michigan workers overall (84% and 11%, respectively).

Body Part and Severity

As shown in Table 3 nearly all amputations were to fingers (96.2%). Data from hospital/ED medical records, which provide more detail on finger injuries than workers' compensation claims data, were available for five-hundred-seventeen finger amputation cases. The following analyses are limited to these cases. Of 517 finger amputation incidents, 58 (11.2%) involved multiple fingers. The distal phalanges of the middle and index fingers (sections G and J in Figure 2) were the most frequently amputated areas. The distal phalanges comprised 88% of all finger sections lost (excluding cases in which this information was unknown). Table A-3 and Table A-4 in Appendix A provide these data for the left and right hand separately for single-finger and multiple-finger amputation incidents, respectively.

TABLE 3
Work-related amputations
by injured body part
Michigan residents, 2008

Part of Body Amputated	Number of Workers	%
Upper Extremity	597	98.0
Finger	*586*	*96.2*
Hand	*3*	*0.5*
Arm	*7*	*1.1*
Unknown	*1*	*0.2*
Lower Extremity	9	1.5
Toe	*4*	*0.7*
Foot	*2*	*0.3*
Leg	*0*	*0.0*
Unknown	*3*	*0.5*
Unspecified Body Part	3	0.5
Total	609	100.0

Data Sources: Michigan hospital/ED medical records and Michigan Department of Energy, Labor and Economic Growth Workers' Compensation Agency

Overall, workers sustained more upper extremity injuries to their left side than their right side. This was especially true for right-handers (Table 4). For 45% of the 525 upper extremity amputation cases, hand dominance was not specified in medical records.

Case Study One

A 38-year-old worker caught his hand in a grinding press, severing his left index finger at the proximal interphalangeal joint. The amputated portion of the finger could not be surgically replaced. The case was referred to MIOSHA. They identified six violations and fined the company $900.

County of Residence

Table 5 illustrates the number of workers sustaining an amputation and the corresponding rate by a worker's county of residence. Note that the table does not necessarily reflect the counties with the highest risk worksites because people may work in a county other than the one in which they live. Seven counties had no cases and another 48 had between one and five, too few to calculate statistically valid rates. Montcalm County had the highest rate although there were only thirteen cases. Among the most populous counties in the state, Kent County had the highest rate (18.5 per 100,000 workers) while Oakland County had the lowest (5.1 per 100,000).

FIGURE 2
Work-related finger amputations
by digit and portion of finger lost
Michigan residents, 2008

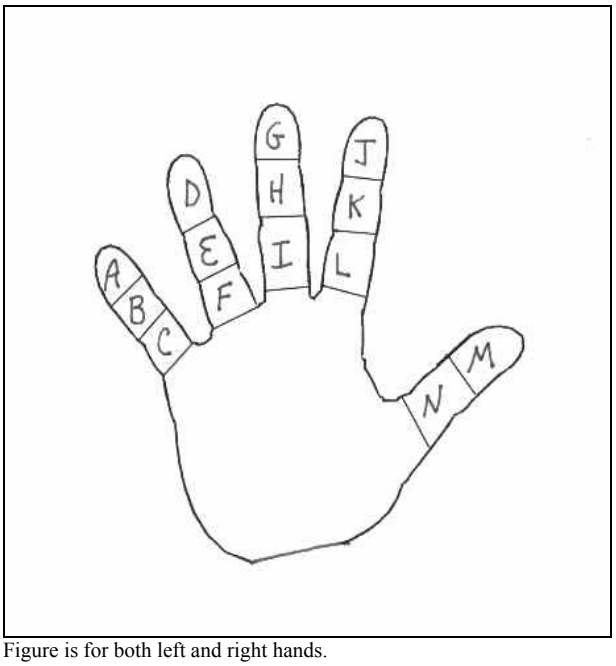


Figure is for both left and right hands.

Finger	Section	Number	%
Little	A	45	8.1
	B	9	1.6
	C	5	0.9
Ring	D	70	12.6
	E	9	1.6
	F	3	0.5
Middle	G	143	25.7
	H	10	1.8
	I	5	0.9
Index	J	148	26.6
	K	15	2.7
	L	7	1.3
Thumb	M	86	15.5
	N	1	0.2
Total		556	100.0

In 38 cases, the section(s) of finger lost was unknown.
In one case, the digit was unknown.
Data Source: Michigan hospital/ED medical records

TABLE 4
Work-related upper extremity amputations
by side injured and dominant hand
Michigan residents, 2008

Side Injured	Dominant Hand				Total
	Right	Left	Both	Unknown	
Right	100	16	0	95	211
Left	157	17	0	136	310
Both	1	0	0	0	1
Unknown	0	0	0	3	3
Total	258	33	0	234	525

Data Source: Michigan hospital/ED medical records

TABLE 5
Number and rate of work-related amputations
by county of residence, Michigan residents, 2008

County	Number	Rate	County	Number	Rate
Alcona	0	—	Lapeer	4	*
Alger	0	—	Leelanau	4	*
Allegan	6	11.6	Lenawee	6	13.5
Alpena	2	*	Livingston	11	12.7
Antrim	2	*	Luce	0	—
Arenac	2	*	Mackinac	2	*
Baraga	1	*	Macomb	62	16.3
Barry	3	*	Manistee	2	*
Bay	4	*	Marquette	6	17.7
Benzie	2	*	Mason	2	*
Berrien	9	12.1	Mecosta	5	*
Branch	7	34.6	Menominee	1	*
Calhoun	11	17.0	Midland	3	*
Cass	3	*	Missaukee	0	—
Charlevoix	3	*	Monroe	11	15.7
Cheboygan	2	*	Montcalm	13	55.0
Chippewa	3	*	Montmorency	1	*
Clare	1	*	Muskegon	14	17.0
Clinton	4	*	Newaygo	1	*
Crawford	2	*	Oakland	29	5.1
Delta	2	*	Oceana	6	47.0
Dickinson	1	*	Ogemaw	2	*
Eaton	12	21.5	Ontonagon	1	*
Emmet	4	*	Osceola	4	*
Genesee	21	11.4	Oscoda	1	*
Gladwin	0	—	Otsego	2	*
Gogebic	4	*	Ottawa	18	14.2
Grand Traverse	10	21.9	Presque Isle	1	*
Gratiot	8	44.9	Roscommon	1	*
Hillsdale	2	*	Saginaw	9	10.3
Houghton	1	*	St. Clair	15	20.3
Huron	4	*	St. Joseph	10	35.3
Ingham	20	13.9	Sanilac	5	*
Ionia	4	*	Schoolcraft	1	*
Iosco	0	—	Shiawassee	5	*
Iron	1	*	Tuscola	5	*
Isabella	5	*	Van Buren	7	18.8
Jackson	10	14.1	Washtenaw	13	7.3
Kalamazoo	8	6.3	Wayne, including Detroit	75	9.6
Kalkaska	1	*	*Detroit*	*27*	*8.9*
Kent	56	18.5	Wexford	4	*
Keweenaw	0	—	Unknown	5	—
Lake	1	*	Michigan	609	13.5

* Statistically reliable rate could not be calculated. See *Methods*.
Rates are the number of workers sustaining an amputation per 100,000 workers.
Data Sources: Number of amputations – Michigan hospital/ED medical records and Michigan Department of Energy, Labor and Economic Growth Workers' Compensation Agency; Number of workers used to calculate rates – Bureau of Labor Statistics' Local Area Unemployment Statistics

Industry

Table 6 illustrates the number and corresponding rate of work-related amputations by industry. For 14% of cases, there was insufficient information in either the medical records provided or workers' compensation claims data to make an industry classification. Forty-five workers were described in medical records as self-employed. Industry could be ascertained for fourteen of these self-employed workers; the remaining 31 were included in Unknown Industry. Among two-digit NAICS industry sectors, Agriculture/Forestry/Fishing/Hunting had the highest rate (33.8 per 100,000 workers). However, there were nearly fourteen times as many incidents within Manufacturing. In addition, certain three-digit NAICS subsectors within Manufacturing had very high rates, notably Paper Manufacturing (125 per 100,000) and Wood Product Manufacturing (119 per 100,000).

Case Study Two

A 37-year-old worker was hired at a company through an employment agency. He caught his right hand in a band saw, amputating nearly his entire index finger along with the tip of his middle finger. When interviewed, he reported that the saw was very old and had no safety guards. The case was referred to MIOSHA which subsequently found 44 violations at the worksite and fined the company $9,000.

TABLE 6
Number and rate of work-related amputations
by worker industry, Michigan residents, 2008

Industry Classification (NAICS industry sector code)	Number	Rate
Agriculture, Forestry, Fishing, Hunting (11)	17	33.8
Mining (21)	2	*
Utilities (22)	4	*
Construction (23)	64	25.2
Manufacturing (31 – 33)	235	28.8
Food Manufacturing (311)	*20*	*59.9*
Wood Product Manufacturing (321)	*16*	*119.3*
Paper Manufacturing (322)	*12*	*125.2*
Plastics & Rubber Products Manufacturing (326)	*20*	*62.4*
Primary Metal Manufacturing (331)	*22*	*82.9*
Fabricated Metal Product Manufacturing (332)	*48*	*91.8*
Machinery Manufacturing (333)	*26*	*36.8*
Transportation Equipment Manufacturing (336)	*36*	*9.7*
Furniture & Related Product Manufacturing (337)	*11*	*40.1*
Wholesale Trade (42)	30	30.2
Retail Trade (44 – 45)	46	8.4
Transportation & Warehousing (48 – 49)	15	8.5
Information (51)	2	*
Finance & Insurance (52)	1	*
Real Estate and Rental & Leasing (53)	6	9.6
Professional, Scientific, and Technical Services (54)	7	2.9
Administration & Support Services and Waste Management & Remediation Services (56)	11	6.7
Educational Services (61)	6	1.5
Health Care & Social Assistance (62)	5	*
Arts, Entertainment & Recreation (71)	7	9.3
Accommodation & Food Services (72)	47	15.1
Food Services & Drinking Places (722)	*46*	*16.3*
Other Services (81)	12	4.9
Public Administration (92)	6	3.6
Unknown Industry	86	---
Total	609	13.5

* Statistically reliable rate could not be calculated. See *Methods*.
Rates are the number of workers sustaining an amputation per 100,000 workers.
Data Sources: Number of amputations – Michigan hospital/ED medical records and Michigan Department of Energy, Labor and Economic Growth Workers' Compensation Agency; Number of workers by industry used to calculate rates: Bureau of Labor Statistics' Current Population Survey

Causes of Amputations

Causes of work-related amputations are illustrated in Table 7. (This information was unavailable in workers' compensation claims data, so the table is limited to the 532 cases for which a medical record was available.) Sharp objects were identified in nearly one-third (31.0%) of the cases. Power saws (e.g., table saws, miter saws) comprised one-half of sharp object injuries. Presses caused one in eight (12.4%) amputations. Medical records generally did not specify the type of press.

TABLE 7
Number of work-related amputations, by cause of injury
Michigan residents, 2008

Cause of Injury	Number	%
Sharp object	165	31.0
Power saw	*83*	*15.6*
Knife	*31*	*5.8*
Meat slicer	*18*	*3.4*
Router	*5*	*0.9*
Lawn mower	*2*	*0.4*
Other sharp object	*26*	*4.9*
Press	66	12.4
Mechanical/punch/stamping press	*7*	*1.3*
Hydraulic press	*4*	*0.8*
Other press	*6*	*1.1*
Unspecified type of press	*49*	*9.2*
Pinched between objects	68	12.8
In door	*12*	*2.3*
Struck by falling object	29	5.5
Struck by object – other	7	1.3
Caught in chain/pulley/gears/belt	39	7.3
Grinder	10	1.9
Fan	4	0.8
Snowblower	4	0.8
Machine – other specified type	17	3.2
Machine – unspecified type	43	8.1
Other specified cause	19	3.6
Unspecified cause	61	11.5
Total	532	100.0

* Workers' compensation claims data do not contain cause of injury information and thus are excluded from the table.
Data Source: Michigan hospital/ED medical records

An assortment of other machinery, many of which were unspecified in the medical records, caused one in nine amputations. Another frequent cause of amputations was workers getting pinched or crushed between objects, such as doors. Finally, medical records provided no information on cause for 11.5% of cases.

Source of Payment

As shown in Table 8, workers' compensation was the expected payer in 399 (75.0%) of the 532 cases for which there was a medical record. For 29 cases payment source could not be identified. Note that of the 133 cases for which workers' compensation was not listed as a payment source in medical records, 40 were linked to workers' compensation claims data. Workers' compensation was the expected payer for 80.9% of the 492 patients that were not self-employed.

TABLE 8
Work-related amputations
by payment source overall and for non-self-employed workers
Michigan residents, 2008

Expected Source of Payment	Total		Non-self-employed	
	Number	%	Number	%
Workers' compensation	399	75.0	398	80.9
Commercial insurance	70	13.2	51	10.4
Other	34	6.4	19	3.9
Not specified	29	5.5	24	4.9
Total	532	100.0	492	100.0

Data Source: Michigan hospital/ED medical records

Temporal Characteristics

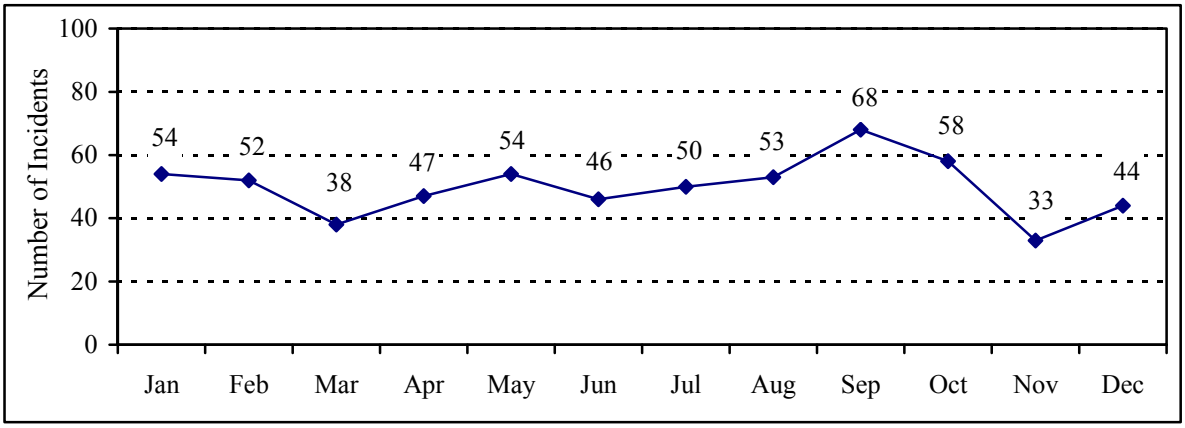
Incidents by Month

No seasonal trend was apparent for amputation incidents. The greatest number of cases occurred in September and the least in November (Figure 3).

Incidents by Day of Week

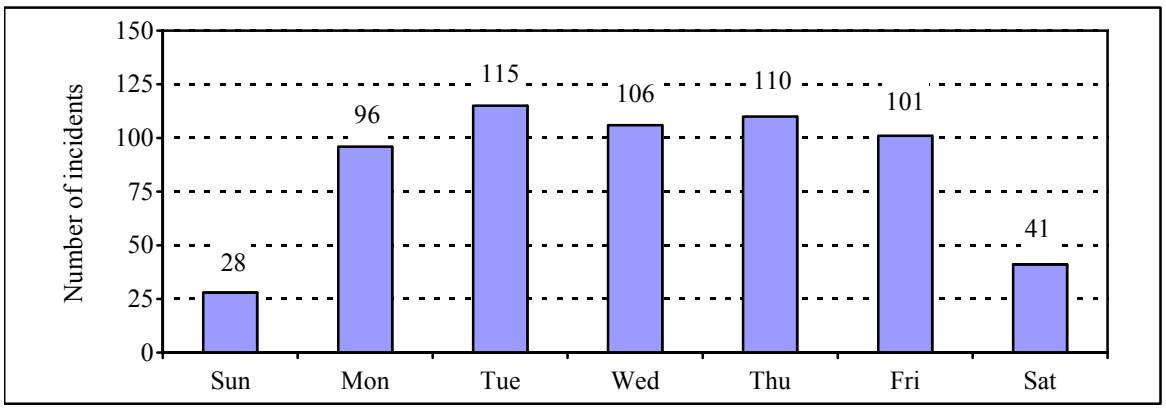
Amputation occurrence was slightly elevated Tuesday through Thursday and was much lower during the weekend (Figure 4).

FIGURE 3
Work-related amputations
by incident month
Michigan residents, 2008



Month of incident was unknown for twelve cases.
Data Sources: Michigan hospital/ED medical records and Michigan Department of Energy, Labor and Economic Growth Workers' Compensation Agency

FIGURE 4
Work-related amputations
by day of incident
Michigan residents, 2008

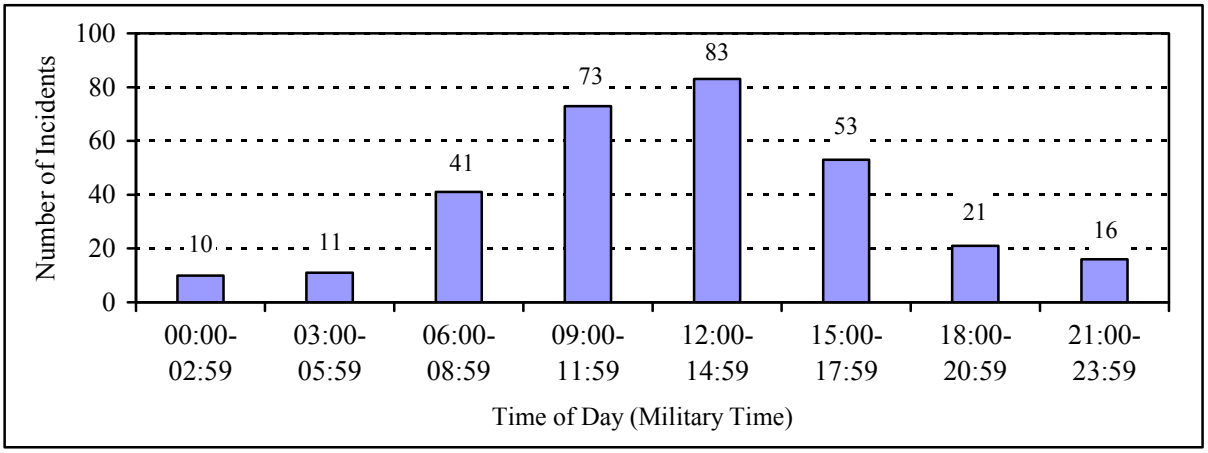


Day of incident was unknown for twelve cases.
Data Sources: Michigan hospital/ED medical records and Michigan Department of Energy, Labor and Economic Growth Workers' Compensation Agency

Incidents by Time of Day

Figure 5 illustrates the number of amputations by incident time. Most occurred between 9:00 AM and 2:59 PM. (Cases identified solely via workers' compensation claims are not shown because these records do not include incident time.) For 42% of incidents, the time of occurrence was unavailable in medical records.

FIGURE 5
Work-related amputations
by time of incident
Michigan residents, 2008



Time of incident was unknown for 224 cases.
Data Source: Michigan hospital/ED medical records

Referrals to MIOSHA

One hundred fourteen (114) of the 532 work-related amputations for which there was a hospital/ED medical record met the MIOSHA referral criteria.* Most of these cases (N=109) involved one amputation per worksite. However, at one worksite, three separate amputation incidents occurred and at another worksite, two separate incidents occurred. Thus, MSU referred 111 worksites to MIOSHA.

As of December 2010, there were 35 referrals without final resolution. Of the remaining 76 worksites, MIOSHA inspected 39 subsequent to a referral based on a hospital/ED medical record (Table 9). It is likely that at least four of these worksites would not have been inspected if not for the hospital/ED referrals since they were not on MIOSHA's priority list. Referrals were likely responsible for most of the inspections at another 31 worksites. All 31 were inspected within two months of a hospital/ED medical record referral. Because of limited resources, MIOSHA does not inspect all the companies on their priority list.

* Cases identified solely through workers' compensation records were not referred to MIOSHA. See *Methods*.

TABLE 9
Outcome of work-related amputation referrals to MIOSHA
Michigan residents, 2008

Outcome of Referral	Number of Worksites	%
Worksite inspected subsequent to referral	39	35.1
Company not on MIOSHA priority list	*4*	*3.6*
Company on MIOSHA priority list	*9*	*8.1*
Unknown if company on MIOSHA priority list	*26*	*23.4*
Worksite not inspected subsequent to referral	37	33.3
Worksite inspected prior to referral	*6*	*5.4*
Worksite not inspected	*31*	*27.9*
Inspection attempted or initiated, but not completed	*8*	*7.2*
Not yet determined*	35	31.5
Total	111	100.0

* As of December 2010, the final resolution of 35 worksites referred had yet to be determined.

Table 9 also illustrates that in 37 cases, MIOSHA did not perform inspections following hospital/ED referrals. In six instances, they had inspected the worksite prior to receiving the referral. For 31 worksites that were referred, MIOSHA conducted no inspections. For eight of these, they attempted or initiated an inspection without completing it (e.g., company was out of business, the machine in question was no longer in use). For 24 cases, no attempt was made to perform an inspection. Of these, the reasons listed by MIOSHA for not inspecting included: a) the case was too old (i.e., the time for assigning the referral for inspection had been exceeded); b) the cause of injury was not a violation of MIOSHA safety standards (e.g., object fell on worker's hand, worker's finger was caught between two pieces of steel); and c) insufficient information was provided as to the cause of injury.

The following analyses examine the outcome of the 35 MIOSHA inspections that were likely due to referrals based on hospital/ED medical records, as noted above.

Table 10 summarizes the number of violations identified in these inspections. For only one inspection, were no violations noted. The maximum number of violations was 44 and

the median was nine. Table 11 illustrates the distribution of assessed penalties. The highest penalty was $13,800 and the median was $1,350. MIOSHA cited six companies for mechanical power press violations.

TABLE 10
Violations identified in worksite inspections
conducted following an MSU referral
Michigan residents, 2008

Number of Violations	Number of Inspections	%
0	1	2.9
1-9	17	48.6
10-19	13	37.1
20+	4	11.4
Total	35	100.0

Data Source: MIOSHA inspection reports

TABLE 11
Penalties assessed in worksite inspections
conducted following an MSU referral
Michigan residents, 2008

Penalty Assessed	Number of Inspections	%
$0	4	11.4
$1 - $999	12	34.3
$1,000 - $4,999	11	31.4
$5,000 - $9,999	6	17.1
$10,000 and above	2	5.7
Total	35	100.0

Data Source: MIOSHA inspection reports

Case Study Three

A 38-year-old worker had his arm caught in a hydraulic press crushing his left distal forearm and hand. He subsequently underwent surgery in which his hand was removed at the wrist. The case was referred to MIOSHA. The result: three violations and $3,100 in fines.

Discussion

The Michigan work-related amputation surveillance system is valuable in several ways. First, the system provides information to allow MIOSHA to inspect worksites and find hazards that might otherwise remain undetected. In 2008, there were as many as 35 such cases. This identification and referral system directly provides support to MIOSHA in addressing Objective 1.1 of their 2009-2013 Strategic Plan[8]:

> *Reduce by 20% the rate of worker injuries and illnesses in high-hazard industries (defined as those in the following NAICS subsectors: 312, 321, 326, 327, 331, 332, 333, 336, 423930, 561730, 622, 623).*

In addition, the system provides information on the number of amputation incidents by worker demographics and type of industry. The corresponding rates identify high risk worker groups and industries. Lastly, the system can be used to highlight temporal characteristics and the leading causes of amputations.

Evaluation of Surveillance System Attributes

There are seven measures by which a surveillance system can evaluated to determine if it is effective and efficient.[9] These attributes are used to characterize the Michigan work-related amputation surveillance system.

Sensitivity – the proportion of all cases that are detected by the surveillance system

The surveillance system is designed to detect work-related amputations treated in Michigan hospitals or for which the worker submits a claim for wage reimbursement. The following factors prevented the system from being 100% sensitive in 2008:

1) *Incomplete submission of cases by hospitals* – Six hospitals reported treating no patients with work-related amputations in 2008 and consequently submitted no medical records to MSU. Two additional hospitals failed to submit medical records. An analysis of Michigan

inpatient and outpatient visits (MIDB-MODB)* in 2008 identified twelve Michigan residents treated at three of these eight hospitals that had an amputation diagnosis and workers' compensation listed as a source of payment. Based on matching zip code of residence, date of birth and date of injury/hospital admission, two of these twelve individuals were among the 77 cases identified solely through workers' compensation claims data (i.e., although these two cases were not submitted by hospitals, the surveillance system was able to capture them).

Several hospitals submitted medical records only for amputations that they identified as work-related. Because work-relatedness is not always readily apparent (e.g., MSU staff were able to identify some cases only through an interview), it is likely that these hospitals did not submit records for all cases. Statewide emergency department data would provide the best estimate of under-reporting due to incomplete record submission by hospitals. However, this data source currently does not exist in Michigan. The surveillance system's sensitivity will be improved in future years by requiring hospitals to submit medical records for all amputations rather than asking hospitals to filter out non-work-related cases.

2) *Incomplete identification of work-relatedness in medical records* – For 74 cases, work-relatedness could not be determined through patient interviews or because records could not be linked to workers' compensation claims data. Some of these amputations may have been work-related.

There are other work-related amputations that occur in Michigan that the system is not designed to capture, but are worth noting:

* This database is comprised of outpatient procedures and hospitalizations (inpatient stays). Thus, it misses most patients who are treated and released from emergency departments.

1) *Treatment at out-of-state hospitals* – Some amputations that occurred at Michigan worksites were likely treated at out-of-state hospitals. These out-of-state hospitals were not required to report the incidents to Michigan agencies. The MIDB-MODB can be used to approximate the number of incidents that were not identified for this reason. While the MIDB and MODB do not specify state of injury occurrence, they do contain information on Michigan residents treated out of state. In 2008, four Michigan residents treated for an amputation for which the primary or secondary payer was workers' compensation were seen at an out-of-state hospital. Two of these four individuals were among the 77 cases identified solely through workers' compensation claims data. Based on this information, it is estimated that in 2008, the surveillance system missed less than 1% of work-related amputations occurring in Michigan due to treatment at out-of-state hospitals.

2) *Non-hospital medical treatment with no workers' compensation claim submission* – The hospital/ED record component of the surveillance system misses workers who either are not treated medically (an unlikely occurrence) or are treated at non-hospital settings (e.g., company clinics, urgent care centers). The workers' compensation component misses cases in which injured workers do not submit a claim for wage reimbursement for lost work time. The number of such cases is unknown but presumably limited to the less severe cases.

While the surveillance system does not identify all work-related amputations in Michigan, it is much more sensitive than the system conducted by the Bureau of Labor Statistics (BLS). The BLS reported 250 work-related amputations in Michigan in 2008 – 59% fewer than our system (N=609). There are some definitional differences between the two systems: BLS measures those who work in Michigan, not Michigan residents, excludes the self employed (N=45) and individuals without lost work time, and requests

that employers do not report amputations that do not result in bone loss. The BLS figure is not a count of all amputations but rather is an estimate based on a sample of employer-reported injuries and thus is dependent upon the sample drawn and the degree to which employers record worker injuries. Finally, some injuries classified as amputations in medical records may have been recorded by employers as something else (e.g., crush, laceration).

Predictive Value Positive (PVP) – the proportion of persons identified as cases that actually have the condition being monitored

The PVP of cases identified from hospital medical records is likely high (i.e., greater than 95%). For these to be classified as cases: 1) the incident must have occurred at work; and 2) the injury must have been coded as an amputation. Incidents were coded as work-related if: a) medical records documented that they occurred at work; b) the expected payer was workers' compensation; or c) the patient reported the incident as work-related during the phone interview. In a few instances, injuries were described as serious avulsions in medical records, but were subsequently coded (using ICD-9-CM) as amputations. The PVP of cases identified solely through workers' compensation records may be slightly lower because information on injury type is provided by employers rather than medical professionals.

Representativeness – the degree to which identified cases accurately describe all cases

The surveillance system appears to be geographically representative. Most hospitals submitted medical records and it appears that few cases were lost due to those hospitals that did not provide records (see sensitivity discussion above). Self-employed workers were more likely than other workers to be under identified because work-relatedness for this group often could not be determined from medical records and they are not covered by workers' compensation. While self-employed workers comprised 7.4% of all Michigan resident work-related amputation cases, they comprised 23.0% (17 of 74) of the cases for which work-relatedness could not be determined.

Timeliness – the delay between any two or more steps in the system

The timeliness of the system is its weakest attribute. Medical records for patients treated in 2008 were initially received in February 2009. The last reporting hospital submitted records in January 2010. In June 2010, patient interviewing was completed (i.e., either patients were successfully contacted and interviewed or it was determined that the patient could not be interviewed), all medical records were reviewed and data on work-related amputations entered into a database. At this point, data from workers' compensation claims were obtained and record matching was performed. Timeliness is also a concern with regard to making referrals to MIOSHA. Worksite inspections could be better targeted if the time between injury incidence and MIOSHA referral was reduced. This deficiency will be addressed in the coming year as hospitals will be required to report on a quarterly basis.

Flexibility – the ability of the system to adapt to changing needs

The system is highly flexible. Data items ascertained from medical records or through follow-up interviews have been added or deleted as their usefulness has become apparent. In addition, the criteria for cases to be referred to MIOSHA have evolved. For example, in September 2008, MIOSHA changed the composition of industry types eligible for referral. The surveillance system was able to immediately comply with this change in a seamless fashion.

Simplicity – the ease of operating the system and the complexity of its design

The case definition is easy to apply and usually cases are identified quickly. For 188 of 1,685 (11%) of the medical records reviewed case identification was more complex because additional information was sought through an interview. However, it is likely that the number of interviews will decrease in the future. Recently the Workers' Compensation Agency has provided their claims database in a timely manner so that work-relatedness can quickly be determined by searching for the case in the database. Almost none of the data items ascertained from medical records or MIOSHA inspection reports are complex. There are a small number of individuals involved in maintaining the

system. At MSU, one person is responsible for pursuing hospital medical record submission, and one person reviews medical records, makes referrals to MIOSHA, performs data abstraction, data entry, links medical records and workers' compensation claims records, and performs data analysis. All individuals working on the system spend only a portion of their time on this project. At MIOSHA, there is one point of contact who receives referrals and returns inspection reports.

Acceptability – the willingness of individuals and organizations to participate

All but two hospitals responded to MSU's request for medical records on work-related amputations either by submitting records or reporting having no cases. Project staff had a 63% success rate in obtaining information from patients via phone interview. Unsuccessful attempts were due mainly to an inability to contact patients because of out-of-date mailing addresses or phone numbers. A few were due to their unwillingness to participate. MIOSHA has stated that they value referrals although they would prefer better timeliness. The Workers' Compensation Agency readily provides access to their data.

Limitations

The surveillance system had several limitations due to the quality and type of information provided in medical records and workers' compensation claims data.

1. Medical records often were non-specific in documenting the causes of amputations. This was especially detrimental when injuries were caused by a "press": either a power press was incorrectly listed as the cause, or a power press was in fact the cause, but not explicitly noted.
2. Medical records sometimes provided insufficient information to identify an industry and assign a NAICS code without patient interviews. This is likely to have resulted in some cases not being referred to MIOSHA that should have been.
3. Hospitals varied substantially in the degree to which they provided information on patient race and Hispanic ethnicity. Overall, there was too much missing information for these important demographics to be analyzed.

4. Workers' compensation claims data did not include information on injury cause and lacked detailed injury information (e.g., single vs. multiple digit loss, which hand/finger was injured). Thus, results on these characteristics could not be fully described.
5. The success of record linkage depended upon the accuracy of the linking variables. If any case listed by workers' compensation as an amputation should have been linked to a medical record but was not, it was counted more than once.

Conclusions

This surveillance system, which uses hospital reporting and workers' compensation claims data, provides a more accurate estimate of the true number of work-related amputations than the employer-based reporting system maintained by the Bureau of Labor Statistics, which is the basis for the official count of workplace injuries. In addition, the hospital-based data can be used for public health interventions to identify and mitigate the hazards that cause amputations. Given the success of the surveillance system, we plan to continue tracking amputations and facilitating workplace investigations. The ultimate objective is to significantly reduce the incidence of this serious injury.

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APPENDIX A

Data Tables

TABLE A-1
Number and rate of work-related amputations
by age and sex
Michigan Residents, 2008

Age Group	Male		Female		Total	
	Number	Rate	Number	Rate	Number	Rate
16-19	22	24.2	2	*	24	12.4
20-24	66	29.3	8	4.0	74	17.5
25-34	114	24.9	15	3.5	129	14.6
35-44	107	18.2	21	4.2	129	11.8
45-54	140	23.3	16	3.1	156	13.9
55-64	74	23.8	10	3.1	84	13.3
65+	10	10.1	1	*	11	6.3
Total	534	22.5	73	3.4	609	13.5

* Statistically stable rate could not be calculated.
Rates are the number of workers sustaining an amputation per 100,000 workers.
Age was unknown for one male. Gender was unknown for one case aged 35-44. Age and sex were unknown for one case.
Data Sources: Number of amputations – Michigan hospital/ED medical records and Michigan Department of Energy, Labor and Economic Growth Workers' Compensation Agency; Number of workers employed by age group used to calculate rates - Bureau of Labor Statistics' Current Population Survey

TABLE A-2
Number of work-related amputations
by race and Hispanic ethnicity
Michigan residents, 2008

Race	Hispanic Ethnicity			Total
	Yes	No	Unknown	
White	0	0	256	256
Black	0	0	30	30
Other	0	0	10	10
Unknown	31	0	282	313
Total	31	0	578	609

Data Sources: Michigan hospital/ED medical records and Michigan Department of Energy, Labor and Economic Growth Workers' Compensation Agency

TABLE A-3
Work-related single-finger amputation incidents (N=459)
by injured hand and amount of finger lost
Michigan residents, 2008

Hand	Finger	Section Lost				Total
		Distal Phalanx	Middle Phalanx	Proximal Phalanx	Unknown	
Right	Thumb	27		0	2	29
	Index	61	2	4	2	69
	Middle	44	0	0	2	46
	Ring	16	2	0	2	20
	Little	19	1	0	1	21
Left	Thumb	55		1	1	57
	Index	64	7	0	2	73
	Middle	64	4	1	2	71
	Ring	36	2	0	2	40
	Little	19	6	2	3	30
Total		405	24	8	19	456

For three cases, the injured side was unknown.
Data Source: Michigan hospital/ED medical records

TABLE A-4
Work-related multiple-finger amputation incidents (N=58)
by injured hand and amount of finger lost
Michigan residents, 2008

Hand	Finger	Section Lost				Total
		Distal Phalanx	Middle Phalanx	Proximal Phalanx	Unknown	
Right	Thumb	2		0	1	3
	Index	11	2	2	2	17
	Middle	14	3	2	2	21
	Ring	7	1	2	1	11
	Little	4	0	2	1	7
Left	Thumb	2		0	0	2
	Index	12	4	1	2	19
	Middle	21	3	2	2	28
	Ring	11	4	1	3	19
	Little	3	2	1	2	8
Total		87	19	13	16	135

Data Source: Michigan hospital/ED medical records