

# Work-Related Amputations Michigan 2016

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**MICHIGAN STATE**  

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**UNIVERSITY**



# **Work-Related Amputations in Michigan, 2016**

A Joint Report of the

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## Executive Summary

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The Division of Occupational and Environmental Medicine at Michigan State University (MSU) and the Michigan Department of Health and Human Services (MDHHS) direct a surveillance system for monitoring work-related amputations in Michigan. This report describes these injuries for 2016. Key results include:

- The system found 431 work-related amputations among Michigan residents (9.3 per 100,000 employed persons). The official U.S. Department of Labor estimate (240) was 44.3 percent lower.
- From 2006 to 2016, the number of work-related amputations fell 41.8 percent and the rate fell by 40.8 percent. Numbers and rates decreased from 2006 to 2009, then remained fairly level until 2013. There was a slight increase in work-related amputations in 2013, but the number and rate have fallen since then (23.9 percent and 29.0 percent, respectively).
- Most (374) cases were found through hospital/emergency department medical records. Workers' Compensation Lost Wage Claims identified 142 cases, 85 of which were matched to medical records. Work-relatedness could not be determined for two cases based on medical records but was confirmed after linking the cases to the Workers' Compensation database.
- The amputation rate was over seven times higher among males compared to females.
- Over one-third of amputations occurred among workers in the manufacturing industry. The manufacturing sector with the highest rate was Wood Products Manufacturing.
- Power saws were the leading cause, causing 13.9 percent of amputations with a known cause.
- Most (92.8 percent) amputations involved fingers. About one in seven (14.4 percent) finger amputations involved multiple fingers.
- The expected payer for medical costs was Workers' Compensation for 73.3 percent of cases with a specified payment source.
- The Michigan Occupational Safety and Health Administration (MIOSHA) inspected 10 worksites and assessed an average of one violation and \$2,000 in penalties per worksite.

Michigan hospitals, which are required to report work-related amputations, were the primary data source for 86.7 percent of cases in 2016. The remaining 13.3 percent of cases were found only through the Michigan Workers' Compensation Agency. The Workers' Compensation data only includes workers who requested wage replacement due to missing work for more than seven consecutive days or who received compensation based on the percentage of finger(s) lost. It does not include individuals who filed claims for medical care cost reimbursement only. Michigan's surveillance system does not capture workers who don't receive treatment at a hospital in Michigan and don't file a Workers' Compensation claim.

The Michigan work-related amputation surveillance system uncovers hazardous worksites, facilitates worksite remediation, and identifies workers and industries with high amputation risks. By combining data from both medical records and Workers' Compensation claims, it provides a more accurate estimate of the number of amputations that occur in Michigan. The surveillance system found 191 more amputation cases than the official employer-based estimate of 240. This report will be updated annually and made available on the MDHHS Division of Environmental Health and the MSU Division of Occupational and Environmental Medicine websites.

## Introduction

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An amputation is one of the most debilitating injuries that can occur in the workplace. In many cases, medical and surgical treatment cannot restore function of the affected body part. After an amputation, workers may have to make serious physical and psychological adjustments both in the workplace and their personal lives.

The United States Department of Labor, Bureau of Labor Statistics (BLS) estimates that there were 5,250 amputations involving days away from work nationwide in 2016. Workers lost a median of 23 workdays for amputation cases compared to eight days for all work-related injuries.<sup>1</sup> Reducing work-related amputations is a public health priority. The Council of State and Territorial Epidemiologists (CSTE) along with the National Institute for Occupational Safety and Health (NIOSH) have developed a set of 24 occupational health indicators, including two related to work-related amputations to track progress on this goal.<sup>2</sup>

The Michigan Occupational Safety and Health Administration (MIOSHA), established in 1974, is part of the Michigan Department of Licensing and Regulatory Affairs (LARA). MIOSHA works with employers and employees to help prevent workplace injuries, illnesses, and fatalities. To help employers improve the safety and health of their employees, MIOSHA works with the occupational safety and health community to identify and address workplace hazards.

The Occupational and Environment Medicine (OEM) Division, part of the MSU College of Human Medicine, began reviewing hospital records for amputations and referring cases which met criteria to MIOSHA in May 2004. Only cases referred to MIOSHA were tracked through 2005. In 2006, a surveillance system was established to track all work-related amputations treated at Michigan hospitals/emergency departments.<sup>3</sup> The new surveillance system obtained data from the Michigan Workers' Compensation Agency to help provide a more complete count of work-related amputations. This report summarizes work-related amputations identified by this surveillance system for 2016.

## Data Sources

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Work-related amputation cases are identified through medical records submitted by hospitals and emergency departments in Michigan, as required by the Michigan Public Health Code.<sup>4</sup> MSU acts as MDHHS's bona fide agent to oversee this requirement. Medical records are sent directly to the MSU OEM Division.

The LARA Workers' Compensation Agency provides access to wage replacement claims database under a Memorandum of Understanding Agreement. A worker must miss more than seven consecutive days of work (i.e. five weekdays and two weekend days) or experience "specific losses" to qualify for wage replacement. A specific loss includes amputations of at least a full phalanx (the bone of a finger or toe).

MIOSHA inspection reports provide information on the number of violations and total penalties for worksites referred by the surveillance system for inspection.

The NIOSH Employment Labor Force Query System, which uses BLS Current Population Survey (CPS) data, provides the estimated number of employed Michigan residents by age group, gender, and industry for 2016. The BLS Local Area Unemployment Statistics (LAUS) system, which uses CPS data, BLS Current Employment Statistics program data, and state

unemployment insurance system data, provides the number of employed Michigan residents by county. Employment estimates were used to calculate worker-based amputation rates.

## Methods

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Cases identified by hospital medical records were included if they:

- Were 16 years or older at the time of injury and received medical treatment at a Michigan hospital or emergency department.
- Had outpatient surgery, an emergency department visit, or were admitted to a hospital and their medical record included at least one of the following valid amputation diagnosis codes assigned at any level of diagnostic priority: S48, S58, S68, S78, S88, or S98 per the International Classification of Diseases, Tenth Revision, Clinical Modification (ICD-10-CM).<sup>5</sup>
- Sustained the amputation at work in 2016.

Cases identified using the Workers' Compensation system were included if they:

- Were 16 years or older at the time of injury.
- Had a record in the Workers' Compensation lost work time wage replacement database with an accepted work-related amputation which occurred in 2016.

Cases with an amputation of a body part besides an upper or lower extremity amputation (e.g., "eye", "back") were excluded.

MIOSHA reviewed cases if the worksite was in Michigan and the amputation was potentially caused by a mechanical power press\* or other hazard likely to be found in an inspection to determine if an inspection was necessary. MIOSHA did not review cases when the cause of injury was vaguely described in medical records (e.g., "pinched between objects"). MSU staff attempted to interview patients by phone if the records lacked information on where the injury occurred, who the employer was, or other important details. Data provided by the Michigan Workers' Compensation Agency is restricted to research and cannot be used for enforcement purposes, therefore cases found only in Workers' Compensation records were not reviewed by MIOSHA.

Information abstracted from medical records included the hospital name, date of admission, date of discharge, patient demographics, city and county of residence, primary source of payment, company name, address, North American Industry Classification System (NAICS)<sup>6</sup> code, injury date, body part amputated, ICD-10-CM code(s), and cause of injury. For cases inspected by MIOSHA, additional information including the inspection date, number of violations, number of violations related to the identified hazard, whether hazards had been fixed at the time of the inspection, power press violations, and total fines assessed were also collected.

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\*Employers are required to report injuries caused by mechanical power presses to MIOSHA within 30 days of the incident. MIOSHA uses surveillance data to identify companies that fail to comply with this regulation. Often medical records fail to specify the type of press (e.g., mechanical, hydraulic). All cases where the medical record notes only that the injury was caused by a "press" were considered potential mechanical power press cases.

Once medical record abstraction and patient interviews were complete, records were linked to the Workers' Compensation claims database to deduplicate cases and obtain additional information, if available. Record linkage was performed using the RecordLinkage Package in RStudio, Version 1.1.330 (copyright 2009-2017, RStudio, Inc). Records were matched using an iterative probabilistic matching algorithm, which calculates a match probability for all potential pairs within a defined exact match criterion, or 'block'. Three iterations, or 'passes' were performed. The first pass was blocked by standardized last name, date of birth, and month of injury, and match probabilities were calculated based on similarity between first names, Social Security numbers, date of injury, and type of injury. The second pass was blocked by standardized last name, standardized first name, and type of injury and probabilities were calculated based on similarity between the injury day, injury month, birth year, birth month, birth day, and Social Security number. The third and final pass was blocked by type of injury, injury month, birth year, and birth month and probabilities were calculated based on similarity between standardized first and last names, Social Security numbers, date of injury, and birth day. The initial matching process was performed using entire 2016 Workers' Compensation claims database to find matches of cases miscategorized as non-amputations.

Linked cases fell into one of the following eight categories: 1) Workers' Compensation amputation injury case matched with a work-related amputation medical record; 2) Workers' Compensation amputation injury case matched with an amputation medical record in which work-relatedness was undetermined; 3) Workers' Compensation amputation injury case which could not be matched with an amputation medical record; 4) Workers' Compensation non-amputation injury case matched with a work-related amputation medical record; 5) Workers' Compensation non-amputation injury case matched with an amputation medical record in which work-relatedness could not be determined; 6) Work-related amputation medical record without a match to Workers' Compensation; 7) Workers' Compensation non-amputation injury case which was not matched with an amputation medical record; and 8) Amputation medical record with undetermined work-relatedness and no match to Workers' Compensation.

Work-related amputation rates were calculated by sex, age group, county of residence, and type of industry by dividing the number of Michigan resident workers sustaining an amputation by the number of employed persons and multiplying the result by 100,000. Rates were not calculated when the relative standard error (standard error of a rate divided by the rate) was 40 percent or greater as these rates were considered statistically unreliable. Asterisks identify these cases in the tables.

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

## Results

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All 130 acute care hospitals, including the four Veteran's Administration (VA) medical centers in Michigan complied with the reporting requirement. Seventy-nine hospitals submitted medical records and 51 facilities reported that they had no work-related amputation cases in 2016. MSU received and reviewed 1,507 medical records and determined 415 met eligibility criteria. Project staff attempted to interview 24 patients to determine work-relatedness and/or employer information and 21 (87.5 percent) interviews were completed.

In 2016, 385 individuals were treated at a Michigan hospital/emergency department (ED) following a work-related amputation.<sup>†</sup> These workers made a total of 415 hospital visits for care (29 of the 385 workers made multiple hospital visits). Nearly all workers (97.1 percent) were Michigan residents (N=374) (Table 1). The work-related amputation rate for these hospital-treated amputations among Michigan residents was 8.1 per 100,000 workers.

**Table 1: Number and Percentage of Workers Treated for an Amputation at a Michigan Hospital, 2016**

Characteristics of Workers and Healthcare Utilization	Number	Percentage
<b>1) Michigan residents</b>	374	97.1%
a) One visit	345	89.6%
b) Multiple visits*	29	7.5%
<b>2) Out-of-state resident</b>	11	2.9%
a) One visit	11	2.9%
b) Multiple visits*	0	0.0%

\*Multiple visits may include follow-up care or transfer to another hospital

Data source: Michigan hospital/ED medical records

Table 2 provides the number of cases ascertained by the two data sources and the results of the matching process. The Workers' Compensation database contained 142 claims for lost work time from Michigan residents for amputations, of which 128 were paid or partially paid by the end of 2016 and five were expected to receive payment. There was no indication that the remaining nine claims were paid for lost work time. For eight of these nine, the amputation was not contested as being work-related. Some individuals paid for lost work time may not have been out of work more than seven consecutive days because, as described previously, workers are eligible for wage replacement if they sustain "specific losses," such as the loss of a phalanx.

**TABLE 2: Results of Matching Michigan Resident Work-Related Amputation Cases Ascertained from Hospital/ED Medical Records and Workers' Compensation Lost Work Time Claims, 2016**

Was Michigan Resident in Workers' Compensation Database?	Medical Record Stated that Amputation was Work-Related	Medical Record Did Not State Amputation was Work-Related	No Match to Medical Record	Total
Yes, with amputation injury	83	2	57	142
Yes, with non-amputation injury	107	0	19,874	19,981
No	182	1	NA	183
<b>Total</b>	<b>372</b>	<b>3</b>	<b>19,931</b>	<b>20,306</b>

Note: Shaded cells illustrate all work-related amputation cases eligible for inclusion.

Of the 142 Workers' Compensation claims for an amputation injury, 85 (59.9 percent) matched an amputation medical record. There were 57 amputation cases found in Workers'

<sup>†</sup> Some of the cases identified only through Workers' Compensation records may also have been treated at a Michigan hospital/ED, but the hospital either did not assign an amputation code or did not report the case.



Compensation claims that could not be linked to a medical record (first row of Table 2). Of the 375 amputation cases submitted by hospitals and documented as work-related, 83 (22.1 percent) were matched to a Workers' Compensation claim for an amputation injury, 107 (28.5 percent) were matched to Workers' Compensation claim for a non-amputation injury (e.g., crush, fracture, laceration), and 182 (48.5 percent) could not be linked to a Workers' Compensation claim. Of the additional three amputation cases submitted by hospitals without documentation of work-relatedness, two were linked to Workers' Compensation claims for an amputation injury.

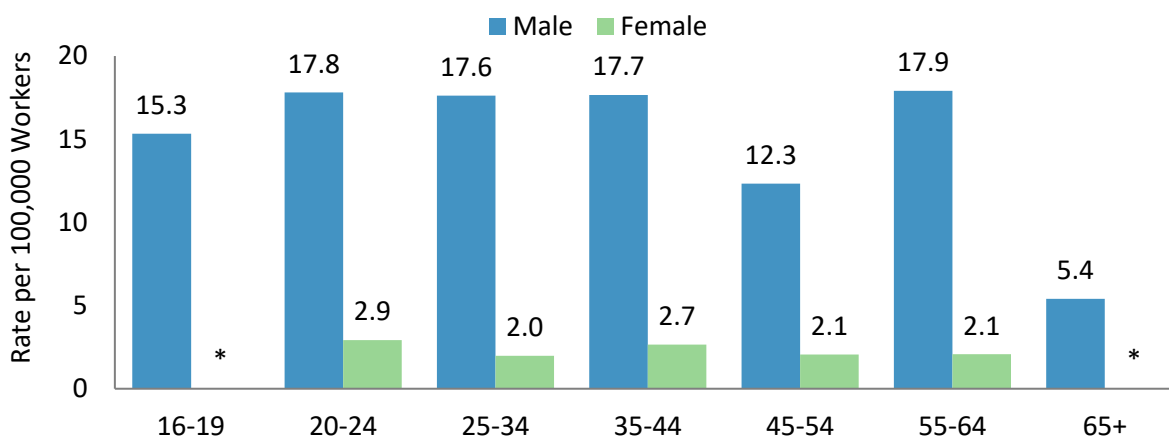
Combining the 374 work-related cases identified through medical records with the 57 that were identified only within the Workers' Compensation database gave a total of 431 Michigan resident workers, corresponding to a rate of 9.3 amputations per 100,000 workers. The following analyses examine these 431 cases.

## Characteristics of Injured Workers

### Age and Sex

Males comprised 88.6 percent of workers who sustained an amputation. Among males, rates were highest for those aged 55-64 years. Among females, rates were highest for those aged 20-24 years. Figure 1 displays amputation rates by age group and sex. (Also, see Table A-1 in Appendix A.)

**FIGURE 1: Work-Related Amputation Rates (per 100,000) among Michigan Residents by Age Group and Sex, 2016**



\* A statistically valid rate could not be calculated for females aged 16-19 and 65+ due to an insufficient number of cases.

Data Sources: Number of amputations – Michigan hospital/ED medical records and Michigan Department of LARA Workers' Compensation Agency; Total number of workers - NIOSH Employment Labor Force Query System.

### Race and Hispanic Ethnicity

There were 146 patients (39.0 percent) who did not have a reported race and 268 patients (71.7 percent) who did not have a reported ethnicity included in their medical records. The race and ethnicity of the 57 individuals identified only through Worker's Compensation claims could not be determined since the Worker's Compensation system does not collect race or ethnicity

information (see Table A-2 in Appendix A). Due to the level of missing information, rates for racial/ethnic groups were not calculated.

### Body Part and Severity

As shown in Table 3, nearly all workers (92.8 percent) sustained finger amputations. Medical records, which provide more detail than Workers' Compensation claims data, were available for 353 finger amputation cases. Of the 353 finger amputation incidents, 51 (14.4 percent) involved multiple fingers. Table 4 displays the distribution of digit(s) and section(s) lost among all finger amputations. The distal phalanx of the index finger (Section J in Figure 2) was the most commonly amputated digit. More than three-fourths (77.4 percent) of finger amputations with a specified digit and section involved the distal phalanx of the index finger. Table A-3 and Table A-4 in Appendix A provide data separately for single- and multiple-finger amputation incidents, respectively.

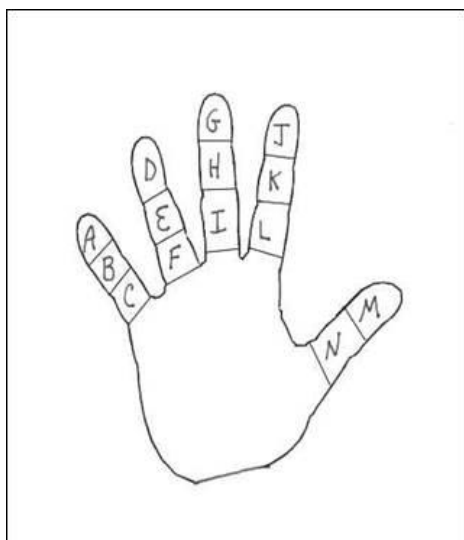
**TABLE 3: Number and Percentage of Work-Related Amputations by Injured Body Part, Michigan Residents, 2016**

Amputated body part	Number of Workers	Percentage
<b>Upper extremity total</b>	<b>410</b>	<b>95.1%</b>
Finger	400	92.8%
Hand	*	*
Arm	*	*
Unspecified	*	*
<b>Lower extremity total</b>	<b>20</b>	<b>4.6%</b>
Toe	14	3.2%
Foot	*	*
Leg	*	*
Unspecified	*	*
<b>Other</b>	*	*
<b>Total</b>	<b>431</b>	<b>100.0%</b>

Data Sources: Michigan hospital/ED medical records and Michigan Department of LARA Workers' Compensation Agency

\* Numbers between 1 and 5 are suppressed to protect confidentiality of individuals.

**FIGURE 2: Location of Finger Amputations by Digit and Section**



**TABLE 4: Number and Percentage of Work-Related Finger Amputations by Digit and Section of Finger Lost, Michigan Residents, 2016**

Digit	Section	Number of Amputations	Percentage
Little	A	25	6.0%
Little	B	8	1.9%
Little	C	10	2.4%
Little	Unknown	2	0.5%
Ring	D	46	11.1%
Ring	E	10	2.4%
Ring	F	8	1.9%
Ring	Unknown	4	1.0%
Middle	G	80	19.3%
Middle	H	8	1.9%
Middle	I	9	2.2%
Middle	Unknown	9	2.2%
Index	J	95	22.9%
Index	K	17	4.1%
Index	L	12	2.9%
Index	Unknown	7	1.7%
Thumb	M	56	13.5%
Thumb	N	6	1.4%
Thumb	Unknown	2	0.5%
<b>Total</b>		<b>414</b>	<b>100.0%</b>

*Includes sections lost in single- and multiple-finger loss incidents. Workers' Compensation claims do not contain data on section of finger lost and thus are excluded from the table.*

*Data Source: Michigan hospital/ED medical records*

### Case Study One

A 38-year-old male working in a food manufacturing facility had his hand caught in the belt of a conveyor, resulting in the amputation of his index finger. MIOSHA inspected the worksite and found four violations, including failing to provide needed training on conveyor belt hazards and safeguards, failing to inspect and maintain conveyor components, and failing to properly guard the conveyor. MIOSHA recommended a fine of \$18,900.

### County of Residence

Table 5 displays the number of work-related amputations and rate per 100,000 workers by county of residence. These data do not necessarily reflect the counties with the highest risk worksites since people may work in a different county than the one they live in. Twenty-four counties had no amputation cases and 37 had too few (<6) to calculate statistically valid rates. Newaygo County had the highest rate (36.1 per 100,000 workers). Among the 20 most populous counties in the state, Muskegon County had the highest rate (21.9 per 100,000) while Oakland County had the lowest (3.5 per 100,000).

**TABLE 5: Number and Rate (per 100,000) of Work-Related Amputations among Michigan Residents by County, 2016**

County	Number	Rate per 100,000	County	Number	Rate per 100,000	County	Number	Rate per 100,000
Alcona	0	0.0	Hillsdale	*	*	Monroe	6	*
Alger	0	0.0	Houghton	0	0.0	Montcalm	*	*
Allegan	*	*	Huron	*	*	Montmorency	0	0.0
Alpena	*	*	Ingham	12	8.4	Muskegon	16	21.9
Antrim	*	*	Ionia	*	*	Newaygo	8	36.1
Arenac	0	0.0	Iosco	0	0.0	Oakland	22	3.5
Baraga	0	0.0	Iron	*	*	Oceana	*	*
Barry	*	*	Isabella	*	*	Ogemaw	0	0.0
Bay	7	14.3	Jackson	10	14.1	Ontonagon	0	0.0
Benzie	0	0.0	Kalamazoo	7	5.5	Osceola	*	*
Berrien	*	*	Kalkaska	0	0.0	Oscoda	*	*
Branch	*	*	Kent	31	9.2	Otsego	*	*
Calhoun	9	14.7	Keweenaw	0	0.0	Ottawa	8	5.3
Cass	*	*	Lake	0	0.0	Presque Isle	0	0.0
Charlevoix	0	0.0	Kent	31	9.2	Roscommon	*	*
Cheboygan	0	0.0	Lapeer	*	*	Saginaw	*	*
Chippewa	*	*	Leelanau	0	0.0	Saint Clair	10	14.3
Clare	0	0.0	Lenawee	*	*	Saint Joseph	6	*
Clinton	*	*	Livingston	8	8.4	Sanilac	*	*
Crawford	*	*	Luce	0	0.0	Schoolcraft	*	*
Delta	*	*	Mackinac	*	*	Shiawassee	*	*
Dickinson	*	*	Macomb	43	10.4	Tuscola	*	*
Eaton	0	0.0	Manistee	0	0.0	Van Buren	10	29.9
Emmet	*	*	Marquette	8	25.5	Washtenaw	10	5.4
Genesee	18	10.5	Mason	*	*	Wayne (incl. Detroit)	67	9.2
Gladwin	0	0.0	Mecosta	*	*	Detroit	24	10.9
Gogebic	0	0.0	Menominee	0	0.0	Wexford	*	*
Grand Traverse	6	*	Midland	7	17.9	Unknown	12	*
Gratiot	*	*	Missaukee	*	*	Michigan	431	9.3

*\*Numbers and rates are suppressed when the numerator is between 1 and 5 to protect the confidentiality of individuals and because rates are not statistically reliable.*

*Data Sources: Number of amputations – Michigan hospital/ED medical records and Michigan Department of LARA Workers' Compensation Agency; Number of workers used to calculate rates – BLS Local Area Unemployment Statistics.*

## **Industry**

Table 6 shows the number and rate of work-related amputations by industry. There was not enough information in either the medical record or Workers' Compensation claim to make an industry classification for 69 cases (16.0 percent). Nineteen workers were described in medical records as self-employed, of which 12 had industry information listed. Eleven people were temporary workers, seven of which sustained the amputation at a manufacturing company, one at a wholesale trade company, and three worked in an unknown industry. Among NAICS industry sectors, Agriculture, Forestry, Fishing, and Hunting had the highest rate (35.5 per 100,000 workers). All 16 amputations happened within the crop and animal production subsector. The greatest number of amputations occurred in Manufacturing, which included 41.7 percent of the 362 incidents in which industry was determined. Certain subsectors within manufacturing had considerably higher rates, notably Wood Products Manufacturing (58.4 per 100,000) and Primary Metal Manufacturing (41.0 per 100,000).

**TABLE 6: Number and Rate (per 100,000) of Work-Related Amputations among Michigan Residents by Industry, 2016**

<b>NAICS Industry Sector Code</b>	<b>Industry Classification</b>	<b>Number</b>	<b>Rate per 100,000</b>
11	<b>Agriculture, Forestry, Fishing and Hunting</b>	16	35.5
111-112	Crop and Animal Production	16	45.3
21	<b>Mining, Quarrying, and Oil and Gas Extraction</b>	*	*
22	<b>Utilities</b>	*	*
23	<b>Construction</b>	48	18.3
31-33	<b>Manufacturing</b>	151	17.2
311	Food Manufacturing	16	28.6
321	Wood Products Manufacturing	13	58.4
322	Paper Manufacturing	6	*
326	Plastics and Rubber Products Manufacturing	*	*
331	Primary Metal Manufacturing	9	32.7
332	Fabricated Metal Product Manufacturing	24	41.0
333	Machinery Manufacturing	11	17.8
336	Transportation Equipment Manufacturing	34	8.5
337	Furniture and Related Product Manufacturing	8	32.9
42	<b>Wholesale Trade</b>	24	23.6
44-45	<b>Retail Trade</b>	22	4.4
48-49	<b>Transportation and Warehousing</b>	13	6.9
51	<b>Information</b>	*	*
52	<b>Finance and Insurance</b>	*	*
53	<b>Real Estate and Rental and Leasing</b>	*	*
54	<b>Professional, Scientific, and Technical Services</b>	*	*
55	<b>Management of Companies and Enterprises</b>	*	*
56	<b>Administrative and Support and Waste Management and Remediation Services</b>	16	7.8
61	<b>Educational Services</b>	*	*
62	<b>Health Care and Social Assistance</b>	*	*
71	<b>Arts, Entertainment, and Recreation</b>	*	*
72	<b>Accommodation and Food Services</b>	32	9.2
722	Food Service and Drinking Places	32	9.9
81	<b>Other Services (except Public Administration)</b>	12	6.7
92	<b>Public Administration</b>	*	*
99	<b>Unknown</b>	69	
<b>NA</b>	<b>Total</b>	<b>431</b>	<b>13.1</b>

*\*Numbers and rates are suppressed when the numerator is between 1 and 5 to protect the confidentiality of individuals and because rates are not statistically reliable.*

*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 LARA Workers' Compensation Agency; Number of workers by industry used to calculate rates: – NIOSH Employment Labor Force Query System. Non-bolded industry classifications represent industry subsectors.*

## Causes of Amputations

Table 7 displays amputation causes. Cause was not recorded in Workers' Compensation claims; therefore, these data were limited to the 374 cases with available medical record data. Sharp objects caused almost one-quarter (24.3 percent) of amputations. Power saws (e.g., table saws, miter saws) accounted for more than half of all sharp object amputations. Presses caused one in 11 (9.1 percent) amputations. Various types of other machinery, many of which were unspecified in the medical records, caused roughly one in five (20.6 percent) amputations. Another frequent cause of amputations was being caught in chains, pullies, gears, or belts (10.4 percent). Medical records provided no information on cause for 8.0 percent of cases.

**TABLE 7: Number and Percentage of Work-Related Amputations among Michigan Residents by Cause of Injury, 2016**

<b>Cause of injury</b>	<b>Number</b>	<b>Percentage</b>
<b>Sharp object</b>	91	24.3%
Power saw	52	13.9%
Knife	22	5.9%
Food slicer	11	2.9%
Lawn mower	0	0.0%
Other	6	1.6%
<b>Press</b>	34	9.1%
Mechanical	10	2.7%
Other or unspecified press	24	6.4%
<b>Pinched between objects</b>	31	8.3%
In door/safe	6	1.6%
<b>Struck by falling object</b>	19	5.1%
<b>Struck by object – other</b>	6	1.6%
<b>Caught in chain, pulley, gears, or belt</b>	39	10.4%
<b>Grinder</b>	0	0.0%
<b>Forklift/Hi-lo</b>	7	1.9%
<b>Machine – other specified type</b>	40	10.7%
<b>Machine – other unspecified type</b>	37	9.9%
<b>Other specified cause</b>	40	10.7%
<b>Unspecified cause</b>	30	8.0%
<b>Total</b>	<b>374</b>	<b>100.0%</b>

*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*

## Source of Payment

As shown in Table 8, Workers' Compensation was the expected payer in 274 (73.3 percent) of the 374 cases with a medical record. Payment source could not be determined for 41 cases. Among the 100 cases which did not have Workers' Compensation listed as a payment source in medical records, 32 were linked to Workers' Compensation claims. Workers' Compensation was the expected payer for 76.9 percent of the 355 patients that were not self-employed.

**TABLE 8: Number and Percentage of Work-Related Amputations among Michigan Residents by Payment Source Overall and for Non-self-employed Workers, 2016**

	Total Number	Total Percentage	Non-Self-Employed Number	Non-Self-Employed Percentage
Workers' Compensation	274	73.3%	273	76.9%
Commercial insurance	38	10.2%	28	7.9%
Other	21	5.6%	17	4.8%
Not specified	41	11.0%	37	10.4%
<b>Total</b>	<b>374</b>	<b>100.0%</b>	<b>355</b>	<b>100.0%</b>

Data Source: Michigan hospital/ED medical records

### Case Study Two

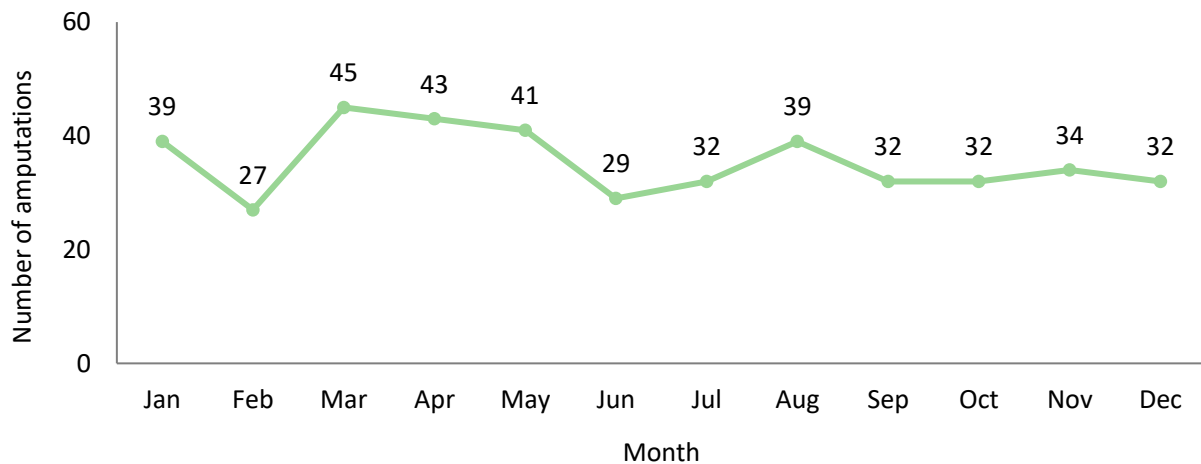
A 21-year-old female was working as a temporary employee in a motor vehicle parts manufacturing facility when she lost her index finger at the distal interphalangeal joint while using a mechanical power press. MIOSHA inspected the facility and found six serious violations including several related to not properly inspecting, maintaining, and repairing power presses. The company was also cited for not having control systems in place that would ensure the press could be shut down during malfunctions and repeatedly failing to properly train employees on power press safety procedures. MIOSHA proposed a penalty of \$28,000 for all six violations.

## Trends

### Incidents by Month

Incidents occurred most frequently during the spring months and were least frequent during February and June (Figure 3). There were six amputations with an unknown month of injury.

**FIGURE 3: Number of Work-Related Amputations among Michigan Residents by Incident Month, 2016**



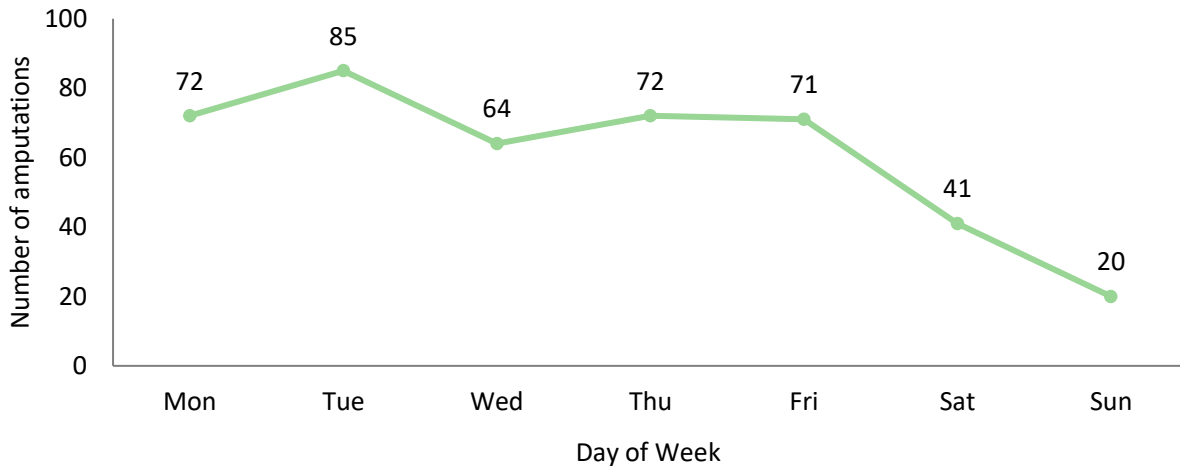
Data Sources: Michigan hospital/ED medical records and Michigan Department of LARA Workers' Compensation Agency



### Incidents by Day of Week

Amputations occurred most frequently on Tuesdays and were less frequent during the weekend (Figure 4). There were six amputations with an unknown day of injury.

**FIGURE 4: Number of Work-Related Amputations among Michigan Residents by Incident Day of the Week, 2016**



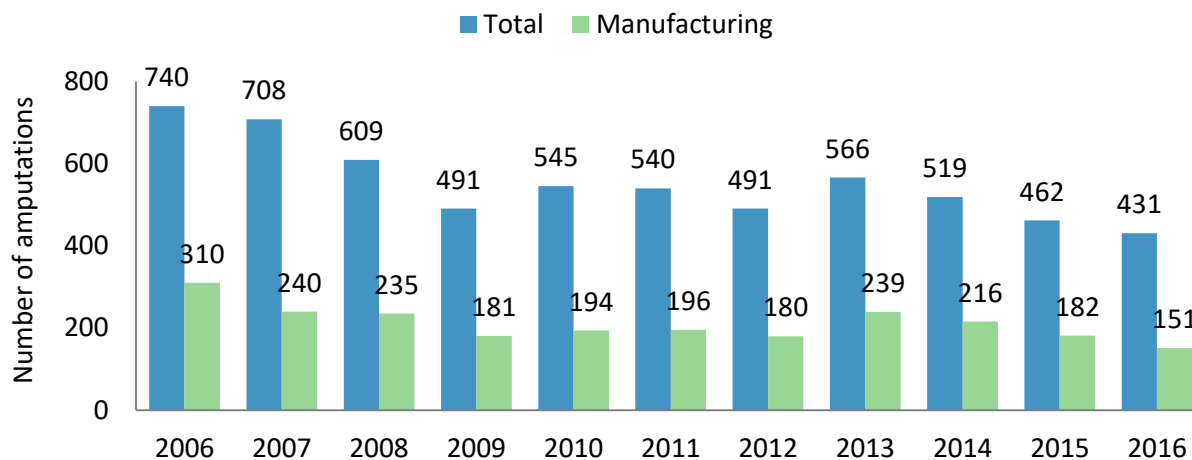
*Data Sources: Michigan hospital/ED medical records and Michigan Department of LARA Workers' Compensation Agency*

### Amputations by Year

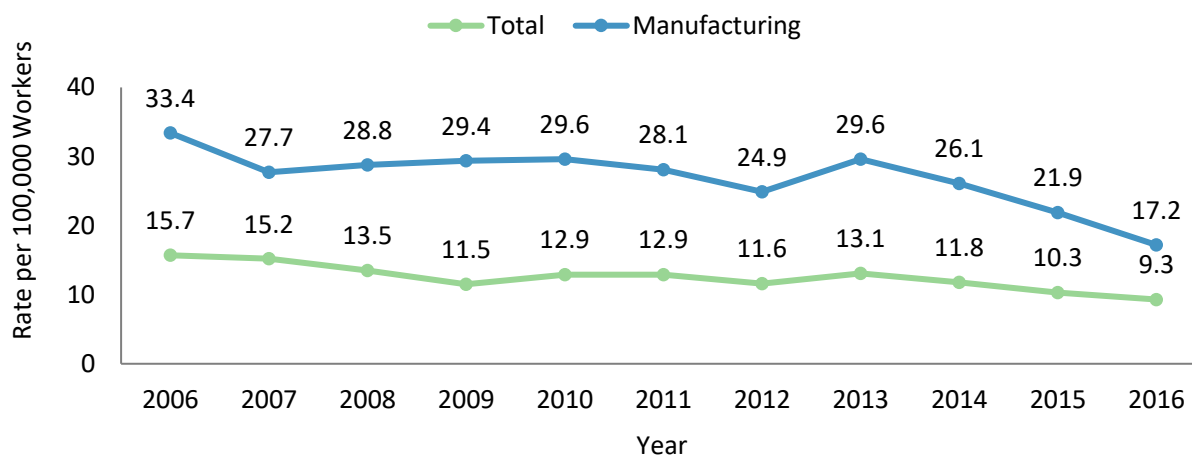
The annual number of cases has decreased by 41.8 percent during the 11 years the surveillance system has been in place, from 740 in 2006 to 431 in 2016 (Figure 5). The decline in the number of amputations may be partially explained by lower employment overall in Michigan; however, total employment decreased by only 2.5 percent over the 11-year period and has rebounded since 2012, whereas the number of amputations continued a steady decline. The rate of amputations also fell from 15.7 per 100,000 employed persons in 2006 to 9.3 per 100,000 employed persons in 2016, representing a 40.8 percent decline. The dramatic decrease in the number and rate of amputations is likely impacted by changes in industry employment patterns in Michigan, which has seen a shift from higher risk industries such as agriculture/forestry, construction, and mining to lower risk industries such as healthcare and social services (see Table A-5 in Appendix A).<sup>7</sup>

Figures 5 and 6 also display the annual number of cases and rates for the manufacturing industry, where the greatest number of amputations occur. The number and rate of manufacturing-related amputations peaked in 2006 and declined between 2013 and 2016, similar to the pattern observed among all industries.

**FIGURE 5: Annual Number of Work-Related Amputations among Michigan Residents by Year, Total and for the Manufacturing Industry, 2006-2016**



**FIGURE 6: Annual Rate (per 100,000) of Work-Related Amputations among Michigan Residents by Year, Total and for the Manufacturing Industry, 2006-2016**



### MIOSHA Reviews

MIOSHA reviewed 14 amputation cases and inspected 10 worksites. Table 9 summarizes the number of violations found in these inspections. The number of violations ranged from zero to six. Table 11 shows the distribution of penalties. There was no penalty issued for four. The maximum penalty was \$28,000 and the median was \$1,850. MIOSHA cited two companies for hydraulic press violations and one company for mechanical press violations.

**TABLE 9: Violations Identified in MIOSHA Worksite Inspections, 2016**

Number of Violations	Number of Inspections	Percentage
0	4	40.0%
1-2	4	40.0%
3-4	1	10.0%
5-6	1	10.0%
<b>Total</b>	<b>10</b>	<b>100.0%</b>

Data Source: Michigan hospital/ED medical records

**TABLE 10: Penalties Assessed in MIOSHA Worksite Inspections, 2016**

Penalty Assessed	Number of Inspections	Percentage
\$0	4	40.0%
\$1 - \$999	0	0.0%
\$1,000 - \$9,999	4	40.0%
\$10,000+	2	20.0%
<b>Total</b>	<b>10</b>	<b>100.0%</b>

*Data Source: Michigan hospital/ED medical records*

## Discussion

The Michigan work-related amputation surveillance system provides valuable information for MIOSHA worksite inspections, helping to identify hazards that might otherwise go undetected. In 2016, the work-related amputation surveillance system led to 10 MIOSHA worksite inspections. This identification and referral system directly supports Objectives 1.1 and 1.2 of MIOSHA’s 2014-2018 Strategic Plan<sup>8</sup>:

- Objective 1.1: Reduce by 15 percent the rate of worker injuries and illnesses in high-hazard industries (defined as those in the following NAICS subsectors: 312, 331, 332, 333, 336, 488, 493, 622, 623, 721).
- Objective 1.2: Reduce by 15 percent the rate of worker injuries, illnesses, and fatalities in workplaces experiencing high rates or with targeted hazards or exposures not covered by Emphasis 1.1.

In addition, the system provides details on the demographic and industry characteristics of affected workers, helping to identify high-risk worker groups and industries. Lastly, the system can be used to understand trends and the leading causes of amputations.

## Evaluation of Surveillance System Attributes

The overall effectiveness and efficiency of the Michigan work-related amputation surveillance system was evaluated using the seven criteria specified by the U.S. Centers for Disease Control and Prevention (CDC), including sensitivity, positive predictive value, representiveness, timeliness, flexibility, simplicity, and acceptability.<sup>9</sup>

### Sensitivity

Sensitivity refers to the proportion of true cases that are detected by the surveillance system. Five factors which may reduce the sensitivity of the work-related amputation surveillance system were identified.

1. **Incomplete submission of cases:** Hospitals which fail to submit all eligible work-related amputation cases may reduce the sensitivity of the surveillance system. An analysis of 2016 Michigan Inpatient and Outpatient Databases (MIDB, MODB)<sup>‡</sup> identified 46 additional eligible<sup>§</sup> cases among the 51 hospitals that reported no work-related

<sup>‡</sup> The 2016 MIDB includes inpatient admissions. The MODB includes emergency visits and outpatient procedures. Prior to 2016, the MODB only included outpatient procedures. Five acute care hospitals in Michigan (3.8%) did not provide emergency department visit data in 2016.

<sup>§</sup> Eligible cases included Michigan residents aged 16 years and older who were admitted between January 1, 2016 and December 31, 2016 with an eligible ICD-10-CM amputation code and Workers’ Compensation listed as the primary or secondary payer.

amputations. It is not known if these cases were included in the amputations found in the Workers' Compensation Database due to lack of personally identifying information. Several hospitals submitted medical records only for amputations that they self-determined were work-related, but because work-relatedness is not always documented in the medical record and may require a case interview, it is possible that these hospitals excluded some work-related cases.

2. **Undetermined work-relatedness:** A review of medical records could not determine if the amputation was work-related for three cases and interviews were not able to be completed with the patients. Two of these cases were linked to the Workers' Compensation database, leaving a single amputation case without substantiating work-relatedness information.
3. **Eligible cases coded by hospitals as non-amputations injuries:** Amputation cases that are coded as another injury type (e.g., crush, laceration) by hospitals were not submitted for review and therefore may result in an undercount of the number of amputation cases. For example, the number of work-related amputations in 2014 would have increased by 16 cases (or 3.5 percent) had these cases been accurately coded and submitted.<sup>10</sup>
4. **Treatment at out-of-state hospitals:** Hospitals outside Michigan are not required to report amputations, therefore, workers treated for work-related amputations at hospitals in other states are not captured. The number of amputations that were not identified for this reason may be estimated using MIDB data. While the MIDB does not specify which state the injury occurred in, it does contain records of Michigan residents treated out-of-state. The 2016 MODB did not include any hospitals outside the State of Michigan, therefore only MIDB was evaluated for work-related amputations treated in other states. In 2016, one Michigan resident was treated for an amputation at an out-of-state hospital with Workers' Compensation listed as a primary or secondary payer. This individual was not identified by the surveillance system through medical records or Workers' Compensation claims. Based on this finding, it is estimated that in 2016, the surveillance system missed 0.2 percent of eligible cases due to treatment at out-of-state hospitals.
5. **No hospital medical treatment and no Workers' Compensation claim submission:** An individual must have a hospital/ED medical record or have submitted a Workers' Compensation claim for wage reimbursement to be included by the surveillance system. Workers who do not submit Workers' Compensation claims and who don't seek medical care or exclusively receive medical care in a non-hospital setting (e.g., urgent care center, company clinic), will not be detected. The number of such cases is unknown but presumably limited to less severe cases. Some types of workers who are not eligible for Workers' Compensation, such as the self-employed, federal employees and railroad workers are more likely to be missed by the surveillance system.

It is estimated that up to 14.4 percent of work-related amputations among Michigan residents were not captured by the surveillance system in 2016 based on factors that reduce sensitivity. However, the Michigan surveillance system has a higher sensitivity compared to the Injuries, Illnesses, and Fatalities System conducted by the BLS. The BLS reported 240 work-related amputations in Michigan in 2016 – 44 percent fewer than our system (N=431). There are several important differences between the two systems: the BLS system is based on the worksite state instead of the state of worker residence, and it excludes the self-employed and individuals without lost work time. Furthermore, the BLS data is an estimate based on a random

selection of employers and is influenced by how closely the selected employers represent all employers and the accuracy of employer responses.\*\*

### **Predictive Value Positive (PVP)**

PVP is the percentage of identified cases that truly have the condition of interest. The PVP of cases identified from medical records is likely high since the case had to have documentation that the injury occurred at work and have an amputation code documented in the medical record. Incidents were considered work-related if the medical record stated that they occurred at work, the expected payer was Workers' Compensation, or the patient reported the incident was work-related during a phone interview. The PVP of cases identified solely through Workers' Compensation records may be slightly lower because employers, rather than medical professionals, provide information on injury type.

### **Representativeness**

Representativeness describes the surveillance system's ability to capture all cases. The surveillance system is geographically representative, with all Michigan hospitals either submitting medical records or responding that they had no cases. Self-employed workers are less likely to be represented because Workers' Compensation claims are often needed to determine if an injury was work-related, yet self-employed individuals are not eligible for Workers' Compensation coverage. Self-employed workers made up 5.1 percent of the 374 work-related amputation cases with a medical record. There was no indication that the single case for which work-relatedness could not be determined was self-employed.

### **Timeliness**

Timeliness is the speed between steps in the surveillance system. The timeliness of the system has improved since 2011 when hospitals transitioned from submitting records once at the completion of the year to submitting records on a quarterly basis. Medical records for patients treated in January-March of 2016 were received in April 2016 and the last records for 2016 were received in March 2017. In September 2017, patient interviewing was completed (i.e., either patients were successfully contacted and interviewed, or it was determined that they could not be interviewed), all medical records were reviewed, and data were entered into a database. The improved timeliness of the system has allowed MIOSHA to inspect more worksites within six months of the amputation. Since January 1, 2016, MIOSHA regulations require employers to report amputations directly to MIOSHA within 24 hours, further improving timeliness. Future analysis will focus on evaluating the completeness of employer reporting.

### **Flexibility**

Flexibility is the ability of the system to adapt to changing needs. The Michigan work-related amputation surveillance system has a high degree of flexibility, as data elements can be quickly abstracted from medical records or through follow-up interviews as needed.

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\*\*Prior to 2011, another reason for a discrepancy may have been that the BLS required bone loss to classify an injury as an amputation whereas our system did not. As of 2011, this restriction was removed making the BLS system potentially more comparable to ours. However, even with this change, the BLS estimate of the number of amputations remained appreciably less than our multisource system in 2013 and does not explain the BLS undercount, which is comparable to previous years, when BLS only counted amputations that included bone loss (2010 – 67% fewer, 2009 – 65% fewer, 2008 – 59% fewer, 2007 – 77% fewer and 2006 – 20% fewer).

## **Simplicity**

Simplicity is the ease of operating the system and the complexity of its design. The case definition is easy to apply, and cases are usually identified quickly. Case ascertainment was more challenging for the 24 cases that required a patient interview to obtain needed information. The number of interviews has decreased since 2009 (during 2006-2008, there were an average of 165 interviews per year). More recently, the Workers' Compensation Agency has provided the claims database sooner so that work-relatedness and/or employer name can be quickly determined. Very few data elements obtained from medical records or MIOSHA inspection reports are complex, the most time-consuming item being the identification of employer NAICS code. There are three individuals involved in maintaining the system. One person is responsible for pursuing hospital medical record submission, a separate person who performs medical record reviews, data abstraction, data entry, and MIOSHA referrals and a third links medical records and Workers' Compensation claims records and performs data analysis.

## **Acceptability**

Acceptability is the willingness of individuals and organizations to participate in the surveillance system. All hospitals responded to requests for medical records on work-related amputations by either submitting records or reporting zero cases. Project staff had an 87.5 percent success rate in completing patient phone interviews. MIOSHA has stated they value the surveillance system for initiating inspections. The Workers' Compensation Agency readily provides access to their data.

## **Limitations**

The quality of information provided in medical records and Workers' Compensation claims data presented several limitations of the system. Medical records often did not document the specific cause of amputation, especially when injuries were related to presses. MIOSHA has a specific interest in injuries caused by mechanical power presses; however, medical records did not include information on the type of press for 24 of the 34 press amputations. Medical records often lacked enough information to identify the industry and appropriate NAICS code. Patient interviews were not attempted to determine industry unless the case was eligible for a MIOSHA inspection. Medical records very rarely included visual documentation of injuries, such as photographs, making accurate classification of the injury difficult. It was unclear in some cases why an amputation diagnosis code was assigned when, for example, medical records described the suture of a tissue-only laceration. The extent of information on patient race and Hispanic ethnicity varied by hospital. Analysis of these important demographics could not be completed due to the amount of missing data.

Workers' Compensation claims data do not include information on injury cause and lacked detailed injury descriptions (e.g., single vs. multiple digit loss, which finger was injured). Thus, analyses of these characteristics excluded cases with only Workers' Compensation data. Record linkage depended upon the accuracy of the common variables. If a duplicated case in the Workers' Compensation database and hospital-submitted medical records could not be linked, it was counted more than once.

## **Conclusions**

The Michigan work-related amputation surveillance system leverages both hospital reporting and Workers' Compensation claims data, providing a much higher number of work-related amputations than the official estimate based on the employer-based reporting system

maintained by the BLS. In addition, the hospital-based data is used for public health interventions to find and reduce workplace amputation hazards. Given the success of the surveillance system, we plan to continue tracking amputations and facilitating workplace investigations. We are encouraged that the number and rate of amputations has decreased since 2006. However, since 2008, rates have ranged from 9.3 to 13.5 per 100,000 workers. The ultimate objective is to significantly reduce the occurrence of this serious injury.

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## Appendix A: Additional Data Tables

**TABLE A-1: Number and Rate (per 100,000) of Work-Related Amputations among Michigan Residents by Age and Sex, 2016**

	Male Number	Male Rate	Female Number	Female Rate	Total Number	Total Rate
16-19	14	15.3	2	*	16	9.4
20-24	46	17.8	7	2.9	54	10.9
25-34	90	17.6	9	2.0	99	10.2
35-44	83	17.7	11	2.7	95	10.7
45-54	70	12.3	10	2.1	80	7.6
55-64	71	17.9	8	2.1	79	10.1
65+	8	5.4	0	-	8	3.1
<b>Total</b>	<b>382</b>	<b>15.6</b>	<b>47</b>	<b>2.2</b>	<b>431</b>	<b>9.3</b>

*\*Statistically stable rate could not be calculated.*

*Gender was unspecified for two cases (age 20-24 and age 35-44).*

*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 LARA, Workers' Compensation Agency; Number of workers employed by age group used to calculate rates - NIOSH Employment Labor Force Query System.*

**TABLE A-2: Number of Work-Related Amputations among Michigan Residents by Race and Hispanic Ethnicity, 2016**

Race	Hispanic	Non-Hispanic	Unknown	Total
White	9	76	114	199
Black	0	12	11	23
Other	3	0	3	6
Unknown	6	0	140	146
<b>Total</b>	<b>18</b>	<b>88</b>	<b>268</b>	<b>374</b>

*Data Source: Michigan hospital/ED medical records*

**TABLE A-3: Number of Work-Related Single-finger Amputations among Michigan Residents (N=302) by Digit and Section of Finger Lost, 2016**

<b>Digit</b>	<b>Distal phalanx</b>	<b>Middle Phalanx</b>	<b>Proximal Phalanx</b>	<b>Unknown</b>	<b>Total</b>
Thumb	54	n/a	4	1	59
Index	80	15	5	2	102
Middle	60	3	1	1	65
Ring	30	5	2	0	37
Little	25	8	4	2	39
Unknown	0	0	0	0	0
<b>Total</b>	<b>249</b>	<b>31</b>	<b>16</b>	<b>6</b>	<b>302</b>

*Data Source: Michigan hospital/ED medical record*

**TABLE A-4: Number of Work-Related Multiple-finger Amputations among Michigan Residents (N=51) by Amount of Finger Lost, 2016**

<b>Digit</b>	<b>Distal phalanx</b>	<b>Middle Phalanx</b>	<b>Proximal Phalanx</b>	<b>Unknown</b>	<b>Total</b>
Thumb	2	n/a	2	1	5
Index	15	2	7	5	29
Middle	20	5	8	8	41
Ring	16	5	6	4	31
Little	0	0	6	0	6
Unknown	0	0	0	1	1
<b>Total</b>	<b>53</b>	<b>12</b>	<b>29</b>	<b>19</b>	<b>113</b>

*Data Source: Michigan hospital/ED medical records*

**TABLE A-5: Number of Employed Michigan Residents by Primary Employment Industry, 2006-2016**

Year	Agriculture forestry, fishing	Mining	Construction	Manufacturing	Trade	Transportation, Warehousing, Utilities	Services	Health, Social Services
2006	63,653	5,380	284,404	934,558	667,784	186,120	2,006,008	584,160
2007	50,523	5,956	271,034	865,106	680,849	197,290	1,983,708	612,317
2008	50,266	8,726	253,534	815,752	645,223	214,499	1,941,722	612,443
2009	54,702	9,286	229,813	616,390	574,186	185,054	1,924,872	659,212
2010	67,621	7,513	200,470	655,761	570,325	180,184	1,876,018	675,283
2011	68,264	9,313	222,314	697,109	541,490	166,209	1,839,887	656,055
2012	52,450	7,817	205,485	723,119	580,737	183,651	1,849,258	644,326
2013	55,043	4,732	207,494	806,458	568,183	199,148	1,828,331	650,437
2014	69,844	2,556	202,405	828,421	602,367	202,117	1,812,073	687,734
2015	61,003	1,106	241,544	830,725	614,435	218,973	1,849,160	687,861
2016	45,126	1,066	261,858	876,683	603,558	218,235	1,913,197	696,033
<b>Net Percent Change*</b>	<b>-29.1%</b>	<b>-80.2%</b>	<b>-7.9%</b>	<b>-6.2%</b>	<b>-9.6%</b>	<b>17.3%</b>	<b>-4.6%</b>	<b>19.2%</b>

Data Source: NIOSH Employment Labor Force Query System.

\* The net percent change is relative percentage difference between the number of employed Michigan residents in 2006 and 2016 for each industry category.