# Work-Related Amputations in Michigan, 2015

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MICHIGAN STATE
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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 in collaboration with the Michigan Department of Health and Human Services maintains a multi-source system for collecting data on work-related amputations in Michigan. This report characterizes these injuries for 2015. The salient findings are as follows:

- The system identified a total of 462 Michigan resident work-related amputations. This corresponds to a rate of 10.3 per 100,000 workers. In comparison, the official U.S. Department of Labor estimate (240) was 48% lower.

- From 2006 to 2015, the number of work-related amputations in Michigan decreased 37.6% and the rate decreased 34.4%. In 2006, there were 740 cases with a corresponding rate of 15.7 per 100,000. The number and rate of work-related amputations decreased from 2006 to 2009. From 2009 to 2012, the number and rate were relatively level. From 2012 to 2013, the number increased 15.3% and the rate increased 12.9%. And from 2013 to 2015, the number decreased 18.4% and the rate decreased 21.4%.

- Hospital/emergency department medical records identified 411 cases. Workers' Compensation lost work time claims data identified 132 cases, 82 of which were linked to medical records. There was one case for which work-relatedness could not be determined based on the medical record but it was filed in the Workers' Compensation database as a non-amputation injury. Including this case, there were 51 cases that would have been missed had Workers' Compensation claims data not been used to supplement medical records.

- The amputation rate for males was almost seven times the rate for females. Among males, rates were highest for those aged 16-24 years.

- Forty-four percent of the amputations occurred among those working in the manufacturing industry. The specific manufacturing group with the highest rate was Primary Metal Manufacturing.

- Power saws were the leading cause of amputations, accounting for 12.5% of cases for which injury cause was specified.

- Ninety-six percent of amputations involved fingers. About one in eight (12.9%) finger amputation injuries involved multiple fingers.

- Workers' Compensation was the expected source of payment of hospitalization or emergency department care for 80.7% of the cases for which payment source was identified. Payer source could not be determined for 9.2% of medical records reviewed.

- The Michigan Occupational Safety and Health Administration (MIOSHA) inspected 7 worksites identified through medical records and assessed an average of three violations and $2,500 in penalties per worksite inspected.

All of Michigan's hospitals are required to report work-related amputation cases and were the primary source of data for most (89.0%) of the identified cases for 2015. Data provided by the Michigan Workers' Compensation Agency identified an additional 11.0% of cases that were not identified by hospital-based surveillance alone. The Workers' Compensation data were limited to individuals who requested wage replacement for being off work for more than seven consecutive days or received a set amount based on the percentage of finger(s) amputated and did not include individuals who had claims for medical care cost reimbursement alone. Therefore, Michigan's 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 file a Worker Compensation claim for 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 462 amputations identified are appreciably larger than the official employer-based estimate of 240.

This report will be updated annually and made available on the websites of the Michigan Department of Health and Human Services, 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 5,700 amputations resulting in days away from work occurred nationally in 2015. The median number of lost workdays was 22 for amputation cases compared to 8 days for all work-related injuries.[1] Reducing the incidence of work-related amputations is a public health priority. The Council of State and Territorial Epidemiologists (CSTE) in collaboration with the National Institute for Occupational Safety and Health (NIOSH) has developed a set of twenty-two occupational health indicators,[2] two of which are measures of work-related amputations.

The Michigan Occupational Safety and Health Administration (MIOSHA) was established in 1974. MIOSHA, which is part of the Michigan Department of Licensing and Regulatory Affairs (LARA), strives to work collaboratively with employers and employees to better prevent workplace injuries, illnesses, and fatalities. One strategy MIOSHA uses to assist employers in improving the safety and health of their employees 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. Only those cases resulting in a MIOSHA referral 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.[3] 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 2015.

## 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.[4] MSU acts as MDHHS's bona fide agent to administer this law and medical records are sent directly to MSU's OEM Division.

Under a Memorandum of Understanding Agreement (MUA), the LARA 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 more than 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 (BLS), was the source of the estimated number of employed Michigan residents by defined age groups, gender, and industry groups for 2015. 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 at the time of injury receiving medical treatment at a Michigan hospital/emergency department for whom: a) an amputation diagnosis was assigned

(codes 885.0-.1, 886.0-.1, 887.0-.7, 895.0-.1, 896.0-.3, and 897.0-.7 per the International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM[5]) or codes S48, S58, S68, S78, S88, and S98 per the International Classification of Diseases, Tenth Revision, Clinical Modification (ICD-10-CM[6])[*] ; and b) the incident was documented as having occurred at work in 2015. 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 at the time of injury who was in the WC lost work time wage replacement database with an accepted work-related amputation occurring in 2015. 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 criteria were referred to MIOSHA: a) the worksite was located in Michigan; and b) the amputation potentially was caused by a mechanical power press[Δ] or another hazard likely to be found upon inspection. Worksites were not referred when the cause of injury was vaguely described in medical records (e.g., "pinched between objects").

An MSU referral to MIOSHA included a description of the injury, its cause, and employer information. MIOSHA staff reviewed referred cases to determine if they would conduct a worksite inspection. Referrals of 2015 cases were made to MIOSHA between April 2015 and April 2016.

[*] Diagnoses were coded according to ICD-9-CM up through September 30, 2015. Starting on October 1, 2015, diagnoses were coded according to ICD-10-CM.

[∞] 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 caused by a "press" were considered potential mechanical power press cases and were referred.

Some medical records lacked information as to whether an injury 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, date of discharge, patient demographics, city and county of residence, primary source of payment, company name, address, NAICS[7] code, injury date, body part amputated, ICD-9-CM and ICD-10-CM code(s), and cause of injury. For cases referred to MIOSHA, additional information was obtained, including: whether an inspection was performed, inspection date, number of violations, number of violations presumably pertaining to the hazard identified by MSU staff, whether hazards had been abated at the time of the MIOSHA inspection, power press violations, and total fines assessed.

Once case ascertainment from medical record review and patient interviews were completed, records in the work-related amputation database were linked to records in the Workers' Compensation claims database using SAS® software, version 9.2 of the SAS® System for Windows (copyright 2002-2008 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 often were all that medical records provided), date of injury (or date of hospital admission), worker's name, and date of birth. For cases that matched, the linked record was visually verified. The matching process was performed on the entire 2015 Workers' Compensation claims database to allow for links to cases not categorized as amputations by that system.

Upon completion of linkage, records were assigned to one of the following eight categories: 1) Workers' Compensation case where injury was an amputation and was matched with a work-related amputation from the medical records; 2) Workers'

Compensation case where injury was an amputation and was matched with an amputation from the medical records in which work-relatedness could not be determined from the medical records; 3) Workers' Compensation case where injury was an amputation but could not be matched with an amputation from the medical records; 4) Workers' Compensation case where injury was not an amputation but was matched with a work-related amputation from the medical records; 5) Workers' Compensation case where injury was not an amputation but was matched with an amputation from the medical records in which work-relatedness could not be determined from the medical records; 6) work-related amputation from the medical records but with no match to Workers' Compensation; 7) Workers' Compensation case where injury was not an amputation and was not matched with an amputation from the medical records; and 8) unknown if work-related amputation from the medical records and could not be matched 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 when the relative standard error (standard error of a rate divided by the rate) was 40% 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 SAS® software.

**SYMBOLS USED IN TABLES**

| | |
|---|---|
| No cases occurred within category | – |
| Rate is considered statistically unreliable | * |

## RESULTS

All 130 non-federal acute care hospitals and four Veteran's Administration (VA) medical centers in Michigan complied with the reporting requirement. One-hundred-and-one hospitals submitted medical records. The other 33 facilities reported that they had no work-related amputation cases in 2015. The total number of records received and reviewed was 1,058, including 8 from the VA medical centers. Project staff attempted to interview 36 patients to ascertain work-relatedness and/or employer information and completed 26 (72.2%) of these interviews.

In 2015, 426 individuals were treated at a Michigan hospital/emergency department (ED) following a work-related amputation.[*] These included 425 originally identified through medical records and another one that was treated at a Michigan hospital, but could not be identified as work-related until linked to a Workers' Compensation record. These workers made a total of 474 hospital visits for care (43 of the 426 workers made multiple hospital visits). Nearly all workers (96.7%) were Michigan residents (N=412) (Table 1). The work-related amputation rate for these hospital-treated amputations among Michigan residents was 9.2 per 100,000 workers.

TABLE 1
Workers Treated for an Amputation at a
Michigan Hospital/ED, 2015

| Characteristics of Workers and Healthcare Utilization | Number of Workers | % |
|---|---|---|
| Received treatment at a Michigan hospital/ED | | |
| Michigan resident | 412 | 96.7 |
| *One hospital visit* | *371* | *87.1* |
| *Multiple hospital visits (follow-up care or transfer to another hospital)* | *41* | *9.6* |
| Out-of-state resident | 14 | 3.3 |
| *One hospital visit* | *12* | *2.8* |
| *Multiple hospital visits (follow-up care or transfer to another hospital)* | *2* | 0.5 |

Data Source: Michigan hospital/ED medical records

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

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 132 lost work time claims from Michigan residents with amputations. One hundred twenty-three (123) were paid for lost work time and four more were expected to receive payment. There was no indication that the remaining five individuals were paid for lost work time. For three of these five, the amputation was not contested as being work-related. Some of the individuals paid for lost work time may not have been out of work more than seven consecutive days because, as described previously (Page 2), 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, 2015

| 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 | Unknown | | |
| Yes, with amputation injury | 82 | 0 | 50 | 132 |
| Yes, with a non-amputation condition | 129 | 1 | 20,714 | 20,844 |
| No | 200 | 8 | NA | 208 |
| Total | 411 | 9 | 20,764 | 21,184 |

Shaded cells illustrate work-related amputation cases.

Eighty-two (82) of the 132 Workers' Compensation claims (62.1%) matched an amputation case identified from medical record review. For 50 cases, hospitals/EDs did not submit a medical record of an amputation (first row of Table 2). One hundred twenty-nine (129) of the 411 hospital-record-based amputation cases (31.4%) 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) (see column labeled "Yes" in Table 2). There were nine cases in which medical records did not indicate whether the amputation was work-related or not and this could not be ascertained via phone interview. One of these was matched to a Workers' Compensation claims record, which classified the injury as something other than an amputation (see column labeled "Unknown" in Table 2).

Adding the 411 cases that were identified using medical records to the 51 that could be identified only through linkage to Workers' Compensation records yields a total of 462 Michigan resident workers. This corresponds to a rate of 10.3 amputations per 100,000 workers. The following analyses examine these 462 cases.

## Characteristics of Injured Workers

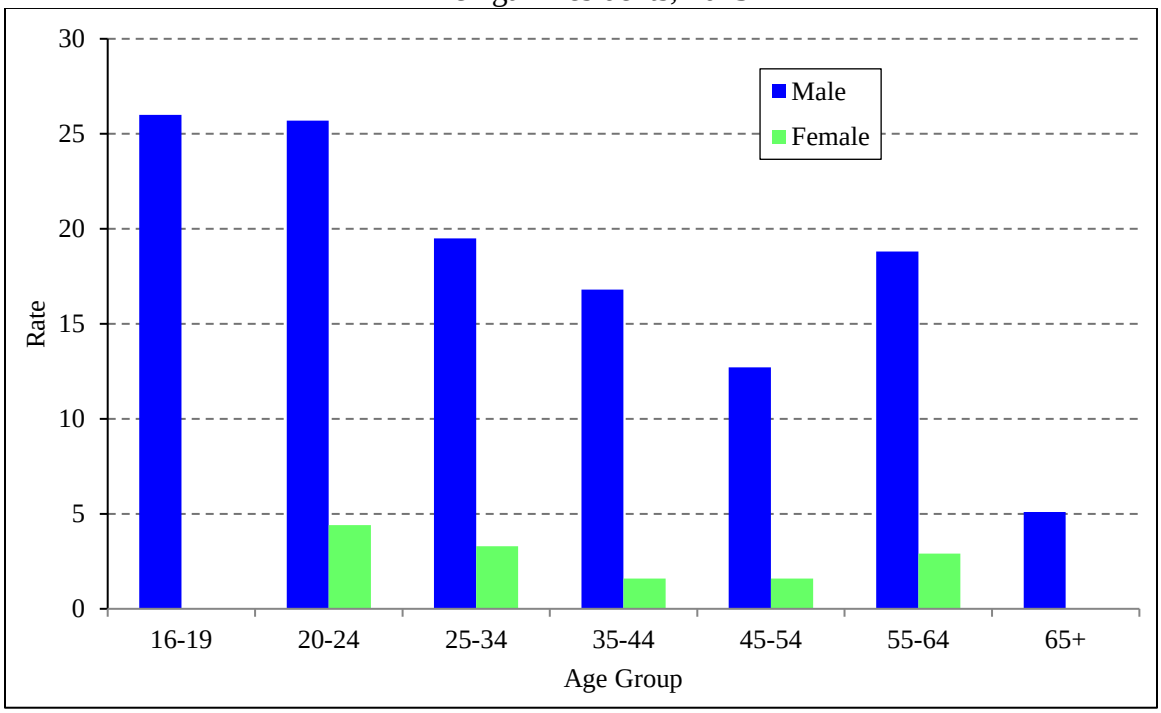
### *Age and Gender*

Males comprised 88.1% of workers who sustained an amputation. Among males, rates were highest for those aged 16-24 years. Among females, rates were highest for those aged 20-24 years. Figure 1 displays amputation rates by age group and gender. (Also, see Table A-1 in Appendix A.)

### *Race and Hispanic Ethnicity*

Information on patient race and Hispanic ethnicity was missing in 45% and 75% 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.

FIGURE 1
Work-Related Amputation Rates
by Age Group and Gender
Michigan Residents, 2015




Rates are the number of workers sustaining an amputation per 100,000 workers.
A statistically valid rate 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 Licensing and Regulatory Affairs Workers' Compensation Agency; Number of workers employed by age group used to calculate rates - Bureau of Labor Statistics' Current Population Survey

*Body Part and Severity*

As shown in Table 3, nearly all workers (96.1%) sustained finger amputations. Data from hospital/ED medical records, which provide more detail on finger injuries than Workers' Compensation claims data, were available for 397 finger amputation cases. The following analyses are limited to these cases. Of 397 finger amputation incidents, 51 (12.8%) involved multiple fingers. The distal phalanx of the index finger (Section J in Figure 2) was the most frequently amputated area. The distal phalanges comprised 81.1% 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 separately for single-finger and multiple-finger amputation incidents, respectively.

TABLE 3
Work-Related Amputations
by Injured Body Part
Michigan Residents, 2015

| Part of Body Amputated | Number of Workers | % |
|---|---|---|
| Upper Extremity | 450 | 97.4 |
| *Finger* | *444* | *96.1* |
| *Hand* | *4* | *0.9* |
| *Arm* | *2* | *0.4* |
| Lower Extremity | 12 | 2.6 |
| *Toe* | *8* | *1.7* |
| *Foot* | *0* | *0.0* |
| *Leg* | *2* | *0.9* |
| Total | 462 | 100.0 |

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

FIGURE 2
Work-Related Finger Amputations
by Digit and Section of Finger Lost
Michigan Residents, 2015

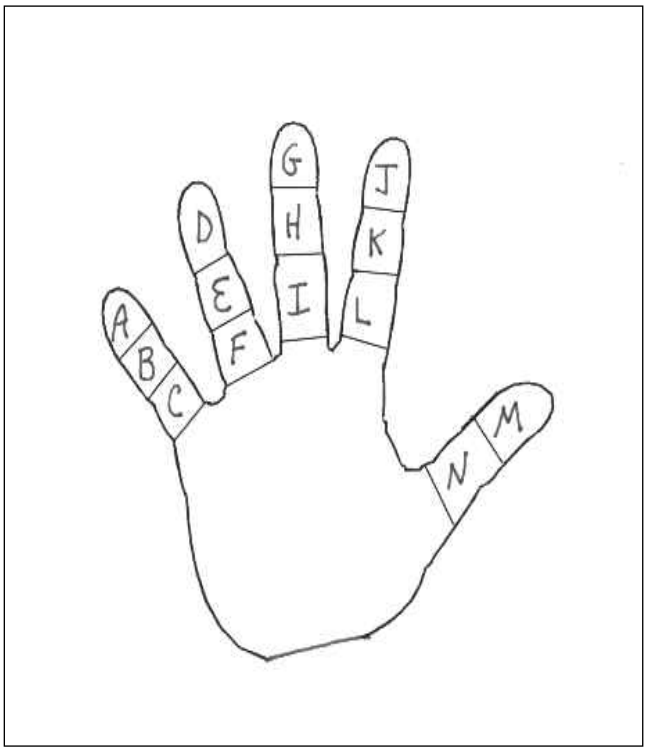



Figure is for both left and right hands.

| Finger | Section | Number | % |
|---|---|---|---|
| Little | A | 39 | 8.4 |
| | B | 5 | 1.1 |
| | C | 4 | 0.9 |
| | Unknown | 2 | 0.4 |
| Ring | D | 60 | 12.9 |
| | E | 13 | 2.8 |
| | F | 6 | 1.3 |
| | Unknown | 2 | 0.4 |
| Middle | G | 102 | 21.9 |
| | H | 13 | 2.8 |
| | I | 10 | 2.2 |
| | Unknown | 2 | 0.4 |
| Index | J | 109 | 23.4 |
| | K | 19 | 4.1 |
| | L | 10 | 2.2 |
| | Unknown | 1 | 0.2 |
| Thumb | M | 59 | 12.7 |
| | N | 6 | 1.3 |
| Unknown | Unknown | 3 | 0.6 |
| Total | | 465 | 100.0 |

Includes sections lost in single and multiple-finger loss incidents.
Workers' Compensation claims data do not contain data on section of finger lost and thus are excluded from the table.
Data Source: Michigan hospital/ED medical records

*County of Residence*

Table 4 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. Eighteen counties had no cases and another 42 had between one and five, too few to calculate statistically valid rates. Hillsdale County had the highest rate (30.2 per 100,000 workers). Among the most populous counties in the state, St. Clair County had the highest rate (25.3 per 100,000 workers) while Oakland County had the lowest (4.2 per 100,000).

TABLE 4
Number and Rate of Work-Related Amputations
by County of Residence, Michigan Residents, 2015

| County | Number | Rate | County | Number | Rate |
|---|---|---|---|---|---|
| Alcona | 1 | * | Lapeer | 8 | 22.0 |
| Alger | - | - | Leelanau | - | - |
| Allegan | 7 | 12.0 | Lenawee | 5 | * |
| Alpena | 2 | * | Livingston | 10 | 11.1 |
| Antrim | 1 | * | Luce | - | - |
| Arenac | 1 | * | Mackinac | 2 | * |
| Baraga | 1 | * | Macomb | 36 | 9.2 |
| Barry | 5 | * | Manistee | - | - |
| Bay | 7 | 14.1 | Marquette | 3 | * |
| Benzie | - | - | Mason | 2 | * |
| Berrien | 9 | 12.8 | Mecosta | 1 | * |
| Branch | 5 | * | Menominee | - | - |
| Calhoun | 8 | 13.0 | Midland | 4 | * |
| Cass | 2 | * | Missaukee | 1 | * |
| Charlevoix | - | - | Monroe | 5 | * |
| Cheboygan | 1 | * | Montcalm | 7 | 26.4 |
| Chippewa | 1 | * | Montmorency | - | - |
| Clare | 5 | * | Muskegon | 11 | 15.0 |
| Clinton | 2 | * | Newaygo | 3 | * |
| Crawford | 2 | * | Oakland | 25 | 4.2 |
| Delta | 1 | * | Oceana | 1 | * |
| Dickinson | 3 | * | Ogemaw | 2 | * |
| Eaton | 6 | 11.1 | Ontonagon | - | - |
| Emmet | 1 | * | Osceola | 2 | * |
| Genesee | 16 | 9.3 | Oscoda | - | - |
| Gladwin | 1 | * | Otsego | - | - |
| Gogebic | - | - | Ottawa | 17 | 11.5 |
| Grand Traverse | 4 | * | Presque Isle | 1 | * |
| Gratiot | 4 | * | Roscommon | - | - |
| Hillsdale | 6 | 30.2 | Saginaw | 6 | 7.1 |
| Houghton | - | - | St. Clair | 17 | 25.3 |
| Huron | 4 | * | St. Joseph | 3 | * |
| Ingham | 7 | 5.0 | Sanilac | 2 | * |
| Ionia | 6 | 21.2 | Schoolcraft | - | - |
| Iosco | 2 | * | Shiawassee | 4 | * |
| Iron | 2 | * | Tuscola | 1 | * |
| Isabella | 4 | * | Van Buren | 4 | * |
| Jackson | 9 | 13.0 | Washtenaw | 9 | 4.9 |
| Kalamazoo | 9 | 7.2 | Wayne, including Detroit | 51 | 10.5 |
| Kalkaska | - | - | *Detroit* | *23* | *10.9* |
| Kent | 42 | 12.7 | Wexford | - | - |
| Keweenaw | - | - | Unknown | 7 | |
| Lake | 2 | * | Michigan | 462 | 10.3 |

* 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 Licensing and Regulatory Affairs Workers' Compensation Agency; Number of workers used to calculate rates – Bureau of Labor Statistics' Local Area Unemployment Statistics

*Industry*

Table 5 illustrates the number and corresponding rate of work-related amputations by industry. For 51 cases (11.0%), there was insufficient information in either the medical records provided or Workers' Compensation claims data to make an industry classification. Nineteen workers were described in medical records as self-employed. Industry could be ascertained for all but five of these self-employed workers. Twenty-six people were identified as temporary workers. For 16 of these, industry could not be determined; the other ten were injured at manufacturing companies.

Among two-digit NAICS industry sectors, Agriculture, Forestry, Fishing, and Hunting had the highest rate (27.9 per 100,000 workers). All 17 cases occurred specifically within the Agriculture subsector. The greatest number of cases occurred within Manufacturing, which comprised 44.3% of the 411 incidents in which industry could be determined. Certain three-digit NAICS subsectors within Manufacturing had very high rates, notably Primary Metal Manufacturing (86.8 per 100,000).

**Case Study 1**

A 31-year-old temporary worker stuck his hand into a press and sustained a partial amputation at the distal interphalangeal joint of the middle finger. The case was referred to MIOSHA. Following their inspection, MIOSHA cited the company for five violations, four pertaining to hydraulic power presses and one for failure to record the injury on a MIOSHA 300 log. They were fined a total of $5,000.

TABLE 5
Number and Rate of Work-Related Amputations
by Worker Industry, Michigan Residents, 2015

| Industry Classification (NAICS industry sector code) | Number | Rate |
|---|---|---|
| Agriculture, Forestry, Fishing, and Hunting (11) | 17 | 27.9 |
| *Crop Production (111) and Animal Production (112)* | *17* | *35.0* |
| Mining (21) | 1 | * |
| Utilities (22) | 2 | * |
| Construction (23) | 55 | 22.8 |
| Manufacturing (31 – 33) | 182 | 21.9 |
| *Food Manufacturing (311)* | *13* | *25.8* |
| *Wood Product Manufacturing (321)* | *8* | *60.0* |
| *Paper Manufacturing (322)* | *7* | *71.3* |
| *Plastics and Rubber Products Manufacturing (326)* | *16* | *63.5* |
| *Primary Metal Manufacturing (331)* | *22* | *86.8* |
| *Fabricated Metal Product Manufacturing (332)* | *43* | *73.6* |
| *Machinery Manufacturing (333)* | *12* | *19.6* |
| *Transportation Equipment Manufacturing (336)* | *35* | *9.7* |
| *Furniture and Related Product Manufacturing (337)* | *6* | * |
| Wholesale Trade (42) | 21 | 20.6 |
| Retail Trade (44 – 45) | 20 | 3.9 |
| Transportation and Warehousing (48 – 49) | 14 | 7.7 |
| Information (51) | 0 | - |
| Finance and Insurance (52) | 0 | - |
| Real Estate and Rental and Leasing (53) | 5 | * |
| Professional, Scientific, and Technical Services (54) | 4 | * |
| Management of Companies and Enterprises (55) | 0 | - |
| Administration and Support Services and Waste Management and Remediation Services (56) | 19 | 9.1 |
| Educational Services (61) | 4 | * |
| Health Care and Social Assistance (62) | 5 | * |
| Arts, Entertainment and Recreation (71) | 5 | * |
| Accommodation and Food Services (72) | 36 | 12.0 |
| *Food Services and Drinking Places (722)* | *34* | *12.3* |
| Other Services (81) | 14 | 7.3 |
| Public Administration (92) | 7 | 5.6 |
| Unknown Industry | 51 | |
| Total | 462 | 10.3 |

* 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 Licensing and Regulatory Affairs 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 6. This information was unavailable in the Workers' Compensation claims data, so the table is limited to the 412 cases for which a medical record was available. Sharp objects were identified in about one-quarter (24.5%) of the cases. Power saws (e.g., table saws, miter saws) comprised nearly half of sharp object injuries. Presses caused one in ten (10.2%) amputations.

TABLE 6
Number of Work-Related Amputations, by Cause of Injury
Michigan Residents, 2015

| Cause of Injury | Number | % |
|---|---|---|
| Sharp object | 101 | 24.5 |
| *Power saw* | *48* | *11.7* |
| *Knife* | *26* | *6.3* |
| *Food slicer (including "meat saw")* | *8* | *1.9* |
| *Lawn mower* | *5* | *1.2* |
| *Other sharp object* | *14* | *3.4* |
| Press | 42 | 10.2 |
| *Mechanical* | *7* | *1.7* |
| *Other and unspecified type of press* | *35* | *8.5* |
| Pinched between objects | 49 | 11.9 |
| *In door/safe* | *15* | *3.6* |
| Struck by falling object | 21 | 5.1 |
| Struck by object - other | 9 | 2.2 |
| Caught in chain/pulley/gears/belt | 26 | 6.3 |
| Grinder | 14 | 3.4 |
| Forklift/Hi-lo | 7 | 1.7 |
| Machine - other specified type | 29 | 7.0 |
| Machine - unspecified type | 41 | 10.0 |
| Other specified cause | 45 | 10.9 |
| Unspecified cause | 28 | 6.8 |
| Total | 412 | 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 about one in six (17.0%) amputations. Another frequent cause of amputations (11.9%) was workers getting pinched or crushed between objects, such as doors. Finally, medical records provided no information on cause for 6.8% of cases.

Source of Payment

As shown in Table 7, Workers' Compensation was the expected payer in 301 (73.1%) of the 412 cases for which there was a medical record. For 39 cases, payment source could not be identified. Note that of the 111 cases for which Workers' Compensation was not listed as a payment source in medical records, 29 were linked to Workers' Compensation claims data. Workers' Compensation was the expected payer for 76.3% of the 393 patients that were not self-employed.

TABLE 7
Work-Related Amputations
by Payment Source Overall and for Non-self-employed Workers
Michigan Residents, 2015

| Expected Source of Payment | Total | | Non-self-employed | |
|---|---|---|---|---|
| | Number | % | Number | % |
| Workers' Compensation | 301 | 73.1 | 300 | 76.3 |
| Commercial insurance | 41 | 10.0 | 32 | 8.1 |
| Other | 31 | 7.5 | 23 | 5.9 |
| Not specified | 39 | 9.2 | 38 | 9.7 |
| Total | 412 | 100.0 | 393 | 100.0 |

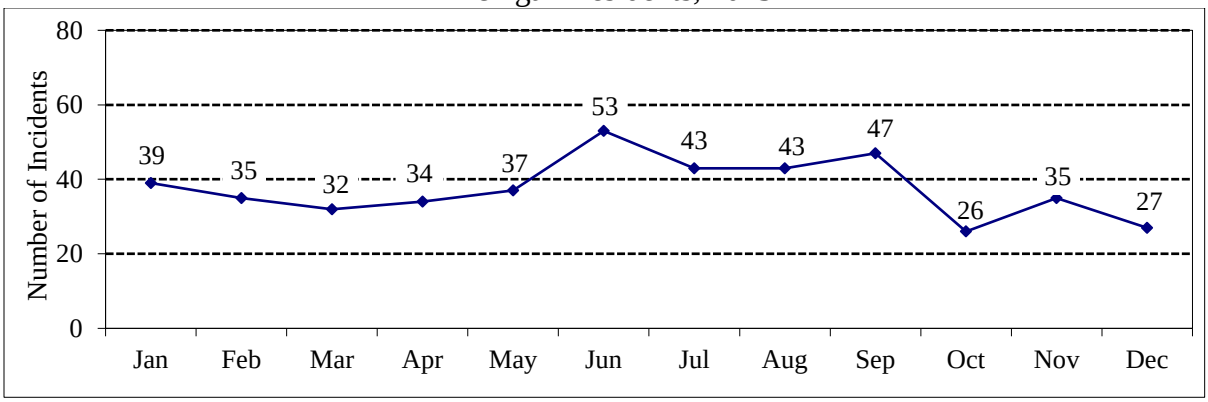
Data Source: Michigan hospital/ED medical records

Temporal Characteristics

*Incidents by Month*

Incidents occurred most frequently during the summer months and were least frequent during October to December (Figure 3).

FIGURE 3
Work-Related Amputations
by Incident Month
Michigan Residents, 2015

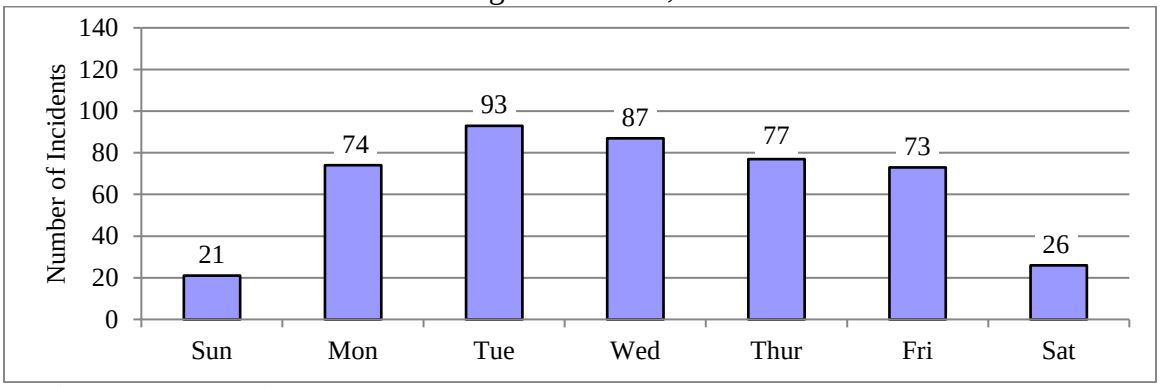



Month of incident was unknown for 11 cases.
Data Sources: Michigan hospital/ED medical records and Michigan Department of Licensing and Regulatory Affairs Workers' Compensation Agency

*Incidents by Day of Week*

Amputations occurred most frequently on Tuesdays and Wednesdays and were much less frequent during the weekend (Figure 4).

FIGURE 4
Work-Related Amputations
by Day of Incident
Michigan Residents, 2015

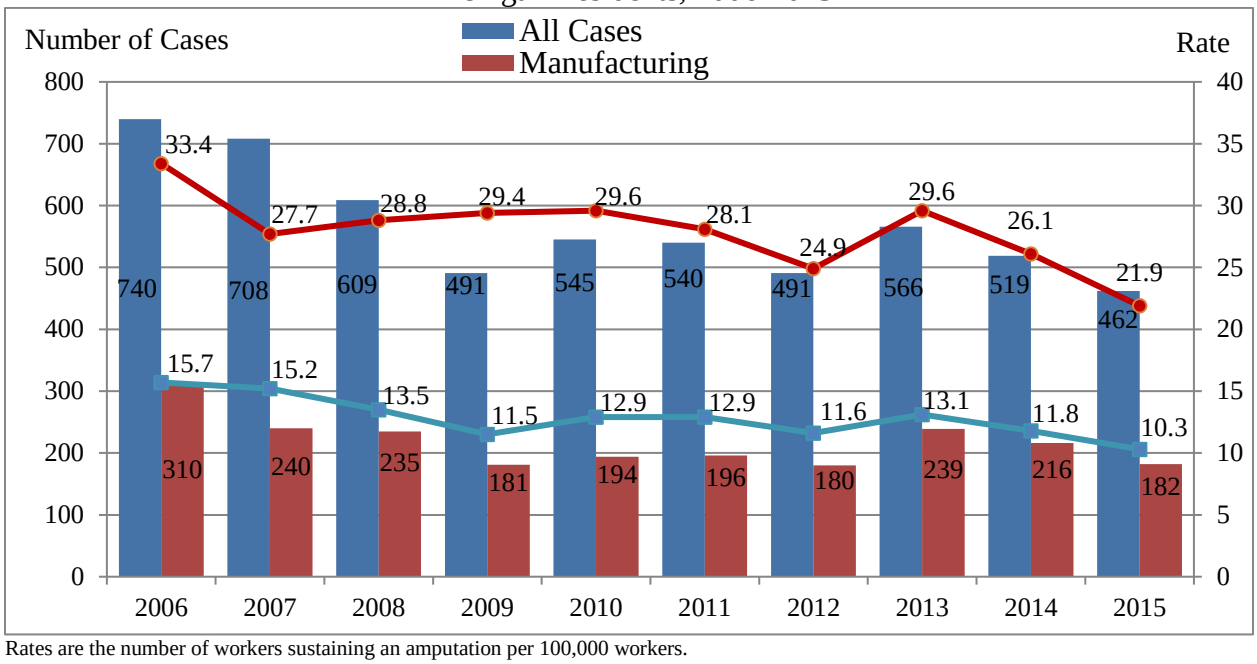



Day of incident was unknown for 11 cases.
Data Sources: Michigan hospital/ED medical records and Michigan Department of Licensing and Regulatory Affairs Growth Workers' Compensation Agency

*Incidents by Year*

During the ten years that the surveillance system has been in place, the annual number of cases has decreased by 37.6% – from 740 in 2006 to 462 in 2015 (Figure 5). This decline in the number of amputations for the most part cannot be explained by the economic recession with fewer individuals employed because rates also decreased, 34.4% (15.7 to 10.3 per 100,000 workers), although the percentage decrease in the rate was slightly smaller than the decrease in the number of amputations. Figure 5 also illustrates the annual number of cases and corresponding rates for manufacturing, the industry in which the greatest number of amputations occur. Rates and frequencies for manufacturing were highest in 2006. They have declined recently (2013-2015) similar to the pattern demonstrated among all industries.

FIGURE 5
Annual Numbers and Rates of Work-Related Amputations
by Year of Incident
Michigan Residents, 2006-2015




Rates are the number of workers sustaining an amputation per 100,000 workers.
Data Sources: Michigan hospital/ED medical records and Michigan Department of Licensing and Regulatory Affairs Workers' Compensation Agency

Referrals to MIOSHA

Twenty-two (22) of the 412 work-related amputations for which there was a hospital/ED medical record met the MIOSHA referral criteria.* MSU referred these 22 worksites to MIOSHA.

MIOSHA inspected seven worksites subsequent to a referral based on a hospital/ED medical record (Table 8). All seven inspections occurred within 91 days of MSU referrals.

TABLE 8
Outcome of Work-Related Amputation Referrals to MIOSHA
Michigan Residents, 2015

| Outcome of Referral | Number of Worksites | % |
|---|---|---|
| Worksite inspected subsequent to referral | 7 | 31.8 |
| *Inspected within 90 days of referral* | *7* | *31.8* |
| Worksite not inspected subsequent to referral | 15 | 68.2 |
| *Worksite inspected prior to referral* | *2* | *9.1* |
| *Worksite not inspected* | *13* | *59.1* |
| Total | 22 | 100.0 |

The following analyses examine the outcome of the seven MIOSHA inspections. Table 9 summarizes the number of violations identified in these inspections. The number of violations ranged from zero to eight with a median of three. Table 10 illustrates the distribution of assessed penalties. For three cases, there was no penalty. The maximum penalty was $35,000 and the median was $2,500. MIOSHA cited one company for hydraulic press violations. No company was cited for mechanical press violations.

* Cases identified solely through Workers' Compensation records were not referred to MIOSHA. See *Methods.*

TABLE 9
Violations Identified in Worksite Inspections
Conducted Following an MSU Referral
Michigan Residents, 2015

| Number of Violations | Number of Inspections | % |
|---|---|---|
| 0 | 1 | 14.3 |
| 1 | 2 | 28.6 |
| 2 | 0 | 0.0 |
| 3-5 | 3 | 42.9 |
| 6+ | 1 | 14.3 |
| Total | 7 | 100.0 |

Data Source: MIOSHA inspection reports

TABLE 10
Penalties Assessed in Worksite Inspections
Conducted Following an MSU Referral
Michigan Residents, 2015

| Penalty Assessed | Number of Inspections | % |
|---|---|---|
| $0 | 3 | 42.9 |
| $1-$999 | 0 | 0.0 |
| $1,000-$9,999 | 3 | 42.9 |
| $10,000+ | 1 | 14.3 |
| Total | 7 | 100.0 |

Data Source: MIOSHA inspection reports

**Case Study 2**

A 38-year-old worker got his hand caught in a buffer machine. He sustained a complete amputation through the middle of the index finger and a partial amputation at the base of the middle finger. The case was referred to MIOSHA. After performing an inspection, MIOSHA cited the company for four violations including one for the lack of appropriate safety devices on a buffing machine. Proposed penalties totaled $35,000, most of which were for violating a standard for which the company had previously been cited.

## 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 2015, there were seven such worksites. This identification and referral system directly provides support to MIOSHA in addressing Objectives 1.1 and 1.2 of their 2014-2018 Strategic Plan[8]:

> *Objective 1.1*
> *Reduce by 15% 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% 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 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 be evaluated to determine if it is effective and efficient.[9] These attributes are used to characterize the Michigan work-related amputation surveillance system.

**Sensitivity** is 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 2015:

1) *Incomplete submission of cases by hospitals* – An analysis of Michigan inpatient and outpatient visits (MIDB-MODB)[*] in 2015 identified three Michigan residents treated at two of the 33 hospitals that reported they had no work-related amputations that had an amputation diagnosis and Workers' Compensation listed as a source of payment. One of these three were found in the Workers' Compensation database as an amputation. Thus, had hospitals reported all amputations identified in the MIDB-MODB database, at least another two work-related amputation cases would have been identified by our surveillance system. This represents 0.4% of our total number.

   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 does not exist in Michigan.

2) *Incomplete identification of work-relatedness in medical records* – For eight amputations, work-relatedness could not be determined by a review of their medical records, we were unable to interview the patients, and we were unable to find them listed in the Workers' Compensation claims data base. Some of these amputations may have been work-related.

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

3) *Amputation cases coded by hospitals as non-amputations* – Amputation cases that are coded as something else (e.g., crush, laceration) by hospitals are not sent to us as amputations for review. For example, the number of work-related amputations in 2014[10] would have increased by 16 cases (or 3.5%) had these cases been accurately coded and submitted.

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

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 2015, three Michigan residents were treated for an amputation at an out-of-state hospital with Workers' Compensation listed as a primary or secondary payer. None of these individuals were identified by the surveillance system. Based on this information, it is estimated that in 2015, the surveillance system missed 0.6% of Michigan resident work-related amputations 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. Workers' Compensation claims are also not available for

those not covered by the system, such as the self-employed, federal employees and railroad workers.

Based on the above discussion, we estimate we miss about five percent of the work-related amputations in Michigan. The Michigan multi-source surveillance system is much more sensitive than the system conducted by the Bureau of Labor Statistics (BLS). The BLS reported 240 work-related amputations in Michigan in 2015 – 48% fewer than our system (N=462). There are some definitional differences between the two systems: the BLS measures those who work in Michigan, not Michigan residents, and excludes the self-employed (N=19) and individuals without lost work time. We have no data to determine what percentage of the amputations we identify had lost work time. The BLS figure is not actually 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)** is 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; or b) the expected payer was Workers' Compensation; or c) the patient reported the incident as work-related during the phone interview. The PVP of cases identified solely through Workers'

[†] 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).

Compensation records may be slightly lower than 95% because information on injury type is provided by employers rather than medical professionals.

**Representativeness** is the degree to which identified cases accurately describe all cases.

The surveillance system appears to be geographically representative. Hospitals either submitted medical records or responded that they had no cases and it appears that only a few cases were lost due to hospitals that did not provide records (see sensitivity discussion above). We presume that self-employed workers were more likely than other workers to be under identified because work-relatedness cannot always be determined from medical records and the payer being Workers' Compensation cannot be used to identify the amputation as work-related since the self-employed are not covered by Workers' Compensation. While self-employed workers comprised 4.6% of the 411 Michigan resident work-related amputation cases for which there was a medical record, they comprised 62.5% of the eight cases for which work-relatedness could not be determined.

**Timeliness** is the delay between any two or more steps in the system.

The timeliness of the system has improved substantially since 2010. Prior to 2011, hospitals submitted medical records for the twelve-month calendar year. Even submissions from the earliest reporting (i.e., February following the end of the year of interest) hospitals would contain cases more than a year old. Beginning in 2011, hospitals were required to report quarterly. Thus, medical records for patients treated in January-March of 2015 were initially received in April 2015 and the last records for 2015 were received in August 2016. In September 2016, 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 on work-related amputations were entered into a database. Lastly, in November 2016, data from Workers' Compensation claims were linked to the medical records database. The improved timeliness of the system has allowed more cases to be referred to MIOSHA within six months of the incident. Since 1/1/2016, MIOSHA regulations require employers to report

amputations directly to MIOSHA within 24 hours of occurrence. This will markedly improve timeliness. We will be evaluating the completeness of employer reporting.

**Flexibility** is 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.

**Simplicity** is 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 36 of 1,058 (3.4%) of the medical records reviewed case identification was more complex because additional information was sought through an interview. The number of interviews has decreased significantly starting in 2009 (during 2006-2008, there were an average of 165 interviews per year). More recently, the Workers' Compensation Agency has provided their claims database sooner so that work-relatedness and/or employer name often can quickly be determined by searching for the case in the database. Few of the data items ascertained from medical records or MIOSHA inspection reports are complex (the most time-consuming item is the identification of employer NAICS code). 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 there is one person who performs medical record reviews, data abstraction and data entry, makes MIOSHA referrals, 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.

**Acceptability** is the willingness of individuals and organizations to participate.

All 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 72% success rate in obtaining information from patients via phone interview. MIOSHA has stated that they value referrals. 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 true when injuries were caused by a "press." MIOSHA is particularly interested in injuries caused by mechanical power presses, however, medical records rarely provide such specificity (in only seven of the 42 injuries caused by presses were mechanical power presses specifically mentioned).
2. Medical records sometimes provided insufficient information to identify an industry and assign a NAICS code. Patient interviews were not attempted to ascertain this information alone when it could be determined that the case would not be a MIOSHA referral (e.g., the case was more than six months old).
3. Almost none of the medical records provided visual documentation of injuries (e.g., photograph), making it difficult to clearly comprehend the injury. It is unclear why coders assigned an amputation diagnosis code when, for example, a patient sustained a tissue-only laceration that was subsequently sutured.
4. 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.
5. Workers' Compensation claims data did not include information on injury cause and lacked detailed injury information (e.g., single vs. multiple digit loss, which finger was injured). Thus, results on these characteristics could not be fully described.
6. The success of record linkage depended upon the accuracy of the linking variables. If a 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 much higher estimate of the 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. We are encouraged that the number and rate of amputations has decreased since 2006. However, since 2008, rates have been in the narrow range of 10.3 to 13.5 per 100,000 workers. The ultimate objective is to significantly reduce the incidence of this serious injury.

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# APPENDIX A

## Additional Data Tables

TABLE A-1
Number and Rate of Work-Related Amputations
by Age and Sex
Michigan Residents, 2015

| Age Group | Male | | Female | | Both Sexes | |
|---|---|---|---|---|---|---|
| | Number | Rate | Number | Rate | Number | Rate |
| 16-19 | 25 | 26.0 | 2 | * | 27 | 15.7 |
| 20-24 | 57 | 25.7 | 10 | 4.4 | 67 | 14.9 |
| 25-34 | 93 | 19.5 | 14 | 3.3 | 107 | 11.9 |
| 35-44 | 83 | 16.8 | 7 | 1.6 | 90 | 9.7 |
| 45-54 | 72 | 12.7 | 8 | 1.6 | 81 | 7.7 |
| 55-64 | 69 | 18.8 | 11 | 2.9 | 80 | 10.8 |
| 65+ | 7 | 5.1 | 2 | * | 9 | 3.6 |
| Ages 16+ | 406 | 17.2 | 55 | 2.6 | 462 | 10.3 |

* Statistically stable rate could not be calculated.
Gender was unspecified for one person aged 45-54.
Age was unspecified for one female.
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 Licensing and Regulatory Affairs, 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, 2015

| Race | Hispanic Ethnicity | | | Total |
|---|---|---|---|---|
| | Yes | No | Unknown | |
| White | 4 | 77 | 114 | 195 |
| Black | 0 | 9 | 17 | 26 |
| Other | 2 | 1 | 4 | 7 |
| Unknown | 10 | 0 | 173 | 183 |
| Total | 16 | 87 | 308 | 411 |

Data Source: Michigan hospital/ED medical records

TABLE A-3
Work-Related Single-finger Amputation Incidents (N=346)
by Amount of Finger Lost
Michigan Residents, 2015

| Finger | Section Lost | | | | Total |
|---|---|---|---|---|---|
| | Distal Phalanx | Middle Phalanx | Proximal Phalanx | Unknown | |
| Thumb | 56 | | 4 | 0 | 60 |
| Index | 94 | 14 | 3 | 1 | 112 |
| Middle | 78 | 3 | 1 | 2 | 84 |
| Ring | 43 | 3 | 1 | 1 | 48 |
| Little | 34 | 3 | 1 | 1 | 39 |
| Unknown | 1 | 0 | 0 | 2 | 3 |
| Total | 306 | 23 | 10 | 7 | 346 |

Data Source: Michigan hospital/ED medical records

TABLE A-4
Work-Related Multiple-finger Amputation Incidents (N=51)
by Amount of Finger Lost
Michigan Residents, 2015

| Finger | Section Lost | | | | Total |
|---|---|---|---|---|---|
| | Distal Phalanx | Middle Phalanx | Proximal Phalanx | Unknown | |
| Thumb | 3 | | 2 | 0 | 5 |
| Index | 15 | 5 | 7 | 0 | 27 |
| Middle | 24 | 10 | 9 | 0 | 43 |
| Ring | 17 | 10 | 5 | 1 | 33 |
| Little | 5 | 2 | 3 | 1 | 11 |
| Total | 64 | 27 | 26 | 2 | 119 |

Data Source: Michigan hospital/ED medical records