

# Work-related Amputations in Michigan, 2009

May 2012

*Michigan Department  
of Community Health*



Rick Snyder, Governor  
Olga Dazzo, Director

MICHIGAN STATE  
UNIVERSITY

# **Work-related Amputations in Michigan, 2009**

A Joint Report

of the

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Bureau of Disease Control, Prevention, and Epidemiology  
Division of Environmental Health  
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**May 2012**

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## EXECUTIVE SUMMARY

The Division of Occupational and Environmental Medicine at Michigan State University has developed a system for collecting data on work-related amputations in Michigan. This report characterizes these injuries for 2009. The salient findings are as follows:

- The system identified a total of 491 Michigan resident work-related amputations. This corresponds to a rate of 11.5 per 100,000 workers. In comparison, the official U.S. Department of Labor estimate (170)<sup>1</sup> was 65% lower.
- The number of work-related amputations in Michigan has decreased 34% since 2006, while the rate has decreased 27%. In 2006, there were 740 cases and a rate of 15.7 per 100,000.
- Hospital/emergency department medical records identified 447 cases. Workers' compensation lost work time claims data identified 143 amputation cases of which 43 were not found using medical records alone. One additional case was identified using a combination of hospital/emergency department medical records and workers' compensation claims.
- The amputation rate for males was seven times that for females. Among males, rates were highest for those aged 25-34.
- Forty-two percent of the incidents occurred among those working in the manufacturing industry. The specific manufacturing group with the highest rate was Wood Product Manufacturing.
- Power saws were the leading cause of amputations, accounting for 18% of cases for which injury cause was specified.
- Ninety-six percent of amputations involved fingers. One in eight finger amputation injuries involved multiple fingers. Thirty percent of finger amputations resulted in bone loss.
- Upper extremity amputations occurred slightly more often on the left side (52%).
- Workers' compensation was the expected source of payment of hospitalization or emergency department care for 73% of the cases for which payment source was identified. Payer source could not be determined for 7.4% of medical records reviewed.

- The Michigan Occupational Safety and Health Administration (MIOSHA) inspected five worksites identified through medical records and assessed an average of six violations.

All of Michigan's acute care hospitals are required to participate in this surveillance system and were the primary source of data for most (91%) of the identified cases for 2009. Data provided by the Michigan Workers' Compensation Agency identified an additional 9% of cases that were not identified by hospital-based surveillance alone. The workers' compensation data were limited to individuals who requested wage replacement and did not include individuals who had claims for medical care cost reimbursement alone. Therefore, the surveillance system missed those cases in which injured workers were treated in non-hospital/emergency department settings or at out-of-state hospitals and did not request wage replacement.

The Michigan work-related amputation surveillance system produces valuable information. It identifies hazardous worksites that otherwise might go undetected and facilitates remediation at these worksites. It provides information that can be used to characterize workers and industries with high amputation rates. Finally, by combining data from two separate systems, medical records and workers' compensation claims, it provides the best estimate of the true number of amputations that occur in Michigan. The 491 amputations identified are appreciably larger than the official employer-based estimate of 170.

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

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## **INTRODUCTION**

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

The Bureau of Labor Statistics estimates that 5,930 amputations resulting in days away from work occurred nationally in the private sector in 2009. The median number of lost workdays was 21 for amputation cases compared to eight days for all work-related injuries.<sup>1</sup> 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 have developed a set of nineteen occupational health indicators,<sup>2</sup> two of which are measures of work-related amputations.

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

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

a more complete count of work-related amputations. This report summarizes work-related amputations identified by this surveillance system for the fourth full year of data, 2009.

## **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.<sup>5</sup> MSU administers this law for both MDLARA and MDCH and medical records are sent directly to MSU's OEM Division.

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

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

The Current Population Survey (CPS), conducted by the U.S. Census Bureau for the Bureau of Labor Statistics, was the source of the estimated number of employed Michigan residents by defined age groups, gender, and industry groups for 2009. The BLS Local Area Unemployment Statistics (LAUS) system, which utilizes CPS data in combination with data from the BLS Current Employment Statistics program and state unemployment insurance systems, was the source of the number of Michigan residents employed by county of residence. The CPS and LAUS employment data were used to calculate worker-based amputation rates.



## Methods

A case identified using hospital medical records was defined as an individual aged 16 years or older receiving medical treatment at a Michigan hospital/emergency department for whom: a) an amputation diagnosis was assigned (ICD-9-CM<sup>6</sup> codes 885.0-.1, 886.0-.1, 887.0-.7, 895.0-.1, 896.0-.3, and 897.0-.7); and b) the incident was documented as having occurred at work in 2009. The level of hospital care included outpatient surgery, emergency department visit, and hospital admission. A case identified using the workers' compensation system was defined as an individual aged 16 years or older who was in their lost work time wage replacement database with an accepted work-related amputation occurring in 2009. 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 either b) the company was within an industry identified by MIOSHA as having a high injury rate or c) the amputation potentially was caused by a mechanical power press.<sup>Δ</sup> The MIOSHA high injury rate industries were those within North American Industry Classification System (NAICS)<sup>7</sup> three-digit codes 312, 321, 326, 327, 331, 332, 333, 336 and specific industry six-digit codes 423930 and 561730.<sup>†</sup>

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

<sup>Δ</sup> 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.

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

An MSU referral to MIOSHA consisted of records that documented the injury, its cause, and the employer (workers' names were suppressed except for cases potentially involving power presses). MIOSHA staff reviewed referred cases to determine if they would conduct a worksite inspection. Referrals were made to MIOSHA between March 2010 and February 2011.

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

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

Once case ascertainment from medical record review and patient interviews was completed, records in the work-related amputation database were linked to records in the workers' compensation claims database using SAS software, version 9.2 of the SAS System for Windows (copyright 2002-2008 by SAS Institute Inc.). There were several

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\* For an injury to be categorized as involving "bone loss," the medical record must have included phrases such as "complete amputation", "through and through amputation", "amputated digit was not recovered", or actual/planned surgery involved "amputation revision", "rongeur", or other bone removal or reduction.

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

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), first three letters of last name, date of birth, and company name. For cases that matched, the linked record was visually assessed to verify the match. Once this set of matched cases was created, additional matches were sought using less unique information (e.g., patient zip code of residence, date of injury plus/minus thirty days). The matching process was performed on the entire 2009 workers' compensation claims database to allow for links to cases not categorized as amputations by that system.

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

Work-related amputation rates were calculated by gender, age group, county of residence and type of industry by dividing the number of Michigan resident workers sustaining an

amputation by the number employed and multiplying the result by 100,000. Rates were not calculated for groups with fewer than six cases because these were considered statistically unreliable. Asterisks identify these cases in the tables.

<b><u>SYMBOLS USED IN TABLES</u></b>	
No cases occurred within category	—
Rate is considered statistically unreliable	*

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

## **RESULTS**

One hundred seven (107) of Michigan's 128 acute care hospitals submitted medical records to MSU. The remaining 21 hospitals submitted no records but reported that they had no work-related amputation cases in 2009. The total number of records received and reviewed was 1,869. Project staff attempted to interview 43 patients to ascertain work-relatedness and/or employer information and completed 14 of these interviews (a 33% success rate).

In 2009, 457 individuals were treated at a Michigan acute care hospital/emergency department (ED) following a work-related amputation\*. These include 456 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 workers' compensation records.

These workers made a total of 522 hospital visits for care (62 of the 457 workers made multiple hospital visits). Nearly all workers (98.0%) were Michigan residents (N=448) (Table 1). The work-related amputation rate for these hospital-treated amputations among Michigan residents was 10.5 per 100,000 workers.

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

TABLE 1  
Workers treated for an amputation at a  
Michigan acute care hospital/ED, 2009

Characteristics of Workers and Healthcare Utilization	Number of Workers	%
Received treatment at a Michigan acute care hospital/ED	457	100.0
<i>Michigan resident</i>	448	98.0
<i>One hospital visit</i>	386	84.5
<i>Multiple hospital visits (followup care or transfer to another hospital)</i>	62	13.6
<i>Out-of-state resident</i>	9	2.0
<i>One hospital visit</i>	9	2.0
<i>Multiple hospital visits (followup care or transfer to another hospital)</i>	0	0.0

Data Source: Michigan hospital/ED medical records

Table 2 illustrates the number of cases ascertained by the two data sources and the results of the matching process. The workers' compensation database contained 143 accepted lost work time claims from Michigan residents with amputations. One hundred thirty eight (138) were paid for lost work time. There was no indication that the remaining five individuals were paid for lost work time. For four of these, the amputation was not contested as being work-related. Some of the 138 individuals paid for lost work time may not have been out of work seven consecutive days. As described previously (page 2), workers are eligible for wage replacement if they sustain "specific losses," such as the loss of a phalanx.

One hundred (100) of the 143 workers' compensation claims (70%) matched an amputation case identified from medical record review. For 43 cases, hospitals/EDs did not submit a medical record of an amputation (first row of Table 2). One hundred twenty eight (128) of the 447 hospital-record-based amputation cases (29%) 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) (first column of Table 2). Finally, of 29 cases for which work-relatedness could not be determined via medical records, one matched a workers' compensation file with a non-amputation injury (third column of Table 2).

**TABLE 2**  
**Results of matching Michigan resident work-related amputation cases**  
**ascertained from hospital/ED medical records and workers'**  
**compensation lost work time claims, 2009**

Was Michigan Resident in Workers' Compensation Database?	Was Michigan Resident Amputation Work-related per Hospital/ED Medical Record?			No Match to Medical Record	Total
	Yes	No	Unknown		
Yes, with amputation injury	100	0	0	43	143
Yes, with a non-amputation condition	128	0	1	24,962	25,091
No	219	0	28	NA	247
Total	447	0	29	25,005	25,481

Shaded cells illustrate work-related amputation cases.

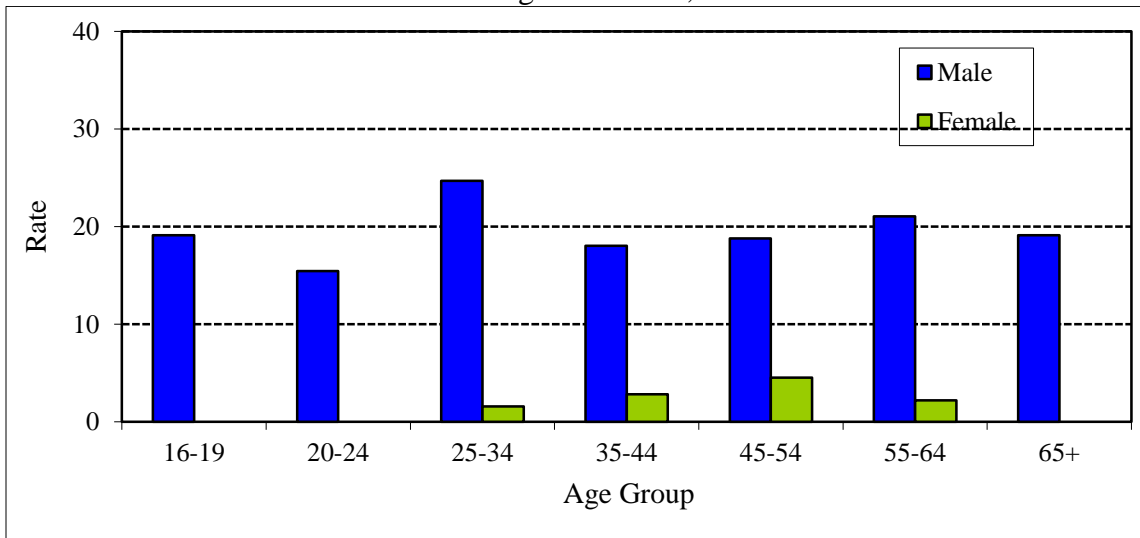
Adding the 44 cases that were identified using workers' compensation records to the 447 hospital-based cases yields a total of 491 Michigan resident workers. This corresponds to a rate of 11.5 amputations per 100,000 workers. The following analyses examine these 491 cases.

## Characteristics of Injured Workers

### *Age and Gender*

Males comprised 88% of workers who sustained an amputation. Among males, rates were highest for workers aged 25-34. Figure 1 displays amputation rates by age group and gender.

FIGURE 1  
Work-related amputation rates  
by age group and gender  
Michigan residents, 2009



Rates are the number of workers sustaining an amputation per 100,000 workers.

Statistically valid rates could not be calculated for females aged 16-19, 20-24 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

### *Race and Hispanic Ethnicity*

Information on patient race and Hispanic ethnicity was missing in 40% and 94% of medical records, respectively, and is not collected in workers' compensation claims (see Table A-2 in Appendix A). Due to these levels of missing information, rates for racial/ethnic groups were not calculated. Of the workers for whom race was specified (N=268), whites comprised 89% and African Americans 9%, similar to the racial composition of Michigan workers overall (84% and 11%, respectively).

### *Body Part and Severity*

As shown in Table 3 nearly all amputations were to fingers (95.5%). Data from hospital/ED medical records, which provide more detail on finger injuries than workers' compensation claims data, were available for 429 finger amputation cases. The following analyses are limited to these cases. Of 429 finger amputation incidents, 53 (12.4%) involved multiple fingers. The distal phalanx of the middle finger (section G in Figure 2) was the most frequently amputated area. The distal phalanges comprised 83% of all finger sections lost (excluding cases in which this information was unknown). Table A-3 and Table A-4 in Appendix A provide these data for the left and right hand separately for single-finger and multiple-finger amputation incidents, respectively. There was bone loss in 127 of the 429 finger amputation cases (29.6%).

TABLE 3  
Work-related amputations  
by injured body part  
Michigan residents, 2009

Part of Body Amputated	Number of Workers	%
Upper Extremity	478	97.4
<i>Finger</i>	469	95.5
<i>Hand</i>	5	1.0
<i>Arm</i>	4	0.8
Lower Extremity	13	2.6
<i>Toe</i>	9	1.8
<i>Foot</i>	0	0.0
<i>Leg</i>	3	0.6
<i>Unknown</i>	1	0.2
<b>Total</b>	<b>491</b>	<b>100.0</b>

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

Overall, workers sustained slightly more injuries to their left side than their right side (52% v. 48%) (Table 4).



**FIGURE 2**  
**Work-related finger amputations**  
**by digit and section of finger lost**  
**Michigan residents, 2009**

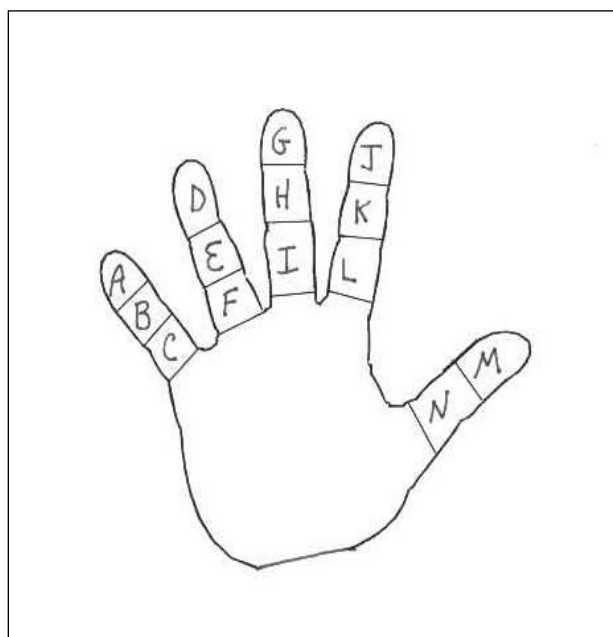


Figure is for both left and right hands.

Finger	Section	Number	%
Little	A	40	8.4
	B	9	1.9
	C	8	1.7
Ring	D	60	12.6
	E	7	1.5
	F	7	1.5
Middle	G	123	25.7
	H	12	2.5
	I	3	0.6
Index	J	103	21.5
	K	18	3.8
	L	9	1.9
Thumb	M	70	14.6
	N	9	1.9
<b>Total</b>		<b>478</b>	<b>100.0</b>

In 10 cases, the section(s) of finger lost was unknown.  
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

**TABLE 4**  
**Work-related amputations**  
**by side and extremity injured**  
**Michigan residents, 2009**

Injured Side	Number of Workers		
	Upper Extremity	Lower Extremity	Total
Right	208	4	212
Left	227	6	233
Both	0	1	1
Unknown	2	0	2
<b>Total</b>	<b>437</b>	<b>11</b>	<b>448</b>

Workers' compensation claims data do not contain information on injured side and thus are excluded from the table.  
Data Source: Michigan hospital/ED medical records

### **Case Study One**

A 26-year-old man stuck his left thumb in a grinding wheel. He sustained a near complete amputation at the distal interphalangeal joint. The worksite was referred to MIOSHA. They cited the company for six violations, including one for the lack of a guard on an abrasive wheel, and fined them \$300.

#### *County of Residence*

Table 5 illustrates the number of workers sustaining an amputation and the corresponding rate by a worker's county of residence. Note that the table does not necessarily reflect the counties with the highest risk worksites because people may work in a county other than the one in which they live. Thirteen counties had no cases and another 50 had between one and five, too few to calculate statistically valid rates. Branch County had the highest rate although there were only six cases. Among the most populous counties in the state, Kent County had the highest rate (14.1 per 100,000 workers) while Oakland County had the lowest (7.4 per 100,000).

TABLE 5  
Number and rate of work-related amputations  
by county of residence, Michigan residents, 2009

County	Number	Rate	County	Number	Rate
Alcona	0	—	Lapeer	7	19.6
Alger	1	*	Leelanau	0	—
Allegan	10	21.3	Lenawee	7	17.3
Alpena	2	*	Livingston	4	*
Antrim	0	—	Luce	0	—
Arenac	1	*	Mackinac	1	*
Baraga	0	—	Macomb	40	11.4
Barry	3	*	Manistee	4	*
Bay	6	12.6	Marquette	2	*
Benzie	3	*	Mason	4	*
Berrien	2	*	Mecosta	4	*
Branch	6	32.7	Menominee	0	—
Calhoun	4	*	Midland	1	*
Cass	1	*	Missaukee	2	*
Charlevoix	4	*	Monroe	1	*
Cheboygan	1	*	Montcalm	3	*
Chippewa	2	*	Montmorency	0	—
Clare	2	*	Muskegon	16	21.5
Clinton	5	*	Newaygo	2	*
Crawford	1	*	Oakland	39	7.4
Delta	2	*	Oceana	3	*
Dickinson	3	*	Ogemaw	0	—
Eaton	14	27.3	Ontonagon	1	*
Emmet	1	*	Osceola	2	*
Genesee	22	13.1	Oscoda	1	*
Gladwin	1	*	Otsego	1	*
Gogebic	1	*	Ottawa	19	16.7
Grand Traverse	5	*	Presque Isle	2	*
Gratiot	3	*	Roscommon	0	—
Hillsdale	4	*	Saginaw	5	*
Houghton	3	*	St. Clair	13	19.2
Huron	3	*	St. Joseph	3	*
Ingham	12	9.0	Sanilac	4	*
Ionia	5	*	Schoolcraft	0	—
Iosco	0	—	Shiawassee	4	*
Iron	1	*	Tuscola	6	25.7
Isabella	3	*	Van Buren	6	17.4
Jackson	8	12.2	Washtenaw	16	9.6
Kalamazoo	11	9.3	Wayne, including Detroit	64	8.8
Kalkaska	1	*	<i>Detroit</i>	20	7.1
Kent	39	14.1	Wexford	3	*
Keweenaw	0	—	Unknown	5	
Lake	0	—	Michigan	491	11.5

\* Statistically reliable rate could not be calculated. See *Methods*.

Rates are the number of workers sustaining an amputation per 100,000 workers.

Data Sources: Number of amputations – Michigan hospital/ED medical records and Michigan Department of Licensing and Regulatory Affairs Workers' Compensation Agency; Number of workers used to calculate rates – Bureau of Labor Statistics' Local Area Unemployment Statistics

## *Industry*

Table 6 illustrates the number and corresponding rate of work-related amputations by industry. For 12% of cases, there was insufficient information in either the medical records provided or workers' compensation claims data to make an industry classification. Forty-three workers were described in medical records as self-employed. Industry could be ascertained for sixteen of these self-employed workers; the remaining 27 were included in Unknown Industry. Among two-digit NAICS industry sectors, Agriculture/Forestry/Fishing/Hunting had the highest rate (42 per 100,000 workers). However, there were nearly eight times as many incidents within Manufacturing. In addition, certain three-digit NAICS subsectors within Manufacturing had very high rates, notably Wood Product Manufacturing (198 per 100,000). Incidents resulting in bone loss were overrepresented in Food Manufacturing (10 bone loss cases among 20 cases overall; 50%), Fabricated Metal Product Manufacturing (14 of 32, 44%) and Construction (18 of 43, 42%). Conversely, only two of the 27 (7%) incidents occurring in Food Services and Drinking Places involved bone loss.

### **Case Study Two**

A 58-year-old man got his right hand caught in the chain and sprocket of a conveyor belt, sustaining a complete amputation of his hand. The worksite was referred to MIOSHA. Their subsequent inspection found 17 violations and fined the company \$750.

TABLE 6  
Number and rate of work-related amputations  
by worker industry, Michigan residents, 2009

Industry Classification (NAICS industry sector code)	Number	Rate
Agriculture, Forestry, Fishing, Hunting (11)	23	42.0
Mining (21)	2	*
Utilities (22)	2	*
Construction (23)	48	20.9
Manufacturing (31 – 33)	181	29.4
<i>Food Manufacturing (311)</i>	23	70.0
<i>Wood Product Manufacturing (321)</i>	14	198.4
<i>Paper Manufacturing (322)</i>	5	*
<i>Plastics &amp; Rubber Products Manufacturing (326)</i>	10	57.9
<i>Primary Metal Manufacturing (331)</i>	15	57.4
<i>Fabricated Metal Product Manufacturing (332)</i>	36	97.0
<i>Machinery Manufacturing (333)</i>	14	21.0
<i>Transportation Equipment Manufacturing (336)</i>	27	10.7
<i>Furniture &amp; Related Product Manufacturing (337)</i>	13	63.8
Wholesale Trade (42)	28	27.4
Retail Trade (44 – 45)	38	8.1
Transportation & Warehousing (48 – 49)	10	7.1
Finance & Insurance (52)	1	*
Real Estate and Rental & Leasing (53)	5	*
Professional, Scientific, and Technical Services (54)	4	*
Administration & Support Services and Waste Management & Remediation Services (56)	16	9.9
Educational Services (61)	13	3.1
Health Care & Social Assistance (62)	8	1.2
Arts, Entertainment & Recreation (71)	2	2.7
Accommodation & Food Services (72)	35	11.7
<i>Food Services &amp; Drinking Places (722)</i>	30	11.5
Other Services (81)	11	4.3
Public Administration (92)	3	*
Unknown Industry	61	
<b>Total</b>	<b>491</b>	<b>11.5</b>

\* 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 7. (This information was unavailable in workers' compensation claims data, so the table is limited to the 448 cases for which a medical record was available.) Sharp objects were identified in nearly one-third (32.6%) of the cases. Power saws (e.g., table saws, miter saws) comprised about one-half of sharp object injuries. Presses caused about one in ten (10.5%) amputations. Medical records generally did not specify the type of press.

TABLE 7  
Number of work-related amputations, by cause of injury  
Michigan residents, 2009

Cause of Injury	Number	%
Sharp object	146	32.6
<i>Power saw</i>	74	16.5
<i>Meat slicer (including "meat saw")</i>	25	5.6
<i>Knife</i>	15	3.3
<i>Lawn mower</i>	4	0.9
<i>Other sharp object</i>	28	6.3
Press	47	10.5
<i>Mechanical/punch/stamping press</i>	1	0.2
<i>Other press</i>	13	2.9
<i>Unspecified type of press</i>	33	7.4
Pinched between objects	45	10.0
<i>In door</i>	16	3.6
Struck by falling object	29	6.5
Struck by object – other	5	1.1
Caught in chain/pulley/gears/belt	26	5.8
Grinder	10	2.2
Roller	5	1.1
Auger	5	1.1
Drill	3	0.7
Logsplitter	3	0.7
Machine – other specified type	32	7.1
Machine – unspecified type	33	7.4
Other specified cause	25	5.6
Unspecified cause	34	7.6
Total	448	100.0

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

An assortment of other machinery, many of which were unspecified in the medical records, caused one in five amputations. Another frequent cause of amputations was workers getting pinched or crushed between objects, such as doors. Finally, medical records provided no information on cause for 7.6% of cases.

Only two of the 25 amputations caused by meat slicers resulted in bone loss. Conversely, 42% of the injuries caused by getting caught in a chain/pulley/gear/belt led to bone loss.

### Source of Payment

As shown in Table 8, workers' compensation was the expected payer in 301 (67.2%) of the 448 cases for which there was a medical record. For 33 cases payment source could not be identified. Note that of the 147 cases for which workers' compensation was not listed as a payment source in medical records, 42 were linked to workers' compensation claims data. Workers' compensation was the expected payer for 74.3% of the 405 patients that were not self-employed.

TABLE 8  
Work-related amputations  
by payment source overall and for non-self-employed workers  
Michigan residents, 2009

Expected Source of Payment	Total		Non-self-employed	
	Number	%	Number	%
Workers' compensation	301	67.2	301	74.3
Commercial insurance	62	13.8	38	9.4
Other	52	11.6	40	9.9
Not specified	33	7.4	26	6.4
<b>Total</b>	<b>448</b>	<b>100.0</b>	<b>405</b>	<b>100.0</b>

Data Source: Michigan hospital/ED medical records

### Temporal Characteristics

#### *Incidents by Month*

The fewest number of cases occurred in the late fall and winter months (November-February) (Figure 3).

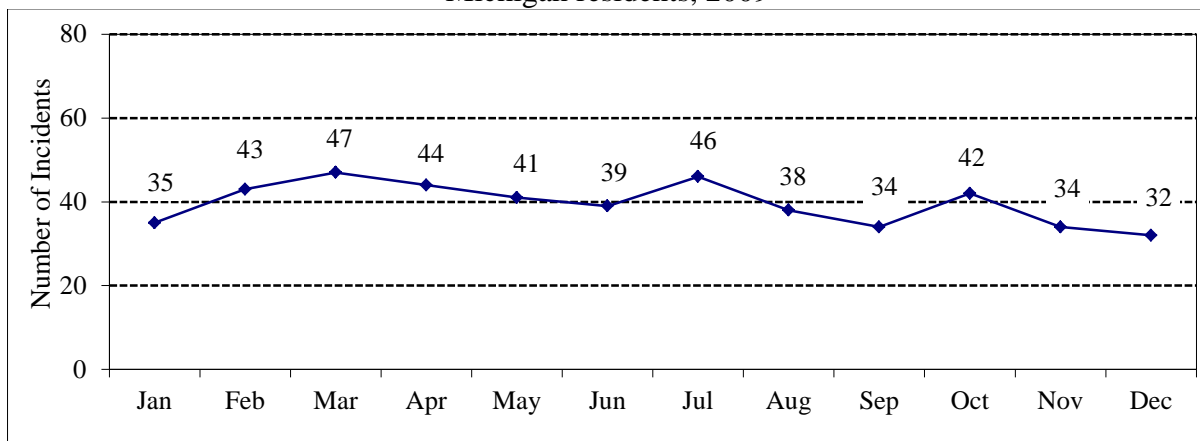
### *Incidents by Day of Week*

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

### *Incidents by Year*

During the four years that the surveillance system has been in place, the annual number of cases decreased consistently – from 740 in 2006 to 491 in 2009, a 33.6% change (Figure 5). This decline in the number of amputations cannot for the most part be explained by the economic recession with fewer individuals employed because rates decreased 26.8% (15.7 to 11.5 per 100,000 workers), a slightly smaller percentage decrease 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. The annual number of amputations in manufacturing also consistently decreased but the amputation rate slightly increased in 2007 and 2008 from its low in 2006. This would suggest that a partial explanation for the overall decrease in the number of amputations were less individuals working in the higher risk manufacturing jobs.

FIGURE 3  
Work-related amputations  
by incident month  
Michigan residents, 2009

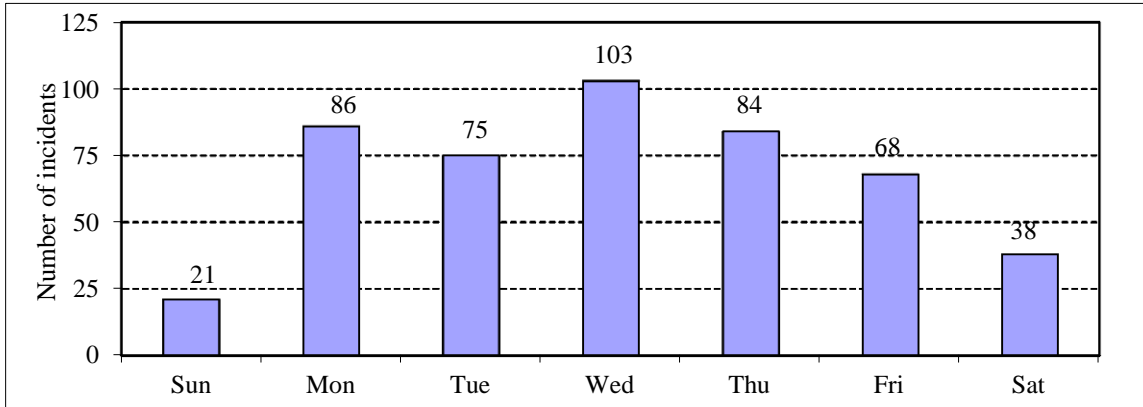


Month of incident was unknown for sixteen cases.

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



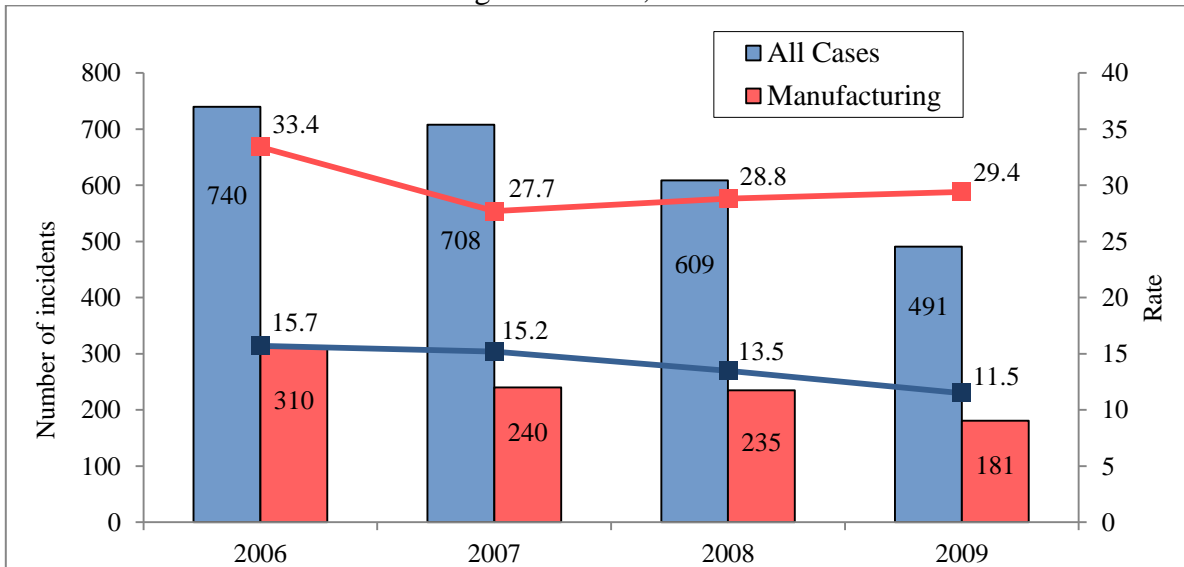
**FIGURE 4**  
**Work-related amputations**  
**by day of incident**  
**Michigan residents, 2009**



Day of incident was unknown for sixteen cases.

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

**FIGURE 5**  
**Work-related amputations**  
**by year of incident**  
**Michigan residents, 2006-2009**



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

Fifty nine (59) of the 457 work-related amputations for which there was a hospital/ED medical record met the MIOSHA referral criteria.\* All but one of these cases involved one amputation per worksite. At one worksite, two separate amputation incidents occurred. Thus, MSU referred 58 worksites to MIOSHA.

MIOSHA inspected twelve worksites subsequent to a referral based on a hospital/ED medical record (Table 9). It is likely that five of these inspections were due to the MSU referral as each occurred within two months of the referral. Note that one inspection that occurred 16 days after a referral was on the MIOSHA priority list.

TABLE 9  
Outcome of work-related amputation referrals to MIOSHA  
Michigan residents, 2009

Outcome of Referral	Number of Worksites	%
Worksite inspected subsequent to referral	12	20.7
<i>Inspected within 60 days of referral</i>	5	8.6
<i>Company not on MIOSHA priority list</i>	2	3.4
<i>Company on MIOSHA priority list</i>	1	1.7
<i>Unknown if company on MIOSHA priority list</i>	2	3.4
<i>Inspected more than 60 days of referral</i>	7	12.1
Worksite not inspected subsequent to referral	46	79.3
<i>Worksite inspected prior to referral</i>	4	6.9
<i>Worksite not inspected</i>	42	72.4
<i>Inspection attempted or initiated, but not completed</i>	1	1.7
Total	58	100.0

Table 9 also illustrates that in 46 cases, MIOSHA did not perform inspections following hospital/ED referrals. In four instances, they had inspected the worksite prior to receiving the referral. For 42 worksites that were referred, MIOSHA conducted no inspections. In one case, they attempted to inspect the worksite, but the company was out of business. For 41 cases, no attempt was made to perform an inspection. Of these, the reasons listed

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

by MIOSHA for not inspecting included: a) the case was too old (i.e., the time for assigning the referral for inspection had been exceeded); and b) the cause of injury was not a violation of MIOSHA safety standards (e.g., object fell on worker's hand).

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

Table 10 summarizes the number of violations identified in these inspections. The number of violations ranged from two to 19 with a median of six. Table 11 illustrates the distribution of assessed penalties. For two cases, there was no penalty. The maximum penalty was \$12,000 and the median was \$300. MIOSHA did not cite any of these companies for mechanical power press violations.

TABLE 10  
Violations identified in worksite inspections  
conducted following an MSU referral  
Michigan residents, 2009

Number of Violations	Number of Inspections	%
1-5	2	40.0
6-9	1	20.0
10+	2	40.0
Total	5	100.0

Data Source: MIOSHA inspection reports

TABLE 11  
Penalties assessed in worksite inspections  
conducted following an MSU referral  
Michigan residents, 2009

Penalty Assessed	Number of Inspections	%
\$0	2	40.0
\$1-\$999	2	40.0
\$1000+	1	20.0
Total	5	100.0

Data Source: MIOSHA inspection reports

## 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 2009, there were as many as five such cases. This identification and referral system directly provides support to MIOSHA in addressing Objective 1.1 of their 2009-2013 Strategic Plan<sup>8</sup>:

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

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

### Evaluation of Surveillance System Attributes

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

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

The surveillance system is designed to detect work-related amputations treated in Michigan hospitals or for which the worker submits a claim for wage reimbursement. The following factors prevented the system from being 100% sensitive in 2009:

- 1) *Incomplete submission of cases by hospitals* – Twenty-one hospitals reported treating no patients with work-related amputations in 2009 and consequently submitted no medical records to MSU. An analysis of Michigan inpatient and outpatient visits (MIDB-MODB)<sup>\*</sup> in 2009 identified

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

four Michigan residents treated at two of these 21 hospitals that had an amputation diagnosis and workers' compensation listed as a source of payment. None of these four individuals were among the 43 cases identified solely through workers' compensation claims data thus they were not ascertained by our surveillance system.

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

- 2) *Incomplete identification of work-relatedness in medical records* – For 28 cases, work-relatedness could not be determined through patient interviews or because records could not be linked to workers' compensation claims data. Some of these amputations may have been work-related.

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

- 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 2009, five Michigan residents treated for an amputation for which the primary or secondary payer was workers' compensation were seen at an out-of-state hospital. Two of these five individuals were among the 43 cases identified solely through workers' compensation claims data. Based on this information, it is estimated that in 2009, the surveillance system missed less than 1% of work-related amputations occurring in Michigan due to treatment at out-of-state hospitals.

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

While the surveillance system does not identify all work-related amputations in Michigan, it is much more sensitive than the system conducted by the Bureau of Labor Statistics (BLS). The BLS reported 170 work-related amputations in Michigan in 2009 – 65% fewer than our system (N=491). There are some definitional differences between the two systems: BLS measures those who work in Michigan, not Michigan residents, excludes the self-employed (N=43) and individuals without lost work time, and requests that employers do not report amputations that do not result in bone loss. This latter criterion may explain much of the estimate disparity between the two sources. We found that only about 30% of amputations resulted in bone loss. [There were another 89 cases (20%) in which bone loss was likely, but was not clearly documented.] The BLS figure is not a count of all amputations but rather is an estimate based on a sample of employer-

reported injuries and thus is dependent upon the sample drawn and the degree to which employers record worker injuries. Finally, some injuries classified as amputations in medical records may have been recorded by employers as something else (e.g., crush, laceration).

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

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

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

The surveillance system appears to be geographically representative. Most hospitals submitted medical records and it appears that few cases were lost due to those hospitals that did not provide records (see sensitivity discussion above). Self-employed workers were more likely than other workers to be under identified because work-relatedness for this group often could not be determined from medical records and they are not covered by workers' compensation. While self-employed workers comprised 8.8% of all Michigan resident work-related amputation cases, they comprised 35.7% of the 28 cases for which work-relatedness could not be determined.

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

The timeliness of the system is its weakest attribute. Medical records for patients treated in 2009 were initially received in February 2010. The last reporting hospital submitted records in April 2011. In January 2012, 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 entered into a database. At this point, data from workers' compensation claims were obtained and record matching was performed. Timeliness is also a concern with regard to making referrals to MIOSHA. Worksite inspections could be better targeted if the time between injury incidence and MIOSHA referral was reduced. This deficiency will be addressed in the coming year as hospitals will be required to report on a quarterly basis.

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

The system is highly flexible. Data items ascertained from medical records or through follow-up interviews have been added or deleted as their usefulness has become apparent. In addition, the criteria for cases to be referred to MIOSHA have evolved. For example, because of its significance in the definition of an "amputation," documented bone loss was added to the data collected for 2009 and has provided valuable information without having a negative impact on the surveillance system.

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

The case definition is easy to apply and usually cases are identified quickly. For 43 of 1,869 (2.3%) 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). The Workers' Compensation Agency provides their claims database in a timely manner so that work-relatedness often can quickly be determined by searching for the case in the database. Almost none of the data items



ascertained from medical records or MIOSHA inspection reports are complex. There are a small number of individuals involved in maintaining the system. At MSU, one person is responsible for pursuing hospital medical record submission, and one person reviews medical records, makes referrals to MIOSHA, performs data abstraction, data entry, links medical records and workers' compensation claims records, and performs data analysis. All individuals working on the system spend only a portion of their time on this project.

**Acceptability** – 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 33% success rate in obtaining information from patients via phone interview. MIOSHA has stated that they value referrals although they would prefer better timeliness. As mentioned above, this is being addressed by the new requirement to have hospitals report quarterly rather than annually. The Workers' Compensation Agency readily provides access to their data.

Limitations

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

1. Medical records often were non-specific in documenting the causes of amputations. This was especially detrimental when injuries were caused by a "press": either a power press was incorrectly listed as the cause, or a power press was in fact the cause, but not explicitly noted.
2. Medical records sometimes provided insufficient information to identify an industry and assign a NAICS code without patient interviews and only one-third of attempted interviews were completed. This is likely to have resulted in some cases not being referred to MIOSHA that should have been.
3. Medical records often contained descriptions which seemed to indicate that there was bone loss without clearly documenting it. For example, a record containing a

sketch illustrating the portion of the finger injured but omitting crucial information regarding the depth of the injury and whether bone was affected.

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 hand/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 any case listed by workers' compensation as an amputation should have been linked to a medical record but was not, it was counted more than once.

### Conclusions

This surveillance system, which uses hospital reporting and workers' compensation claims data, provides a 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 by the decreasing number and rate of amputations since 2006. 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, 2009**

Age Group	Male		Female		Total	
	Number	Rate	Number	Rate	Number	Rate
16-19	17	19.1	4	*	21	11.5
20-24	32	15.5	1	*	33	7.9
25-34	104	24.7	6	1.6	110	13.8
35-44	90	18.0	13	2.8	103	10.8
45-54	108	18.8	24	4.5	132	12.0
55-64	65	21.0	7	2.2	72	11.5
65+	17	19.1	3	*	20	12.1
<b>Total</b>	<b>433</b>	<b>19.8</b>	<b>58</b>	<b>2.8</b>	<b>491</b>	<b>11.5</b>

\* Statistically stable rate could not be calculated.

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, 2009**

Race	Hispanic Ethnicity			Total
	Yes	No	Unknown	
White	0	0	239	239
Black	0	0	24	24
Other	0	0	5	5
Unknown	27	0	196	223
<b>Total</b>	<b>27</b>	<b>0</b>	<b>464</b>	<b>491</b>

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

TABLE A-3  
 Work-related single-finger amputation incidents (N=369)  
 by injured hand and amount of finger lost  
 Michigan residents, 2009

Hand	Finger	Section Lost				Total
		Distal Phalanx	Middle Phalanx	Proximal Phalanx	Unknown	
Right	Thumb	29		2	0	31
	Index	45	5	2	3	55
	Middle	50	2	0	1	53
	Ring	15	1	0	0	16
	Little	20	3	1	1	25
Left	Thumb	40		3	0	43
	Index	43	7	2	2	54
	Middle	47	2	0	1	50
	Ring	22	0	0	0	22
	Little	15	1	1	1	18
Total		326	21	11	9	369

Total includes two cases for which the injured side was unknown.  
 Data Source: Michigan hospital/ED medical records

TABLE A-4  
 Work-related multiple-finger amputation incidents (N=56)  
 by injured hand and amount of finger lost  
 Michigan residents, 2009

Hand	Finger	Section Lost				Total
		Distal Phalanx	Middle Phalanx	Proximal Phalanx	Unknown	
Right	Thumb	0		2	0	2
	Index	3	3	1	0	7
	Middle	10	3	2	0	15
	Ring	7	4	3	0	14
	Little	1	4	2	0	7
Left	Thumb	1		2	0	3
	Index	12	3	4	3	22
	Middle	16	5	1	3	25
	Ring	15	2	4	2	23
	Little	4	1	4	2	11
Total		69	25	25	10	129

Data Source: Michigan hospital/ED medical records