

Work-Related Amputations Michigan 2017

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MICHIGAN STATE

U N I V E R S I T Y

**MICHIGAN DEPARTMENT OF
LABOR AND ECONOMIC OPPORTUNITY**

Work-Related Amputations in Michigan, 2017

A Joint Report of the

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Executive Summary

The Division of Occupational and Environmental Medicine (OEM) at Michigan State University (MSU) and the Michigan Department of Health and Human Services (MDHHS) monitor work-related amputations in Michigan. Michigan hospitals are required to report work-related amputations and serve as the main case-finding source. The MSU OEM Division also uses Michigan Department of Labor and Economic Opportunity (LEO) Workers' Disability Compensation Agency (WDCA) claims to identify additional cases. When the MSU OEM Division identifies potential workplace hazards through surveillance data, that information is shared with the Michigan Occupational Safety and Health Administration (MIOSHA) to determine if a worksite inspection is necessary. Surveillance data is also used to describe trends and identify workers and industries with high amputation risks. This report describes work-related amputations that occurred in 2017. Key results include:

- Hospitals were the primary data source for 84.3 percent of cases in 2017. The remaining 15.7 percent of cases were found only through the WDCA.
- The system found 427 work-related amputations that occurred in Michigan (10.1 per 100,000 employed persons).
- From 2006 to 2017, the number of work-related amputations fell 42.9 percent and the rate fell 43.8 percent.
- The amputation rate was over six times higher among male workers compared to female workers.
- Roughly two out of five work-related amputations occurred in the manufacturing industry. Among all manufacturing sectors, wood products manufacturing had the highest rate of work-related amputations.
- The leading cause of work-related amputations was pinching between objects, causing 16.9 percent of amputations.
- Most (89.5 percent) amputations involved fingers. Almost one in six (16.1 percent) finger amputations involved multiple fingers.
- The expected payer for medical treatment was workers' compensation for 73.3 percent of cases with available medical records.
- The Michigan Occupational Safety and Health Administration (MIOSHA) inspected 18 worksites and assessed an average of 2.1 violations and \$5,861 in penalties per worksite.

By combining data from both medical records and workers' compensation claims, the system provides a more accurate estimate of the number of amputations that occur in Michigan than other sources. In 2017, the surveillance system found 317 more amputation cases than the official Bureau of Labor Statistics (BLS) Survey of Occupational Injuries and Illnesses (SOII) estimate of 110.

Introduction

This report represents the 11th annual report of work-related amputations in Michigan from the MSU OEM Division. Amputations are one of the most debilitating injuries that can occur in the workplace, resulting in the loss of function of the affected body part in many cases. Following an amputation, workers may have to make serious physical and psychological adjustments both in the workplace and their personal lives.

The BLS estimates that there were 4,660 amputations involving days away from work nationwide in 2017. Workers lost a median of 22 workdays for amputation cases compared to nine for all work-related injuries.¹ The Council of State and Territorial Epidemiologists (CSTE) along with the National Institute for Occupational Safety and Health (NIOSH) have established the reduction of work-related amputations as a national public health priority.²

The MSU OEM Division began reviewing hospital records for amputations in 2004. The MSU OEM Division works closely with MIOSHA to ensure that appropriate follow-up occurs for cases identified by the surveillance system that were either not previously reported to MIOSHA or where there is evidence that workplace hazards need to be addressed. Only cases referred to MIOSHA were tracked until 2006 when a comprehensive surveillance system was established to track all work-related amputations occurring in Michigan.³ The new surveillance system obtained data from the Michigan WDCA to help provide a more complete count of work-related amputations. This report summarizes work-related amputations identified by this surveillance system for 2017.

Data Sources

Work-related amputation cases were identified through medical records submitted by Michigan hospitals to the MSU OEM Division, as required by the Michigan Public Health Code.⁴ MSU acts as MDHHS's bona fide agent to oversee this requirement.

The Michigan LEO WDCA provided access to wage replacement claims data under a Memorandum of Understanding Agreement. A worker must miss more than seven or more consecutive days of work (i.e., five weekdays and two weekend days) or experience "specific losses" to qualify for wage replacement. A specific loss includes amputations of at least a full phalanx (the bone of a finger or toe).

MIOSHA inspection reports provided information on the number of violations and total penalties for worksites that were inspected based on data captured in the surveillance system.

The number of workers employed in Michigan by age, sex, and industry was estimated using the Quarterly Workforce Indicators (QWI).⁵ The QWI utilizes data from the Longitudinal Employer-Household Dynamics (LEHD) linked employer-employee microdata. The BLS Local Area Unemployment Statistics (LAUS) system, which is based on the Current Population Survey, BLS Current Employment Statistics program, and state unemployment insurance system data, provides the number of employed Michigan residents by county.⁶

Methods

Cases identified by hospital medical records were included if they:

- Received medical treatment at a Michigan hospital or emergency department.
- Had at least one of the following diagnosis codes assigned at any level of diagnostic priority in the medical record: S48, S58, S68, S78, S88, or S98 per the International Classification of Diseases, Tenth Revision, Clinical Modification (ICD-10-CM).⁷
- Sustained the amputation at work in 2017.

Cases identified from WDCA claims were included if they:

- Had an accepted claim for lost worktime wage replacement related to a work-related amputation occurring in 2017.

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

Information abstracted from medical records included the hospital name, date of admission, date of discharge, patient demographics, city and county of residence, primary source of payment, employer name, employer address, North American Industry Classification System (NAICS)⁸ code, injury date, body part amputated, ICD-10-CM code(s), and cause of injury. MSU staff attempted to interview patients by phone if medical records lacked information on where the injury occurred, who the employer was, or other important details.

Once medical record abstraction and patient interviews were complete, records were linked to the workers' compensation claims database to deduplicate cases and obtain more complete information on the case demographic characteristics (e.g. age, sex), employer industry, and the area of the body that was affected by the amputation, if missing from the medical record.

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

After linkage attempts were completed, cases fell into one of the following five categories: 1) workers' compensation amputation injury case matched with a work-related amputation medical record; 2) workers' compensation amputation injury case that could not be matched with an amputation medical record; 3) workers' compensation non-amputation injury case matched with a work-related amputation medical record; 4) workers' compensation non-amputation injury

case that could not be matched with a work-related amputation medical record; and 5) Work-related amputation medical record without a match to workers' compensation.

Rates were calculated by sex, age group, and type of industry by dividing the number of workers that experienced an amputation by the number of persons employed in Michigan within each category and multiplying the result by 100,000. Rates by county of residence were calculated by dividing the number of Michigan residents who sustained a work-related amputation in each county by the number of employed persons residing in each county and multiplying the result by 100,000. Rates were not calculated when the relative standard error (RSE) was 40 percent or greater due to statistical unreliability. The RSE was calculated by dividing the standard error of a rate by the rate.

MIOSHA reviewed cases if the worksite was in Michigan and the amputation was potentially caused by a mechanical power press* or other hazard likely to be found in an inspection. MIOSHA did not review cases when the cause of injury was vaguely described in medical records (e.g., "pinched between objects"). For cases inspected by MIOSHA, additional information including the inspection date, number of violations, number of violations related to the identified hazard, whether hazards had been fixed at the time of the inspection, power press violations, and total fines assessed were collected by the MSU OEM Division. Data provided by the Michigan WDCA is restricted to surveillance and cannot be used for enforcement purposes, therefore cases found exclusively in workers' compensation records were not reviewed by MIOSHA.

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

Results

All 134 acute care hospitals, including the four Veteran's Administration (VA) medical centers in Michigan complied with the reporting requirement. Eighty-nine hospitals submitted medical records for potential work-related amputations and 45 facilities reported that they had no eligible cases. The MSU OEM Division received and reviewed 916 medical records. Project staff completed 9 interviews to determine work-relatedness and/or employer information.

In 2017, project staff initially determined 371 records met eligibility criteria, however 11 records were for additional visits related to a single injury, leaving 360 unique cases. Nearly all workers (96.9 percent) were Michigan residents (Table 1).

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

TABLE 1: Number and Percent of Workers Treated for an Amputation at a Michigan Hospital, 2017

Worker Residency and Healthcare Utilization	Number	Percent
1) Michigan residents	349	96.9%
a) One visit	338	93.9%
b) Multiple visits [†]	11	3.1%
2) Out-of-state resident	*	*
a) One visit	*	*
b) Multiple visits [†]	0	0.0%
3) Unknown state of residence	*	*
a) One visit	*	*
b) Multiple visits [†]	0	0.0%

**Number was suppressed if the count was between 1 and 5 or if listing the result provided sufficient information to calculate a suppressed count to protect the confidentiality of individuals.*

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

Data source: Michigan hospital medical records

Table 2 displays the number of cases ascertained by each data source and the results of the matching process. The workers' compensation database contained 147 claims for lost work time due to an amputation injury that were either paid, partially paid, or expected to be paid by the end of 2017.

TABLE 2: Results of Matching Work-Related Amputation Cases Ascertained from Hospital Medical Records and workers' compensation Claims, 2017

workers' compensation Database Inclusion	Case Matched to Work-Related Amputation Medical Record		Total
	Yes	No	
Yes, with amputation injury	80	67	147
Yes, with non-amputation injury	83	20,177	20,260
No	197	0	197
Total	360	20,244	20,604

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

Of the 147 workers' compensation claims for an amputation injury, 80 (54.4 percent) matched an amputation medical record and 67 (45.6 percent) could not be linked to a medical record. Of the 360 amputation cases identified through medical records and documented as work-related, 80 (22.2 percent) were matched to a workers' compensation claim for an amputation injury, 83 (23.1 percent) were matched to workers' compensation claim for a non-amputation injury (e.g., crush, laceration), and 197 (54.7 percent) could not be linked to a workers' compensation claim.

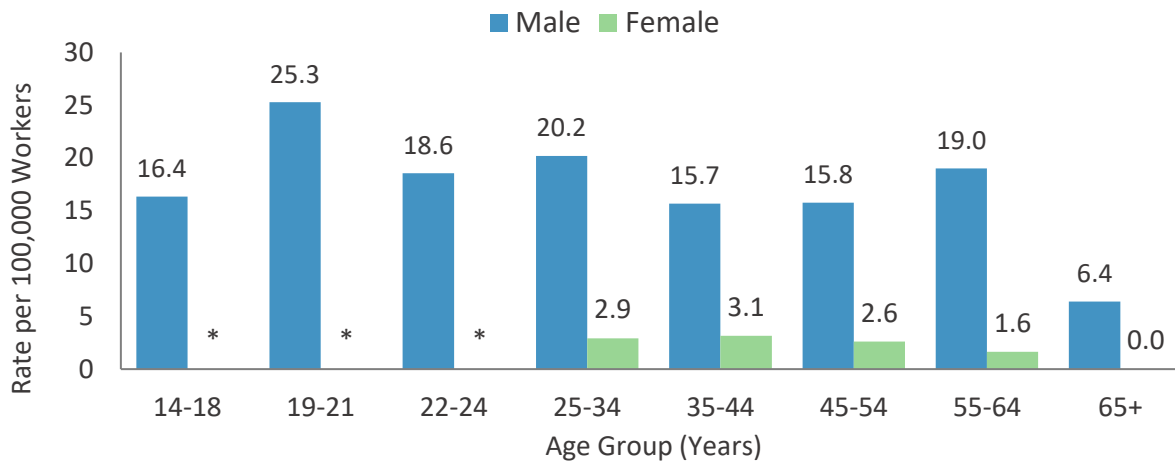
Combining the 360 work-related cases identified through medical records with the 67 that were identified only within the workers' compensation database gave a total of 427 work-related amputations, corresponding to a rate of 10.1 amputations per 100,000 workers.

Characteristics of Injured Workers

Age and Sex

Males comprised 87.1 percent of workers who had a work-related amputation. Rates were highest for males aged 19-21 years. Among females, rates were highest for those aged 35-44 years. Figure 1 displays amputation rates by age group and sex. (see Table A-1 in Appendix A.)

FIGURE 1: Work-Related Amputation Rates (per 100,000) Occurring in Michigan by Age Group and Sex, 2017



* Rates are suppressed if the count is between 1 and 5 because rates are not statistically reliable. Rates are also not calculated when the RSE is 40% or greater.

Data Sources: Number of amputations – Michigan hospital medical records and Michigan Department of LEO WDCA; Number of workers - 2017 Quarterly Workforce Indicators (QWI), U.S. Census Bureau.

Race and Hispanic Ethnicity

Medical records were missing information on race for 175 patients (48.9 percent) and missing information on ethnicity for 273 patients (75.8 percent). Workers' compensation claims do not collect data on race and ethnicity, therefore the race and ethnicity of individuals identified only through Worker's Compensation claims could not be determined (see Table A-2 in Appendix A). Due to the level of missing information, rates for racial/ethnic groups were not calculated.

Body Part and Severity

As shown in Table 3, most workers (89.5 percent) sustained finger amputations. Medical records, which provide more detail than workers' compensation claims, were available for 322 finger amputation cases. Of the 322 finger amputation incidents, 52 (16.1 percent) involved multiple fingers. Table 4 displays the distribution of digit(s) and section(s) lost among all finger amputations. The distal phalanx was the most commonly amputated section, accounting for 78.8 percent of finger amputations.

TABLE 3: Number and Percent of Work-Related Amputations Occurring in Michigan by Injured Body Part, 2017

Amputated body part	Number of Workers	Percent
Finger	382	89.5%
Hand	10	2.3%
Arm	*	*
Unspecified upper extremity	24	5.6%
Toe	*	*
Foot	*	*
Leg	*	*
Unspecified lower extremity	0	0.0%
Other	*	*
Total	427	100.0%

*Number was suppressed if the count was between 1 and 5 or if listing the result provided sufficient information to calculate a suppressed count to protect the confidentiality of individuals.

Data Sources: Michigan hospital medical records and Michigan Department of LEO WDCA

TABLE 4: Number and Percent of Work-Related Finger Amputations Occurring in Michigan by Digit and Section of Finger Lost, 2017[†]

Digit	Section	Number of Amputations	Percent
Little	Distal	32	8.5%
Little	Middle	*	*
Little	Proximal	*	*
Little	Unknown	0	0.0%
Ring	Distal	21	5.6%
Ring	Middle	*	*
Ring	Proximal	*	*
Ring	Unknown	*	*
Middle	Distal	75	19.9%
Middle	Middle	*	*
Middle	Proximal	*	*
Middle	Unknown	*	*
Index	Distal	74	19.6%
Index	Middle	11	2.9%
Index	Proximal	*	*
Index	Unknown	*	*
Thumb	Distal	41	10.9%
Thumb	Proximal	*	*
Thumb	Unknown	*	*
Unknown	Distal	54	14.3%
Unknown	Middle	12	3.2%
Unknown	Proximal	24	6.4%
Unknown	Unknown	*	*
Total	All	377	100.0%

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

*Number was suppressed if the count was between 1 and 5 or if listing the result provided sufficient information to calculate a suppressed count to protect the confidentiality of individuals.

Data Source: Michigan hospital medical records

Case Study One

A 27-year-old male working in a paper mill was attempting to remove paper from a paper press when his arm became trapped between two rollers, resulting in the amputation of two fingers and an avulsion injury to his arm. MIOSHA inspected the worksite and found the employer had failed to ensure a barrier at the nip point of the machine the employee had been injured by. MIOSHA issued a \$1,750 fine for the serious violation of general industry safety and health standards related to the injury.

County of Residence

Table 5 displays the number of work-related amputations and rate per 100,000 workers by county of residence for individuals with Michigan residency. Rates were not calculated for residents of other states. These data do not necessarily reflect the counties with the highest risk worksites because workers may be employed outside their county of residence. Eighteen counties had no residents with work-related amputations and 45 had too few to calculate statistically valid rates. Wexford County had the highest rate (50.1 per 100,000 workers). Among the 20 most populous counties in the state, Allegan County had the highest rate (20.3 per 100,000) while Oakland County had the lowest (3.1 per 100,000).

TABLE 5: Number and Rate (per 100,000) of Work-Related Amputations among Michigan Residents by County of Residence, 2017[†]

County	Number	Rate per 100,000	County	Number	Rate per 100,000	County	Number	Rate per 100,000
Alcona	*	*	Hillsdale	*	*	Monroe	7	9.7
Alger	0	0.0	Houghton	0	0.0	Montcalm	6	*
Allegan	12	20.3	Huron	0	0.0	Montmorency	*	*
Alpena	*	*	Ingham	10	6.9	Muskegon	9	12.2
Antrim	*	*	Ionia	*	*	Newaygo	*	*
Arenac	*	*	Iosco	0	0.0	Oakland	20	3.1
Baraga	0	0.0	Iron	*	*	Oceana	*	*
Barry	*	*	Isabella	0	0.0	Ogemaw	*	*
Bay	*	*	Jackson	14	19.8	Ontonagon	0	0.0
Benzie	*	*	Kalamazoo	14	11.0	Osceola	*	*
Berrien	9	12.8	Kalkaska	*	*	Oscoda	0	0.0
Branch	*	*	Kent	27	7.9	Otsego	*	*
Calhoun	8	13.2	Keweenaw	*	*	Ottawa	13	8.5
Cass	0	0.0	Lake	*	*	Presque Isle	*	*
Charlevoix	0	0.0	Kent	6	*	Roscommon	*	*
Cheboygan	*	*	Lapeer	0	0.0	Saginaw	*	*
Chippewa	0	0.0	Leelanau	*	*	Saint Clair	7	9.8
Clare	0	0.0	Lenawee	*	*	Saint Joseph	*	*
Clinton	*	*	Livingston	0	0.0	Sanilac	*	*
Crawford	*	*	Luce	0	0.0	Schoolcraft	*	*
Delta	*	*	Mackinac	33	7.8	Shiawassee	*	*
Dickinson	*	*	Macomb	0	0.0	Tuscola	*	*
Eaton	*	*	Manistee	*	*	Van Buren	*	*
Emmet	*	*	Marquette	*	*	Washtenaw	6	*
Genesee	14	8.2	Mason	*	*	Wayne (incl. Detroit)	69	9.2
Gladwin	*	*	Mecosta	0	0.0	Detroit	27	12.0
Gogebic	*	*	Menominee	0	0.0	Wexford	7	50.1
Grand Traverse	6	*	Midland	*	*	Unknown	10	n/a
Gratiot	*	*	Missaukee	*	*	Michigan total	414	8.9

*Numbers and rates are suppressed if the count is between 1 and 5 or if listing the result allows the calculation of the suppressed count to protect the confidentiality of individuals and because rates are not statistically reliable. Rates are also not calculated when the RSE is 40% or greater.

†Does not include 13 work-related amputation cases with out-of-state residency

Data Sources: Number of amputations – Michigan hospital medical records and Michigan Department of LEO WDCA; Number of workers used to calculate rates – BLS Local Area Unemployment Statistics.

Causes of Amputations

Table 6 displays the number and percent of work-related amputations by cause. Pinching between objects accounted for the largest proportion of amputation cases (16.9 percent), followed by power saws (e.g., table saws, miter saws) which caused 13.1 percent of work-related amputations. Presses caused roughly one in 14 work-related amputations. Other types of machinery, many of which were not specified, caused 14.8 percent of amputations. The cause of amputation was unknown for 20.6 percent of cases, including all cases identified only through workers' compensation claims.

TABLE 6: Number and Percent of Work-Related Amputations Occurring in Michigan by Cause of Injury, 2017

Cause of injury	Number	Percent
Power saw	56	13.1%
Knife	16	3.7%
Food slicer	8	1.9%
Lawn mower	0	0.0%
Other sharp object	9	2.1%
Press	30	7.0%
Pinched between objects	72	16.9%
Struck by falling object	14	3.3%
Struck by object – other	*	*
Caught in chain, pulley, gears, or belt	28	6.6%
Grinder	0	0.0%
Forklift/Hi-lo	*	*
Machine – other specified type	39	9.1%
Machine – other unspecified type	24	5.6%
Other specified cause	35	8.2%
Unspecified or unknown cause	88	20.6%
Total	427	100.0%

**Numbers and percentages were suppressed if the count was between 1 and 5 or if listing the result provided sufficient information to calculate a suppressed count to protect the confidentiality of individuals. Data Source: Michigan hospital medical records and Michigan Department of LEO WDCA*

Industry

Table 7 shows the number and rate of work-related amputations by industry. There were 78 cases without enough detail to make an industry classification. Only 35.3 percent of self-employed workers had industry information listed. Among main industry sectors, the Agriculture, Forestry, Fishing, and Hunting industry had the highest rate of amputations (55.0 per 100,000 workers) and the crop and animal production subsector accounted for 81.3 percent of amputations in this category. The greatest proportion (40.5 percent) of amputations occurred in the Manufacturing Industry. The wood products manufacturing subsector had a considerably higher rate (148.6 per 100,000) than other manufacturing subsectors.

TABLE 7: Number and Rate (per 100,000) of Work-Related Amputations Occurring in Michigan by Industry, 2017

NAICS Code	Industry Classification	Number	Rate per 100,000
11	Agriculture, forestry, fishing and hunting	16	55.0
111-112	Crop and animal production	13	53.8
21	Mining, quarrying, and oil and gas extraction	*	*
22	Utilities	0	0.0
23	Construction	39	23.3
31-33	Manufacturing	173	28.3
311	Food manufacturing	8	20.9
321	Wood products manufacturing	15	148.6
326	Plastics and rubber products manufacturing	8	20.0
331	Primary metal manufacturing	9	41.8
332	Fabricated metal product manufacturing	38	47.2
333	Machinery manufacturing	26	35.4
336	Transportation equipment manufacturing	21	11.5
42	Wholesale trade	18	10.4
44-45	Retail trade	24	5.2
48-49	Transportation and warehousing	11	9.1
51	Information	0	0.0
52	Finance and insurance	0	0.0
53	Real estate and rental and leasing	*	*
54	Professional, scientific, and technical services	6	*
55	Management of companies and enterprises	0	0.0
56	Administrative and support and waste management and remediation services	8	2.8
61	Educational services	*	*
62	Health care and social assistance	8	1.2
71	Arts, entertainment, and recreation	*	*
72	Accommodation and food services	26	6.7
722	Restaurants, food service and drinking places	21	6.2
81	Other services (except public administration)	6	*
92	Public administration	*	*
99	Unknown	78	n/a
NA	Total	427	10.1

**Numbers and rates are suppressed if the count is between 1 and 5 or if listing the result allows the calculation of the suppressed count to protect the confidentiality of individuals and because rates are not statistically reliable. Rates are also not calculated when the RSE is 40% or greater.*

Data Sources: Number of amputations – Michigan hospital medical records and Michigan Department of LEO WDCA; Number of workers by industry used to calculate rates: –2017 Quarterly Workforce Indicators (QWI), U.S. Census Bureau.

Source of Payment

As shown in Table 8, workers' compensation was the expected payer in 73.3 percent of the 360 cases with a medical record. Payment source could not be determined for 30 cases with medical records. Among the 96 cases which did not have workers' compensation listed as a payment source in medical records, 26 were linked to workers' compensation claims. Although self-employed individuals are not eligible for workers' compensation, two individuals who were

described as self-employed in their medical record had workers' compensation listed as the expected payer.

TABLE 8: Number and Percent of Work-Related Amputations Occurring in Michigan by Payment Source, 2017

	Number	Percent
Workers' compensation	264*	73.3%
Commercial insurance	28	7.8%
Other	38	10.6%
Not specified	30	8.3%
Total	360	100.0%

*Includes two individuals that were described as self-employed in their medical record

Data Source: Michigan hospital medical records

Case Study Two

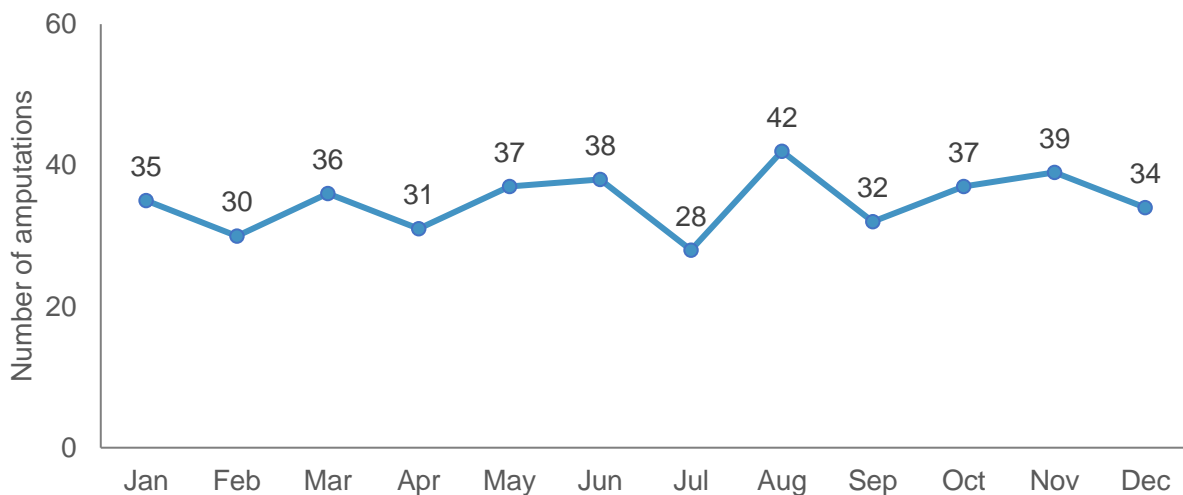
A 44-year-old male employee of a plastics manufacturing facility was attempting to change a cutting blade on a machine. However, the power source of the machine was not locked out and started unexpectedly, resulting in the amputation of the distal portion of the employee's little finger. MIOSHA inspected the facility and found a serious violation related to the injury. The company was also cited for not reporting the amputation injury to MIOSHA within 24 hours of the incident. MIOSHA assessed a total penalty of \$12,000 for these two violations.

Trends

Incidents by Month

Work-related amputations occurred most frequently during August and November and were least frequent during July, February, and April (Figure 2). There did not appear to be any seasonality to amputation events.

FIGURE 2: Number of Work-Related Amputations Occurring in Michigan by Month, 2017*



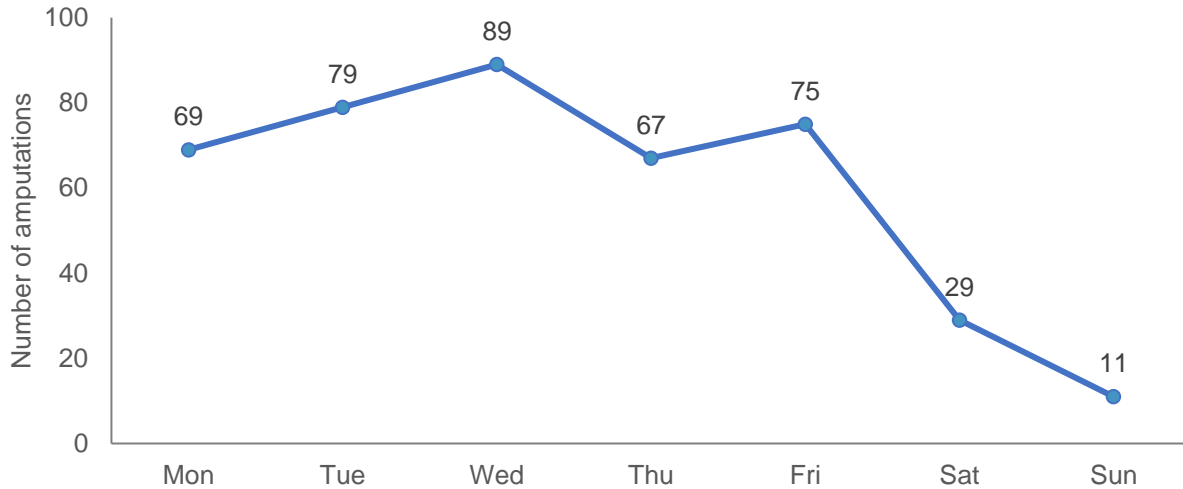
*Excludes eight work-related amputations cases with an unknown date of injury

Data Sources: Michigan hospital medical records and Michigan Department of LEO WDCA

Incidents by Day of Week

Amputations occurred most frequently on Wednesday and were least frequent during weekend days (Figure 3).

FIGURE 3: Number of Work-Related Amputations Occurring in Michigan by Day of the Week, 2017*



**Excludes eight work-related amputations cases with an unknown date of injury*

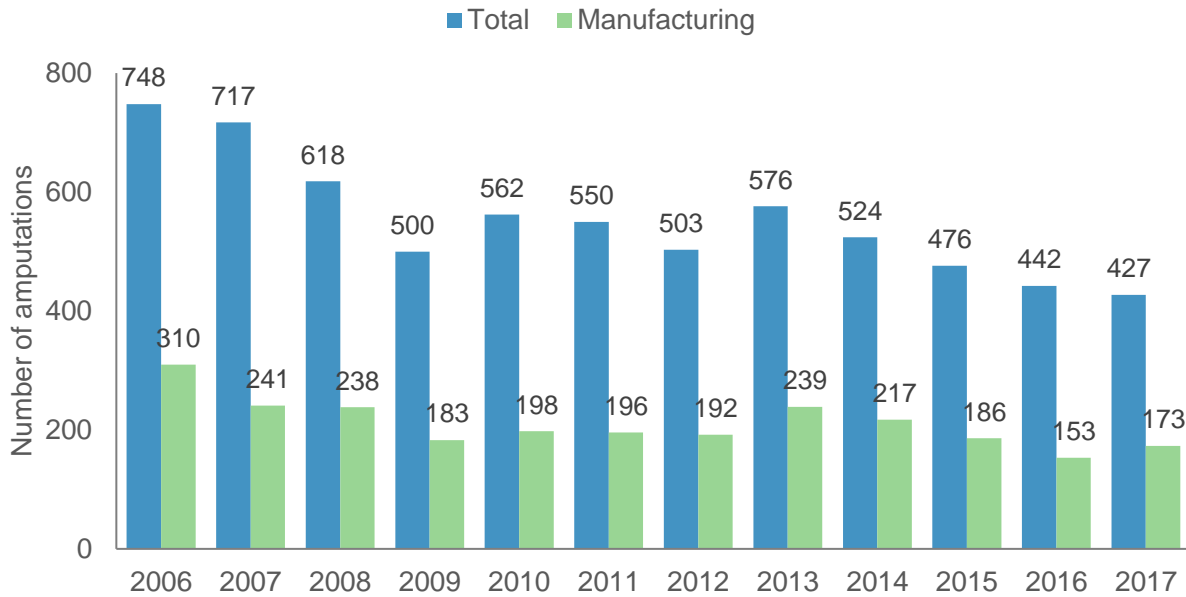
Data Sources: Michigan hospital medical records and Michigan Department of LEO WDCA

Amputations by Year

The annual number of cases has decreased by 42.9 percent during the 12 years the surveillance system has been in place, from 748 in 2006 to 427 in 2017 (Figure 4). The decline in the number of amputations could be partially explained by lower employment overall in Michigan; however, total employment decreased by only 1.9 percent over the 12-year period and has rebounded since 2012, whereas the number of amputations continued a steady decline. The rate of amputations also fell from 18.0 per 100,000 employed persons in 2006 to 10.1 per 100,000 employed persons in 2017, representing a 43.8 percent decline (Figure 5).

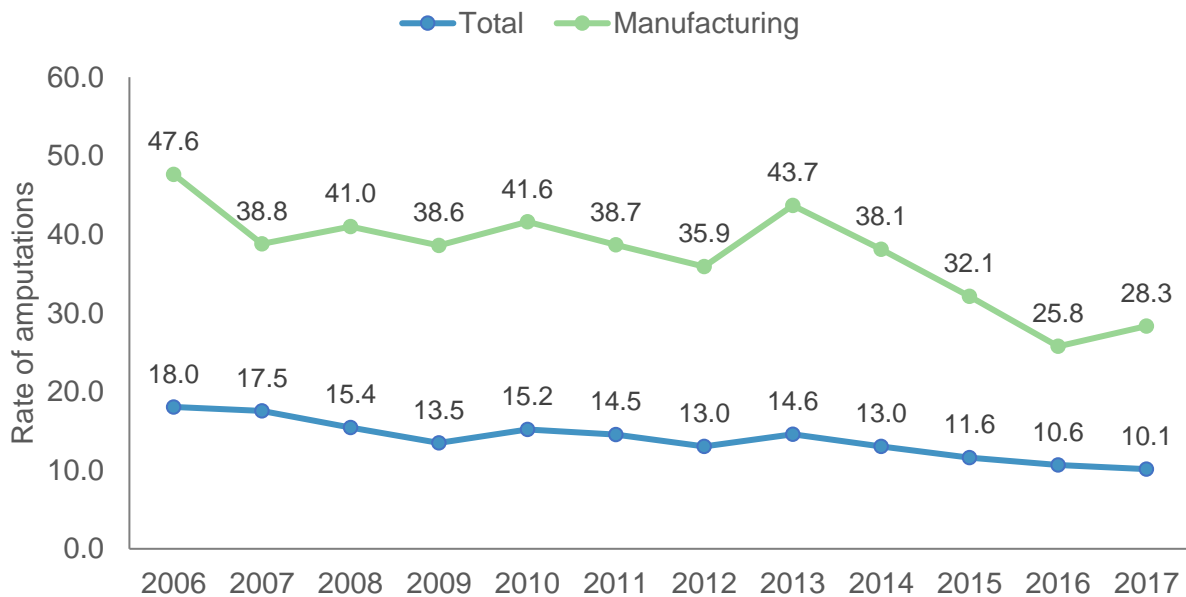
Figures 4 and 5 also display the annual number of cases and rates, respectively for the manufacturing industry, where the greatest number of amputations occurred. The number and rate of manufacturing-related amputations peaked in 2006 and then declined until an uptick during 2013. The rate of manufacturing-related amputations declined annually from 2013 through 2016 but increased by 10.1 percent in 2017.

FIGURE 4: Annual Number of Work-Related Amputations Occurring in Michigan by Year, Total and for the Manufacturing Industry, 2006-2017



Data Sources: Number of amputations – Michigan hospital medical records and Michigan Department of LEO WDCA

FIGURE 5: Annual Rate (per 100,000) of Work-Related Amputations Occurring in Michigan by Year, Total and for the Manufacturing Industry, 2006-2017



Data Sources: Number of amputations – Michigan hospital medical records and Michigan Department of LEO WDCA; Number of workers by industry used to calculate rates: –2017 Quarterly Workforce Indicators (QWI), U.S. Census Bureau.

MIOSHA Reviews

MIOSHA inspected 18 worksites identified through the surveillance system. Table 9 summarizes the number of violations found in these inspections. The number of violations ranged from zero to five. Table 11 shows the distribution of assessed penalties. There was no penalty issued for one company. The maximum penalty was \$19,000 and the median was \$3,600. MIOSHA cited two companies for hydraulic press violations and one company for mechanical press violations. Of the 17 companies cited, only one had fully corrected the hazard thought to be the cause of the amputation at the time of the inspection, which was three to six months after the amputation.

TABLE 9: Violations Identified in MIOSHA Worksite Inspections, 2017

Number of Violations	Number of Inspections	Percent
0	1	5.6%
1	5	27.8%
2	6	33.3%
3	5	27.8%
4	0	0.0%
5	1	5.6%
Total	18	100.0%

Data Source: MIOSHA inspection reports

TABLE 10: Penalties Assessed in MIOSHA Worksite Inspections, 2017

Penalty Assessed	Number of Inspections	Percent
\$0	1	5.6%
\$1 - \$999	1	5.6%
\$1,000 - \$9,999	11	61.1%
\$10,000 - \$19,000	5	27.8%
Total	18	100.0%

Data Source: MIOSHA inspection reports

Discussion

The Michigan work-related amputation surveillance system provides information on the demographic and industry characteristics of affected workers, helping to identify high-risk occupational groups and industries. Surveillance data is used to understand trends and to uncover the leading causes of work-related amputations. The work-related amputation surveillance system also provides critical information to MIOSHA on the circumstances surrounding unreported workplace injuries. The surveillance system supports MIOSHA's 2014-2018 Strategic Plan objectives related to reducing the rate of worker injuries in high-hazard industries.⁹ In 2017, the work-related amputation surveillance system led to 18 MIOSHA worksite inspections.

The Michigan work-related amputation surveillance system has consistently identified a greater number of cases than the BLS SOII. In 2017, the state-based surveillance system detected 317 more cases than BLS SOII. The state-based system has several important advantages over the BLS SOII, including the inclusion of self-employed workers and workers with no lost work time due to their injury. Additionally, the BLS SOII is an estimate based on a random selection of employers and is influenced by how closely the selected employers represent all employers and

the accuracy of employer responses.[†] The state-based surveillance system is not subject to sampling bias because it is designed to capture a census of all work-related amputations.

The accuracy of injury classification is likely better in the state-based surveillance system than the BLS SOII due to the availability of medical records for most cases whereas the BLS SOII must rely on the employer's designation of the injury type. The state-based surveillance system is also equipped to perform worker interviews in cases where there is uncertainty about the injury type or the work-relatedness of an amputation injury.

An additional strength of the state-based surveillance system is its ability to quickly identify potential workplace hazards and share data with MIOSHA. These data are used to support inspection and follow-up activities needed to reduce the risk of further worker injuries. Hospitals submit records to the MSU OEM quarterly, allowing MIOSHA to inspect most worksites with potential injury hazards within six months of the amputation.

Limitations

Despite the advantages of the Michigan work-related amputation surveillance system over the BLS SOII, there are several limitations that potentially impact the ability of the state-based surveillance system to identify all eligible cases. For example, hospitals may not submit all eligible amputation cases if the medical record did not document that the injury was work-related. An analysis of 2017 Michigan Inpatient and Outpatient Databases (MIDB, MODB)[‡] identified 60 additional potentially eligible cases among the 45 hospitals that reported no work-related amputations. It is undetermined if any of these cases were identified through the workers' compensation Database due to lack of personally identifying information.

Other work-related amputation cases may not have been identified if the injury was not assigned an amputation ICD-10-CM code in the medical record, such as amputation injuries that are incorrectly coded as a crush or laceration injury. An analysis of the Michigan work-related amputation surveillance system in 2014 found that the number of work-related amputations would have increased by 3.5 percent if all improperly coded laceration and crush injuries been accurately coded as amputations.¹⁰

Work-related amputation cases may also be missed if workers exclusively receive medical treatment at an out-of-state hospital because hospitals outside Michigan are not required to report amputations to the MSU OEM Division. MIDB and MODB data can be used to estimate the number of amputations not identified for this reason because these data contain records of Michigan residents treated at out-of-state hospitals; however, in 2017, no Michigan residents were treated for an amputation at an out-of-state hospital with workers' compensation listed as a primary or secondary payer.

Lastly, the state-based surveillance system does not capture cases that do not receive any hospital-based medical treatment and that do not submit a workers' compensation claim for wage replacement. This limitation most likely affects workers with less severe amputation

[†]Prior to 2011, BLS required bone loss to classify an injury as an amputation. However, the degree of undercounting of work-related amputation injuries compared to the Michigan-based surveillance system did not substantially improve after the removal of this criteria in 2011.

[‡]The MIDB includes inpatient admissions. The MODB includes emergency visits and outpatient procedures. Six acute care hospitals in Michigan (4.4 percent) did not submit emergency department visit data to MHA in 2017.

injuries who only receive medical care in a non-hospital setting such as an urgent care clinic, and workers who are not eligible for workers' compensation, such as the self-employed, federal employees and railroad workers.

In addition to factors that impact sensitivity, there are limitations related to the specificity and completeness of medical record and workers' compensation claim data. Medical records often did not document the specific cause of the amputation injury. Medical records also often lacked information on the patient's employer or industry, and many did not include information on the patient's race and Hispanic ethnicity. Workers' compensation claims do not collect information on the cause of injury or the worker's race and ethnicity, and many lacked detailed injury descriptions (e.g., single vs. multiple digit loss, specified digit injured). Thus, analyses of these characteristics excluded cases with only workers' compensation data.

Conclusions

The Michigan work-related amputation surveillance system leverages both hospital reporting and workers' compensation claims data, providing a more accurate number of work-related amputations than the official estimate based on the employer-based reporting system maintained by the BLS. In addition, the state-based surveillance system is used for public health interventions to find and reduce workplace amputation hazards. Progress continues to be made in reducing the risk of work-related amputations, evidenced by the decrease in the number and rate of work-related amputations since 2006. The state-based surveillance system provides a vital role in reducing workplace hazards by supporting MIOSHA's inspection activities and by identifying risk factors associated with work-related amputations to target public health interventions.

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Appendix A: Additional Data Tables and Figures

TABLE A-1: Number and Rate (per 100,000) of Work-Related Amputations among Michigan Residents by Age and Sex, 2017

	Male Number	Male Rate	Female Number	Female Rate	Total Number	Total Rate
14-18	*	16.4	*	*	10	9.4
19-21	*	25.3	*	*	30	13.8
22-24	*	18.6	*	*	28	10.7
25-34	95	20.2	13	2.9	108	11.8
35-44	67	15.7	13	3.1	80	9.5
45-54	73	15.8	12	2.6	85	9.2
55-64	71	19.0	6	1.6	77	10.4
65+	7	6.4	0	0.0	7	3.4
Unknown	*	n/a	0	n/a	*	n/a
Total	372	17.5	54	2.6	427	10.1

**Numbers and rates are suppressed if the count is between 1 and 5 or if listing the result allows the calculation of the suppressed count to protect the confidentiality of individuals and because rates are not statistically reliable. Rates are also not calculated when the RSE is 40% or greater.*

Gender was unspecified for two cases (age 65+ and unknown age).

Data Sources: Number of amputations – Michigan hospital medical records and Michigan Department of LEO, WDCA; Number of workers employed by age group used to calculate rates 2017 Quarterly Workforce Indicators (QWI), U.S. Census Bureau.

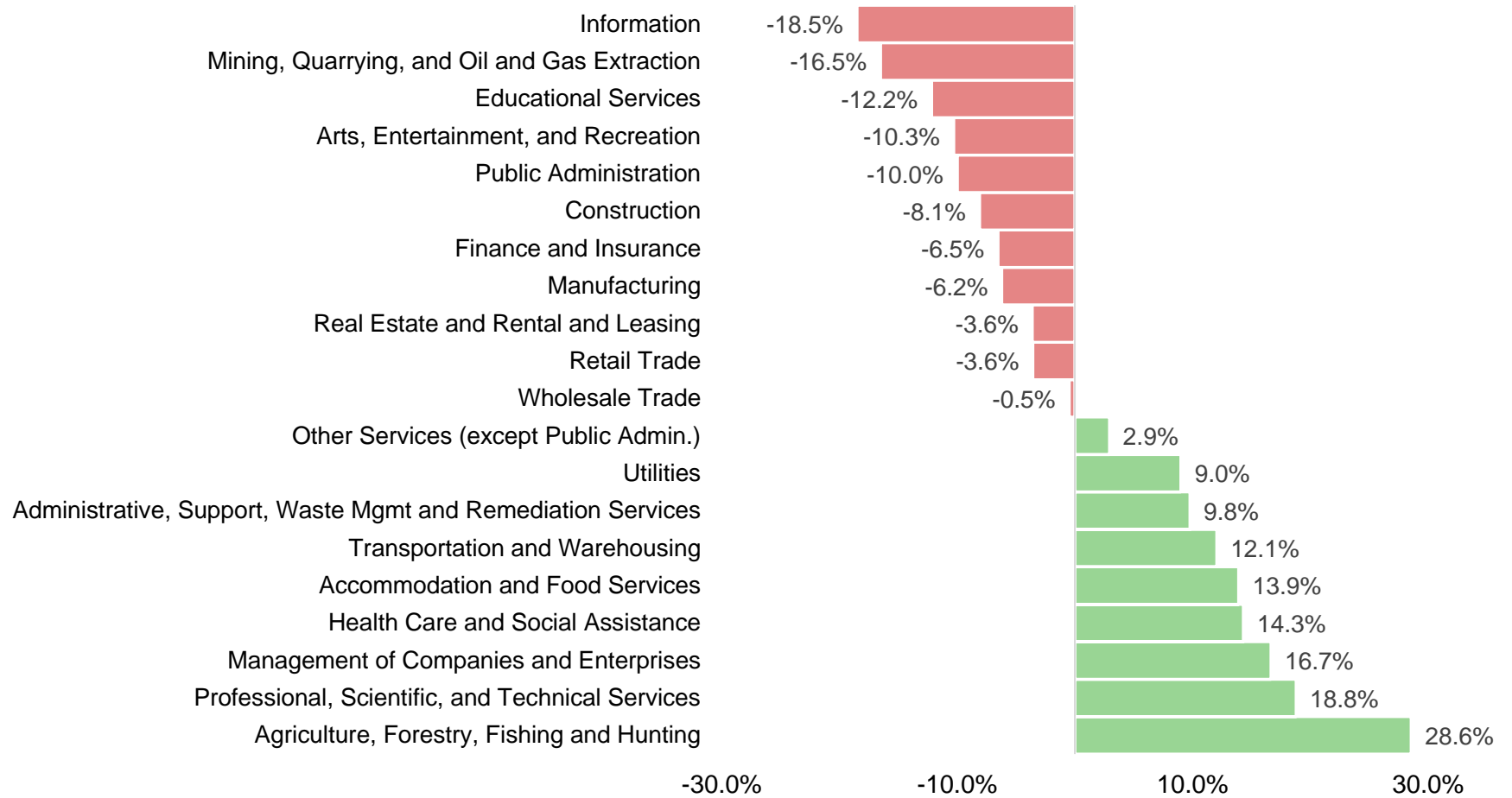
TABLE A-2: Number of Work-Related Amputations among Michigan Residents by Race and Hispanic Ethnicity, 2017

Race	Hispanic	Non-Hispanic	Unknown	Total
White	*	*	91	159
Black	*	*	*	17
Other	*	*	*	8
Unknown	*	*	233	243
Total	12	75	340	427

**Number was suppressed if the count was between 1 and 5 or if listing the result provided sufficient information to calculate a suppressed count to protect the confidentiality of individuals.*

Data Source: Michigan hospital medical records

Figure A-1: Net Percent Change in Number of Workers Employed in Michigan by Industry, 2006 and 2017



* The net percent change is the relative percent difference between the number of persons employed in Michigan in 2006 and 2017 for each industry category.

Data Source: 2017 Quarterly Workforce Indicators (QWI), U.S. Census Bureau.