Work-Related Crushing Injuries in Michigan: First Report (January 2013 – December 2015)

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A Joint Report of

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EXECUTIVE SUMMARY

Michigan State University's Occupational and Environmental Medicine Division compiles data on work-related crushing injuries in the state of Michigan. This is the first report on occupational crushing injuries in Michigan; it covers three years, 2013, 2014 and 2015. These are the key findings:

- Work-related crushing injuries were identified through multiple reporting sources
  - There were 947 work-related crushing injury incidents that represent 946 individuals in 2013.
  - There were 1,080 work-related crushing injury incidents, including two deaths, which represent 1,078 individuals in 2014.
  - There were 1,110 work-related crushing injury incidents that represent 1,109 individuals in 2015
  - Over the three years combined, there were 3,137 work-related crushing injury incidents that represented 3,131 individuals; 4 individuals each sustained 2 unique crushing injuries in the same calendar year and 2 individuals had 2 unique crushing injuries in two different calendar years.
- For 2013 through 2015, the Federal tracking system that relies on employer reporting, estimated only 1,260 work-related crushing injuries in Michigan or 40% of the total of 3,137 crushing injuries we identified in the three years (43.3% of our Michigan multi-source total in 2013, 55.6% of our total for 2014 and 22.5% of our total for 2015). The U.S. Bureau of Labor Statistics' estimated rate was 13 per 100,000 full-time equivalent (FTE) workers in 2013, 19 per 100,000 FTEs in 2014 and 7 per 100,000 FTEs in 2015, which was only 59.1%, 76.0% and 28.0% of the rate of 22, 25 and 25 per 100,000 workers of work-related crushing injuries identified in Michigan's multi-source reporting system.
- The most common type of medical encounter was an emergency room visit (2,411; 77.9%).
- Eighty percent of all work-related crushing injuries were among men and 85.2% were among Caucasians.
- The most common part of the body injured was an upper limb (2,287; 72.9%), followed by a lower limb (663; 21.1%).
- Primary Metal Manufacturing Industry had the highest number of work-related crushing injuries with 694 (26.7%) cases, followed by Construction with 247 (9.5%) cases, and Wood Product Manufacturing with 206 (7.9%) cases. These three industries combined accounted for almost half (44.1%) of all work-related crushing injuries.

- Mining, Quarrying, and Oil and Gas Extraction had the highest rate of crushing injuries with 154.9 per 100,000 workers, followed by the Agriculture, Forestry, Fishing and Hunting Industry with a rate of 59.7 per 100,000 workers, and then the Wholesale Trade Industry with a rate of 57.1 per 100,000 workers.
- “Pinched between objects other than door” and “Struck by falling object” were the two main causes of work-related crushing injuries in the Primary Metal Manufacturing (the industry with the most crushing injuries, 694; 26.7%), with 16.9% and 19.0%, respectively.
- Workers’ Compensation was the expected payer for only 76.0% of the 3,135 crushing injuries that were identified in the hospital/ED records.
- The MIOSHA program completed inspections at 77 worksites identified by the surveillance system where individuals were injured in 2013 through 2015. MIOSHA issued 212 violations and assessed $276,425 in fines. In 45 of these 77 inspections the employer had not addressed the circumstances causing the crushing injury (e.g., no guard on the machine where the crushing injury occurred) even though the MIOSHA inspection was performed months after the occurrence of the injury.

BACKGROUND

This is the first report on occupational crushing injuries in Michigan. The report is based on data for 2013 through 2015. Crushing injury occurs when force or pressure is put on a body part.[1] This type of injury most often happens when part of the body is caught between, squeezed or put under pressure between heavy objects.

Occupational crushing injuries are among the most severe injuries that occur in the workplace. Like all workplace injuries they are potentially preventable. Michigan Department of Health and Human Services' (MDHHS) regulations define traumatic injury as a "bodily damage resulting from exposure to physical agents such as mechanical energy, thermal energy, ionizing radiation, or resulting from the deprivation of basic environmental requirements such as oxygen or heat. Mechanical energy injuries include acceleration and deceleration injuries, blunt trauma, and penetrating wound injuries".[2] Health professionals and health facilities are required to report individuals with all injuries, including crushing injuries, regardless of cause, when requested by the Michigan Department of Health and Human Services. The Michigan work-related crushing injuries surveillance system, based on mandatory reporting, is used to identify causes of work-related crushing injuries, target interventions to reduce crushing injuries and evaluate the effectiveness of these interventions.

The U.S. Bureau of Labor Statistics (BLS), the official source of work-related injury statistics, estimated 12,810 work-related crushing injuries in 2013 nationwide (incidence rate of 12 workers per 100,000 full-time workers), 12,260 in 2014 (incidence rate of 11 workers per 100,000 full-time workers), and 11,260 in 2015 (incidence rate of 10 workers per 100,000 full-time workers).[3,4,5] The BLS estimates are based on employer reporting through the Survey of Occupational Injuries and Illnesses (SOII). The BLS estimate includes private industry and state and local government workers but not the self-employed or farms with fewer than 11 employees. BLS reported 410 non-fatal work-related crushing injuries for Michigan in 2013 (incidence rate of 13 workers per 100,000 full-time workers), 600 in 2014 (incidence rate of 19 workers per 100,000 full-time workers), and 250 in 2015 (incidence rate of 7 workers per 100,000 full-time workers).

Michigan State University's College of Human Medicine, Occupational and Environmental Medicine Division operates the crushing injuries surveillance system as the bona fide agent for the State. Once a work-related diagnosis is confirmed and a case meets designated criteria, information about the employer where the crushing injury took place is referred to the MIOSHA for a possible workplace investigation.

DATA SOURCES AND METHODS

There were three reporting sources of work-related crushing injuries in Michigan:

- Hospitals/Emergency Departments (EDs)/Hospital Outpatients
- Workers' Compensation Agency (WCA)
- Michigan Fatality Assessment and Control Evaluation (MIFACE)[6] Program

All 134 of Michigan's acute care hospitals, including Veterans' Administration Hospitals, were required to report work-related crushing injuries. Discharge summaries and ED notes were reviewed to differentiate the work and non-work-related crushing injuries treated at a hospital/emergency department (ED) or as an outpatient visit at a hospital-based clinic. Cases to be reported were defined as any individual aged 16 years or older receiving medical treatment at a Michigan hospital/ED/hospital outpatient for whom:

(a) A crushing injury-related ICD-9 diagnosis code (Internal Classification of Diseases, Ninth Revision)[7] or ICD-10 diagnosis code[8] was assigned as either the primary or any secondary diagnosis (Table 1), and
(b) The incident was recorded as having occurred at work.

Table 1. Work-Related Crushing Injury ICD-9 and ICD-10 Diagnosis Codes*

Crushing Injury ICD-9 and ICD-10 Codes of the following parts of the body:			
ICD-9 CODES		**ICD-10 CODES**	
925.1-.2	Face, Scalp, and Neck	S07	Head
		S17	Neck
926.0-.9	Trunk	S28	Thorax, and Traumatic Amputation of Part of Thorax
		S38	Abdomen, Lower Back, Pelvis and External Genitals, Including Amputation
927.0-.9	Upper Limb	S47	Shoulder and Upper Arm
		S57	Elbow and Forearm
		S67	Wrist, Hand and Fingers
928.0-.9	Lower Limb	S77	Hip and Thigh
		S87	Lower Leg
		S97	Ankle and Foot
929.0-.9	Multiple and Unspecified Sites		

*As of October 1, 2015, International Classification of Disease, Clinical Modification (ICD-10-CM), has replaced ICD-9-CM. This included both primary and secondary diagnosis.

The Michigan Workers' Compensation Agency (WCA) provided access to a database of workers who received claims for wage replacement due to lost work time. Individuals are eligible for wage replacement when they have had at least seven consecutive days away from work. A case identified using Michigan's Workers' Compensation system was defined as an individual who was in the lost work time wage replacement database with an accepted claim for a "Crush/Contusion" (WCA's Condition Type Code 160) to any part of the body. Crushing injuries in the WCA cannot be distinguished from the much more common contusion injuries as both types of injuries are coded in the worker compensation database with the single code 160.

Cases identified through the MIFACE program were identified as individuals whose underlying cause of death was from a crushing injury.

Information from the hospital/ED medical reports and MIFACE reports on each case were abstracted, including: type of medical care (hospital overnight, ED, outpatient), hospital name, date of admission and discharge, patient demographics, city and county of residence, source of payment, information on whether the worker was self-employed, employer information (name, address, NAICS code), injury date, ICD code, cause of

injury, side injured, digit injured, information on whether a power press injury. Once these crushing injury data were entered into a Microsoft Access database, records were manually linked to records in the Workers' Compensation database. Matches were identified using each individual's first and last name, date of birth and date of injury. Information from Workers' Compensation on matched cases was added to the database. Duplicates identified by more than one reporting source were only counted once, abstracting all information from every data source.

Individuals whose workplaces could not be identified in the records and met the criteria for a MIOSHA referral were contacted by telephone to obtain employer information. The criteria for a referral to MIOSHA were: 1) the individual had to be hospitalized, treated in an emergency department or as an outpatient at a hospital in 2013, 2014 or 2015, 2) the injury did not occur to a self-employed individual or an individual employed by an employer not covered by MIOSHA (e.g., federal, railroad, merchant marine, dock or mine employee), 3) the circumstances of the injury suggested there was an ongoing hazard and 4) the crushing injury occurred in the last six months.

For cases whose employers were referred to MIOSHA, additional information was obtained about the results of the referral, including: date of referral, whether an inspection was performed, inspection date, number of violations, and total fines assessed.

Data analysis was performed using queries conducted in Microsoft Access. Crushing injury rates by age, gender, and industry were calculated using U.S. Census, Department of Labor's Current Population Survey for denominators.

The BLS Occupational Injuries and Illnesses and Fatal Injuries Profiles online tool was used to generate the 2013, 2014 and 2015 BLS estimates and incidence rates of the number of nonfatal occupational injuries and illnesses involving days away from work by selected worker and case characteristics and nature of condition for both private and public ownerships.[9, 10, 11] Codes 1971XX (Crushing Injury – except internal organs or head), 194XXX (Crushing Injury – involving internal organs) and 160XXX (Crushing Injury – to the head) were used to generate the estimates and incidence rates.

RESULTS

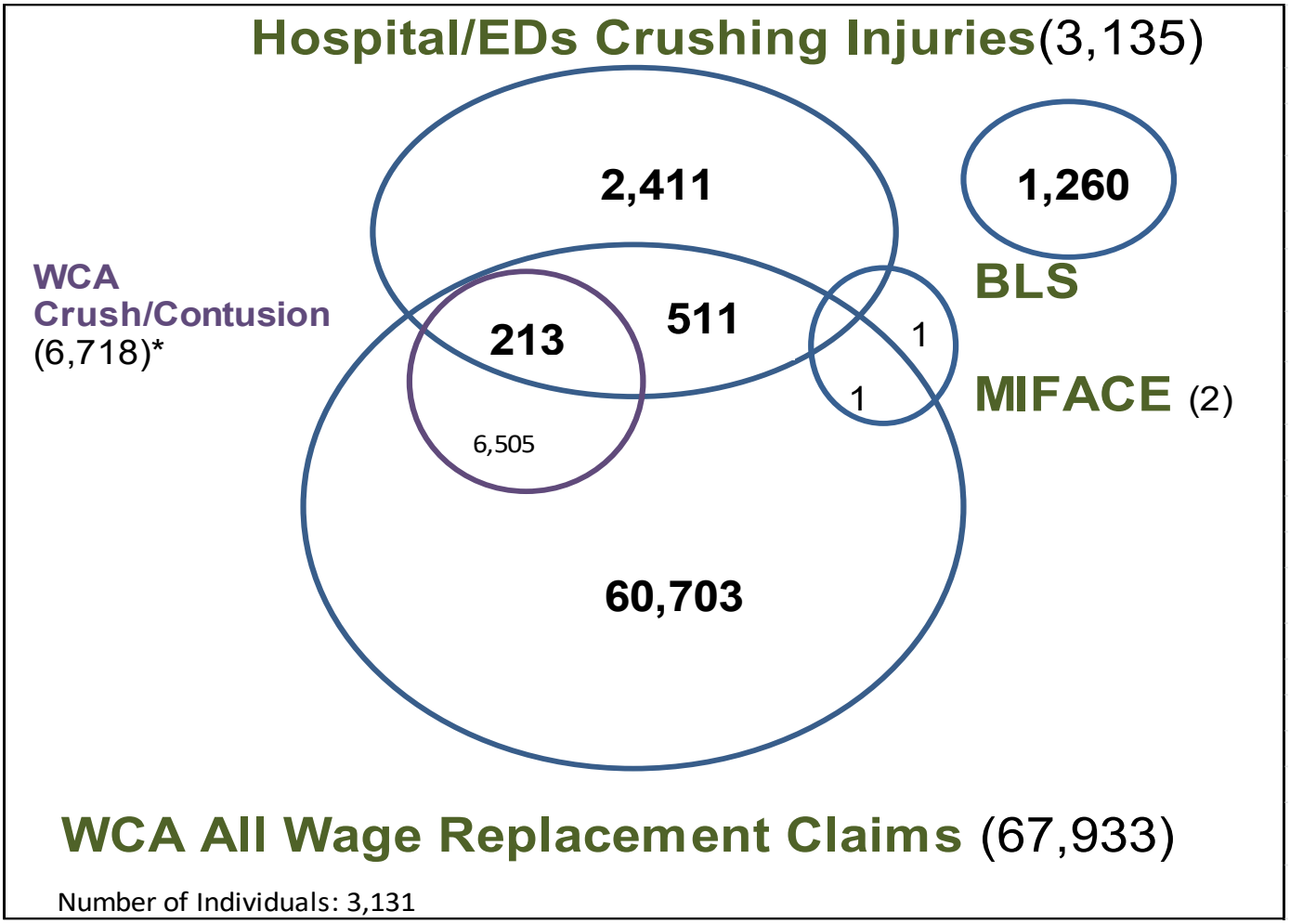
In 2013, there were 947 work-related crushing injury incidents which represent 946 individuals because one individual had two unique crushing injuries in 2013. The rate was 22/100,000 workers. In 2014, there were 1,080 work-related crushing injury incidents which represent 1,078 individuals because two individuals each had two unique crushing injuries in 2014. The rate was 25/100,000 workers. In 2015, there were 1,110 work-related crushing injury incidents which represent 1,109 individuals because one individual had two unique crushing injuries in 2015. The rate was 25/100,000 workers. Two individuals sustained crushing injuries in two separate calendar years.

2013-2015 Combined: There were 3,137 work-related crushing injury incidents that represent 3,131 individuals because four individuals each sustained two unique crushing injuries in the same calendar year and two individuals had two unique crushing injuries in two different calendar years.

Reporting Sources

The number of 2013-2015 work-related crushing injuries in Michigan by the reporting source and a comparison with the number estimated by BLS is shown in Figure 1.

Figure 1. Reporting Sources of Work-Related Crushing Injuries, Michigan 2013-2015



* The same code 160 is used for both crushing injuries and contusions so the two cannot be differentiated in the Workers' Compensation data base.

Hospitals/ED reports identified 3,135 cases and MIFACE program identified 2 cases. Hospital/ED reports matched with 724 WCA reports of crushing and contusion injuries. One MIFACE report matched with one WCA report. One crushing injury case was identified by the MIFACE program only. Because of confidentiality restrictions, no attempt was made to match the Michigan data set with the BLS data set.

There were 724 injuries in the WCA database that matched with work-related crushing injuries identified in the medical record and one WCA injury that matched with a crushing injury fatality identified through the MIFACE program. Two hundred and thirteen hospital/ED reports were matched with the WCA Crush/Contusion records. The

other 512 were included because they matched with names from one or more of the other data sources, although they had an injury description in the WCA as something other than “Crush/Contusion” injury. The descriptions in WCA for these 512 were: 178 “Fracture”, 118 “Cut/Laceration”, 69 “Multiple Injuries”, 48 “Unclassified”, 42 “Amputation”, 39 “Strains/Sprains”, 5 “Dislocation”, 5 “Infl-Joints”, 4 “Burn”, 3 “Other Injury/Nec”, and 1 “No Injury”. Matches were made based on the employee’s first and last name, date of birth, date of injury, employee’s zip code and employer information.

There were another 6,505 crush/contusion injuries identified in the WCA database.

An emergency room visit was the most common type of medical encounter, 2,411 (77.9%) cases (Table 2).

Table 2. Work-Related Crushing Injuries by the Type of Medical Encounter, Michigan 2013-2015*

Medical Encounter Type	Number	Percent
Hospitalization	265	8.6
Emergency Department	2,411	77.9
Outpatient	418	13.5
Total	3,094	100.0

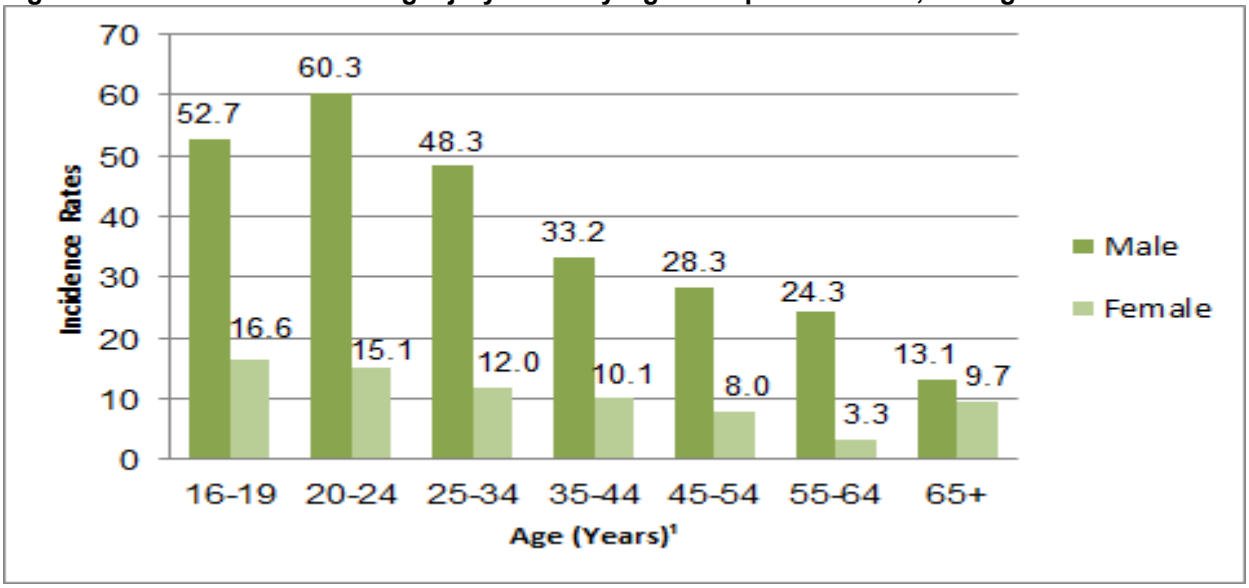
*Information on the type of medical encounter was provided for 3,094 (98.6%) individuals.

Characteristics of Injured Workers

Age and Gender

Gender was not available for one worker and age was not available for 17 male workers and 2 female workers. The age of injured workers varied from 16 to 83 years. The average age was 37.3 and the median age was 35.5. Two thousand five hundred and thirteen (80.3%) of all work-related crushing injuries were among men. Figure 2 displays crushing injury rates by age group and gender. Among males, rates were highest for workers in the 20-24 and 16-20 age groups, 60.3/100,000 and 52.7/100,000, respectively. For females, the age groups with the highest rate of crushing injury were 16-19 and 20-24 with 16.6/100,000 and 15.1/100,000, respectively.

Figure 2. Work-Related Crushing Injury Rates by Age Group and Gender, Michigan 2013-2015*



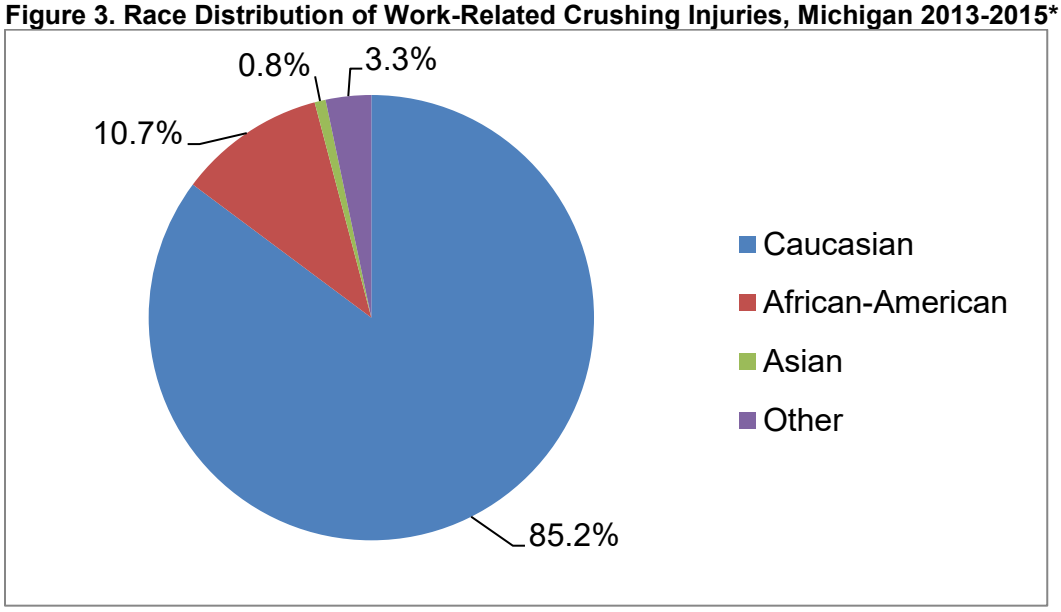
*Rates are the number of workers sustaining a crushing injury per 100,000 workers (number of workers employed by age group used to calculate rates: Bureau of Labor Statistics' Current Population Survey) [12, 13, 14]
[1]Information on age was missing for 16 males, 2 females, and one unknown gender.

Race and Ethnicity

The race of workers with work-related crushing injuries is shown in Figure 3. Among the workers for whom the race was available (1,595 50.9%), 1,359 (85.2%) were Caucasian, 171 (10.7%) were African-American, 12 (0.8%) were Asian, and 53 (3.3%) were "Other".

Information on ethnicity was provided for 1,064 (33.9%) individuals. Of the 1,064 individuals, seventy individuals (6.6%) were of Hispanic origin and 994 individuals (93.4%) were not of Hispanic origin.

Figure 3. Race Distribution of Work-Related Crushing Injuries, Michigan 2013-2015*



*Information on race was available for 1,595 (50.9%) individuals.

Part and Side of Body Injured

Medical records specified the part of body injured and were classified by ICD-9 and/or ICD-10 codes. Table 3 shows the distribution of the part of body injured. Crushing injuries of upper limbs occurred most often (72.9%), followed by crushing injuries of lower limbs (21.1%).

Medical records specified the side of the body injured. Among the workers for whom the side of the body injured was available (1,929, 61.5%), 971 (50.3%) had their left side injured, followed by 904 (46.9%) who had their right side injured, and then 54 (2.8%) who had both sides of their body injured.

Table 3. Work-Related Crushing Injuries by Part of Body Injured, Michigan 2013-2015

Part of Body Injured	Number	Percent
Face, Scalp, Neck	9	0.3
Trunk	72	2.3
Upper Limb	2,287	72.9
Lower Limb	663	21.1
Multiple and Unspecified Sites	106	3.4
Total	3,137	100.0

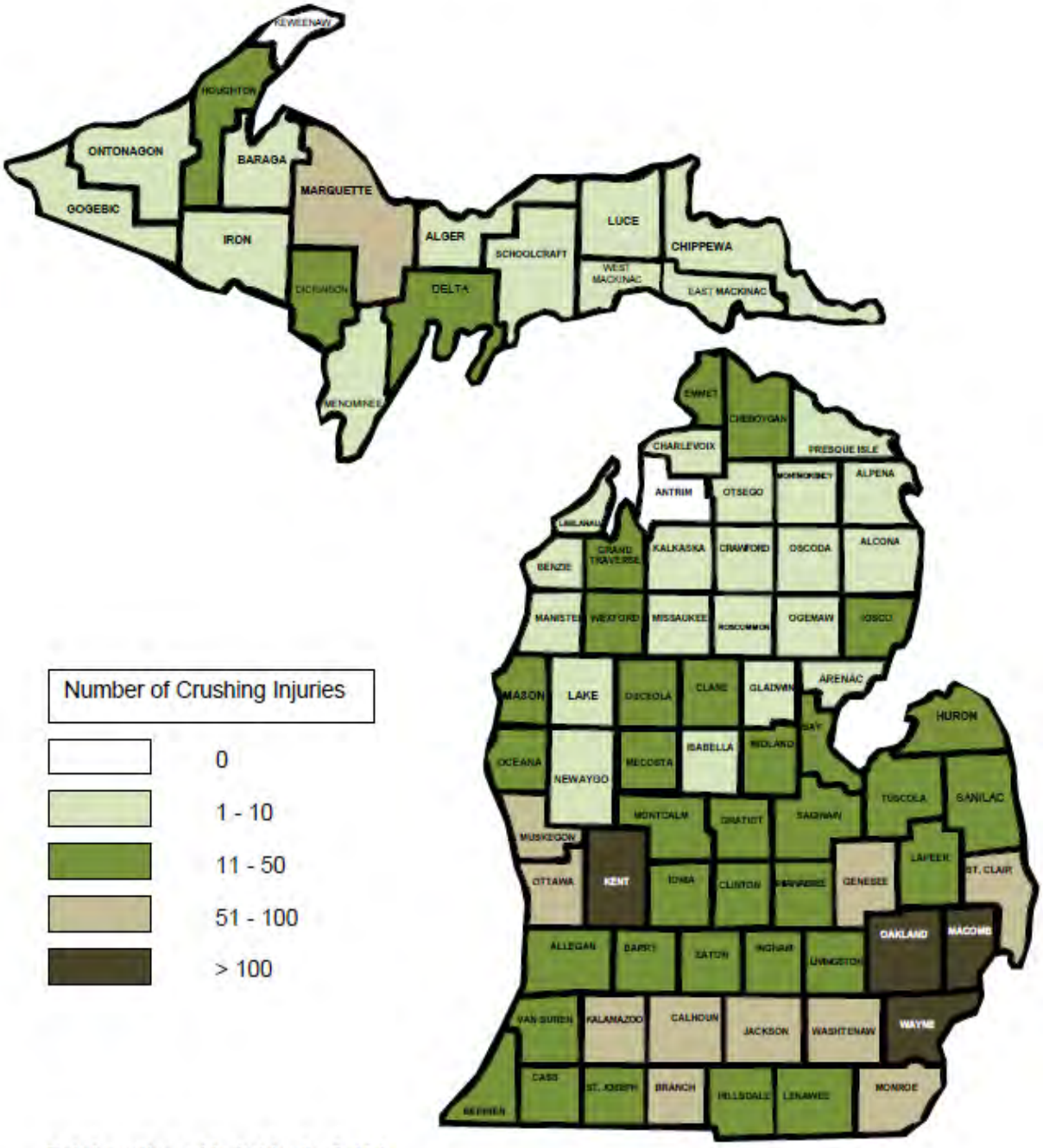
County of Residence

Table 4 and Figure 4 illustrate the worker's county of residence. There were 2,795 Michigan Residents for whom the county of residence was known. There were 75 out-of-state workers, and for 261 Michigan residents county was unknown. It should be noted that the county of residence would not necessarily be the same county where the individual was injured. Wayne County had the highest number of residents with work-related crushing injury with 408 (13.0%) cases, followed by Oakland County with 170 (5.4%) cases, and then Macomb County with 148 (4.7%) cases.

Table 4. Work-Related Crushing Injuries by County of Residence, Michigan 2013-2015

	2013 - 2015			2013 - 2015	
County	**Number**	**Percent**	**County**	**Number**	**Percent**
Alcona	3	0.1	Leelanau	3	0.1
Alger	4	0.1	Lenawee	35	1.1
Allegan	44	1.4	Livingston	46	1.5
Alpena	10	0.3	Luce	6	0.2
Antrim	0	--	Mackinac	5	0.2
Arenac	4	0.1	Macomb	148	4.7
Baraga	3	0.1	Manistee	5	0.2
Barry	34	1.1	Marquette	65	2.1
Bay	14	0.4	Mason	21	0.7
Benzie	8	0.3	Mecosta	16	0.5
Berrien	44	1.4	Menominee	7	0.2
Branch	72	2.3	Midland	29	0.9
Calhoun	92	2.9	Missaukee	6	0.2
Cass	12	0.4	Monroe	78	2.5
Charlevoix	10	0.3	Montcalm	43	1.4
Cheboygan	14	0.4	Montmorency	5	0.2
Chippewa	9	0.3	Muskegon	61	1.9
Clare	11	0.4	Newaygo	10	0.3
Clinton	41	1.3	Oakland	170	5.4
Crawford	3	0.1	Oceana	13	0.4
Delta	23	0.7	Ogemaw	7	0.2
Dickinson	23	0.7	Ontonagon	5	0.2
Eaton	24	0.8	Osceola	17	0.5
Emmet	17	0.5	Oscoda	6	0.2
Genesee	92	2.9	Otsego	7	0.2
Gladwin	3	0.1	Ottawa	70	2.2
Gogebic	4	0.1	Presque Isle	10	0.3
Grand Traverse	21	0.7	Roscommon	2	0.1
Gratiot	29	0.9	Saginaw	47	1.5
Hillsdale	34	1.1	Saint Clair	51	1.6
Houghton	12	0.4	Saint Joseph	18	0.6
Huron	29	0.9	Sanilac	24	0.8
Ingham	50	1.6	Schoolcraft	5	0.2
Ionia	49	0.5	Shiawassee	28	0.9
Iosco	15	0.2	Tuscola	28	0.9
Iron	7	0.2	Van Buren	35	1.1
Isabella	8	0.3	Washtenaw	53	1.7
Jackson	61	1.9	Wayne	408	13.0
Kalamazoo	95	3.0	Wexford	14	0.4
Kalkaska	2	0.1	Out of State	75	2.4
Kent	124	4.0	Unknown	261	8.3
Keweenaw	0	--			
Lake	5	0.2	Total	3,131	100.0
Lapeer	29	0.9			

Figure 4
Work-Related Crushing Injuries by County of Residence, Michigan 2013-2015



Total number of Individuals: 3,131
Out of state Individuals: 75
County was unknown for 261 Individuals

Industry

Table 5 describes work-related crushing injuries by industry using 2-digit North American Industry Classification System (NAICS) codes. Among all crushing injuries, 2,603 (83%) individuals had sufficient information to determine their NAICS industry classification. Among the 53 workers who were self-employed, sufficient information to determine the industry information was available for 32 (60.4%). Primary Metal Manufacturing Industry (NAICS: 33) had the highest number of work-related crushing injuries with 694 (26.7%) cases, followed by the Construction (NAICS: 23) with 247 (9.5%) cases, and then the Wood Product Manufacturing with 206 (7.9%) cases. These three industries combined accounted for almost half (44.1%) of all work-related crushing injuries. Mining, Quarrying, and Oil and Gas Extraction (NAICS: 21) had the highest rate of crushing injuries with 154.9 per 100,000 workers, followed by the Agriculture, Forestry, Fishing and Hunting Industry (NAICS: 11) with rate of 59.7 per 100,000 workers, and then the Wholesale Trade Industry (NAICS: 42) with rate of 57.1 per 100,000 workers.

Table 5. Work-Related Crushing Injuries by Industry, Michigan 2013-2015

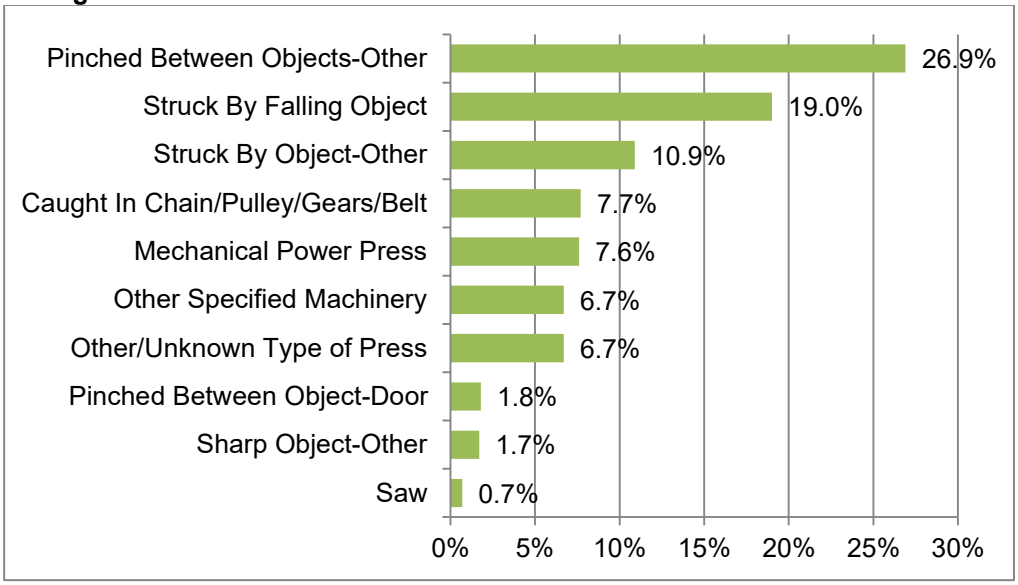
Industry Classification (NAICS)	2013 - 2015		
	Number	Percent	Rate*
Primary Metal Manufacturing (33)	694	26.7	37.8[1]
Construction (23)	247	9.5	37.9
Wood Product Manufacturing (32)	206	7.9	52[1]
Admin. and Support and Waste Management and Remediation Services (56)	183	7.0	33.1
Retail Trade (44)	180	6.9	17.9[2]
Wholesale Trade (42)	173	6.6	57.1
Health Care and Social Assistance (62)	135	5.2	6.7
Agriculture, Forestry, Fishing and Hunting (11)	111	4.3	59.7
Other Services (except Public Administration) (81)	101	3.9	16.9
Transportation and Warehousing (48)	90	3.5	25.5
Accommodation and Food Services (72)	67	2.6	7.6
Public Administration (92)	63	2.4	16.2
Sporting Goods, Hobby, Book and Music Stores (45)	60	2.3	13.5[2]
Food Manufacturing (31)	59	2.3	31.1[1]
Professional, Scientific and Technical Services (54)	54	2.1	7.1
Educational Services (61)	40	1.5	3.6
General Warehousing and Storage (49)	31	1.2	20.3
Arts, Entertainment, and Recreation (71)	27	1.0	9.8
Utilities (22)	21	0.8	18.3
Finance and Insurance (52)	20	0.8	3.7
Real Estate and Rental and Leasing (53)	18	0.7	9.4
Mining, Quarrying, and Oil and Gas Extraction (21)	13	0.5	154.9
Information (51)	9	0.3	5.0
Management of Companies and Enterprises (55)	1	0.0	6.5
Total	2,603**	100.0	23.7

*Rates are the number of workers sustaining a crushing injury per 100,000 workers (number of workers by industry used to calculate rates: Bureau of Labor Statistics' Current Population Survey).[12, 13, 14]
**Sufficient information for industry classification was available for only 2,603 individuals.
[1]The denominator for this rate does not include 45,022 individuals from "Not specified manufacturing industries (Part of 31, 32, and 33)" because the rate of crushing injuries was calculated separately for NAICS 31, 32, and 33. This is 1.8% of workforce with NAICS 31, 32, and 33.
[2] The denominator for this rate does not include 33,628 individuals from "Not specified retail trade (Part of 44, 45)" because the rate of crushing injuries was calculated separately for NAICS 44 and 45. This is 2.3% of workforce with NAICS 44 and 45.

Cause of Crushing Injury in Primary Metal Manufacturing Industry

Figure 5 illustrates the cause of work-related crushing injuries in the Primary Metal Manufacturing Industry which had the most crushing injuries (694; 26.7%). For 99 (14.3%) cases, the cause of injury was not provided in the medical records. The most common cause of crushing injuries was “Pinched between objects other (than door)” in 160 (26.9%) cases, followed by “Struck by falling object” in 113 (19.0%).

Figure 5. Cause of Crushing Injury in Primary Metal Manufacturing Industry, Michigan 2013-2015*



*Cause of Crushing Injury was provided for 595 (85.7%) cases.

Source of Payment

Workers’ Compensation was the expected payer in 2,008 (64.1%) of the 3,135 work-related crushing injuries for which there was a medical record (Table 6). For 494 crushing injuries payment source could not be identified. Of the 633 cases for which Workers’ Compensation was not listed as a payment source in medical records, 74 were matched to a case in the Workers’ Compensation claims database. Of those 74 cases, 19 were classified as a crushing injury and 55 had an injury description in the WCA database as something other than “crushing injury”.

Table 6. Work-Related Crushing Injuries by Payment Source, Michigan 2013-2015*

Expected Source of Payment	All		Non Self-Employed	
	Number	Percent	Number	Percent
Workers' Compensation	2,008	76.0	2,008	77.3
Commercial Insurance	357	13.5	335	12.9
Self Pay	188	7.1	179	6.9
Other**	88	3.3	75	2.9
Total	2,641	100.0	2,597	100.0

Data Source: Michigan hospital/ED medical records.
*Payment source was unknown for 494 (15.8%) of All cases and for 485 (15.7%) of Non-Self Employed cases.
**Other: Medicare, Medicaid

Referrals to MIOSHA

MIOSHA inspected seventy-seven workplaces where crushing injuries occurred between 2013 and 2015. Seventy-four percent of the workplaces inspected were cited for violations of MIOSHA safety rules. For 45 (78.9%) of the 57 companies cited, the employer had not corrected the circumstances causing the crushing injury at the time of the inspection. Ninety-six percent of the companies were cited for at least one violation of the MIOSHA rules directly related to the crushing injury. Table 7 illustrates the distribution of violations, recommendations and penalties assessed by the industry type of the seventy-seven inspected workplaces.

Table 7. Workplaces Inspected by MIOSHA: Violations and Penalties Assessed by Industry, Michigan 2013-2015

Industry Type (NAICS)	# of Enforcement Inspections	# of Companies Cited	# of Violations	# of Recomen-dations	Total Penalties Assessed
Agriculture, Forestry, Fishing and Hunting (11)	2	2	6	0	$3,150
Construction (23)	2	1	6	0	$2,100
Food Manufacturing (31)	7	6	18	0	$42,600
Wood Product Manufacturing (32)	10	7	16	0	$20,550
Primary Metal Manufacturing (33)	33	26	109	2	$154,750
Wholesale Trade (42)	5	4	18	0	$32,450
Retail Trade (44)	3	2	6	1	$3,850
Sporting Goods, Hobby, Book and Music Stores (45)	1	1	1	0	$2,800
Transportation and Warehousing (48)	2	0	0	0	--
General Warehousing and Storage (49)	1	1	1	0	$1,400
Admin. and Support and Waste Management and Remediation Services (56)	5	3	22	1	$7,950
Health Care and Social Assistance (62)	1	0	0	2	--
Arts, Entertainment, and Recreation (71)	1	1	2	0	$600
Accommodation and Food Services (72)	3	2	3	0	$375
Other Services (except Public Administration) (81)	1	1	4	0	$3,850
Total	77	57*	212	6	$276,425

*45 (78.9%) of these companies had not corrected the hazard at the time of the inspection. 55 (96.5%) of these companies were cited for at least one violation of MIOSHA rules directly related to the crushing injury.

Examples of Work-Related Crushing Injury MIOSHA Enforcement Inspections

- *Full Service Restaurants*: A male in his early thirties was placing a roll of dough into a chute of a dough roller that flattens the dough, when his fingers were pulled into the unit. The stop control functioned when his hand entered the dough roller and contacted the safety bar. The employee sustained a crushing injury with fractures to the left ring and middle fingers. MIOSHA found one serious violation for not providing a guard for in-running roll of manually fed dough brake. The company had not corrected the hazard at the time of the inspection.

- *Office Furniture (except Wood) Manufacturing*: A male in his late forties, sustained a crushing injury which included fractures of four fingers of the right hand as a result of his gloved-hand getting caught in a hydraulic power press. MIOSHA found two serious violations: 1) for not utilizing any point-of-operation guard or device, on the Greenerd HPB-15 hydraulic press in the production area; and 2) for not establishing a die setting procedure that (a) Insured that enclosure guards or protective devices were used and properly installed prior to production, and (b) Required the die setter or authorized personnel to ascertain that all point of operation safety devices were effective before the press was released for operation. The company had not corrected the hazard at the time of the inspection.

- *Sheet Metal Work Manufacturing*: A male in his mid-forties sustained a crushing injury to his finger when operating a steel press. The employee was using a metal holder to insert a short piece of metal into the press when he accidentally activated the lever, causing a 20-ton pressure to come down on his finger. MIOSHA found one serious violation for not having an adequate guard with an excessive opening to the blade and powered clamps on the Accurshear metal shear. The company had not corrected the hazard at the time of the inspection.

- *Ice Cream and Frozen Dessert Manufacturing*: A female in her mid-forties, who had four years of experience with the firm as a production operator, noticed one ½-gallon ice cream container that was not properly aligned in the wrapper machine. The employee reached in to straighten the container and the unit closed on her hand. The employee sustained a crushing injury to her left wrist, a laceration that needed sutures and a burn from the heated element used to seal packaging. She indicated she should have pushed the e-stop but did not want to slow down the line. She thought she had time to stick her hand in and out before closure. MIOSHA found one serious violation for not guarding the hazard or not protecting the employee otherwise, when the employee was exposed to a hazard created by a pinch point other than point of operation. The company had not corrected the hazard at the time of the inspection.

- *Beer and Ale Merchant Wholesalers*: A male in his mid-twenties sustained crushing injuries to his left hand after his hand got caught between two belts when he was trying to clear a product jam on a conveyor belt. MIOSHA found thirteen serious violations, including: 1) The employer did not furnish to each employee, employment and a place of employment, which was free from recognized hazards that were causing or were likely to cause death or serious physical harm to the employee: (a) Leaving the raised order picker platform(s) to unguarded deck located approximately 12-feet above the floor to clear jams and/or service conveyors without fall protection; (b) No fall protection when employees are climbing on semi-trailers to clear jams and service overhead conveyors; 2) The floor of a work area, passageway, or aisle was not maintained free of hazardous accumulations of scrap, debris, water, oil, grease, and/or other slip or trip hazards; 3) An open-sided floor or platform four feet or more above adjacent floor or ground level was not guarded by a standard barrier on all open sides; 4) A nip point at a pulley was not guarded by an enclosure or barrier constructed to prevent access by an employee's body members or loose clothing; 5) An employee was allowed to ride, cross, or walk on a conveyor where it was not designed for riding or crossovers; 6) An employer shall provide training to an employee working on or by a conveyor regarding the hazards and safeguards of such work; 7) The employee was not provided with a valid operator permit to operate powered industrial trucks; 8) When lifting an employee with an order picker truck, a platform with railing or other restraining device was not provided; 9) An employer shall not allow employees to exit an elevated aerial work platform, except where elevated work areas are inaccessible or hazardous to reach. Employees may exit the platform with the knowledge and consent of the employer. When employees exit to unguarded work areas, fall protection shall be provided and used as described in construction safety standard Part 45 "Fall Protection"; 10) New machines and equipment that were installed after January 2, 1990, were not provided with energy isolating devices designed to accept lockout devices; 11) Procedures were not developed, documented and utilized for the control of potentially hazardous energy when employees were engaged in activities covered by Part 85 (employees do not lockout the conveyor system

before servicing or clearing jams); 12) The employer did not conduct an annual or more frequent inspection of the energy control procedure to ensure that the procedure and requirements of Part 85 were followed; 13) Authorized employee(s) did not receive training in the recognition of applicable hazardous energy sources, the type and magnitude of the energy available in the workplace, and the methods and means necessary for energy isolation and control (employees not trained to lockout the conveyor system before servicing, clearing jams, or changing conveyor belts). The company had not corrected the hazard at the time of the inspection.

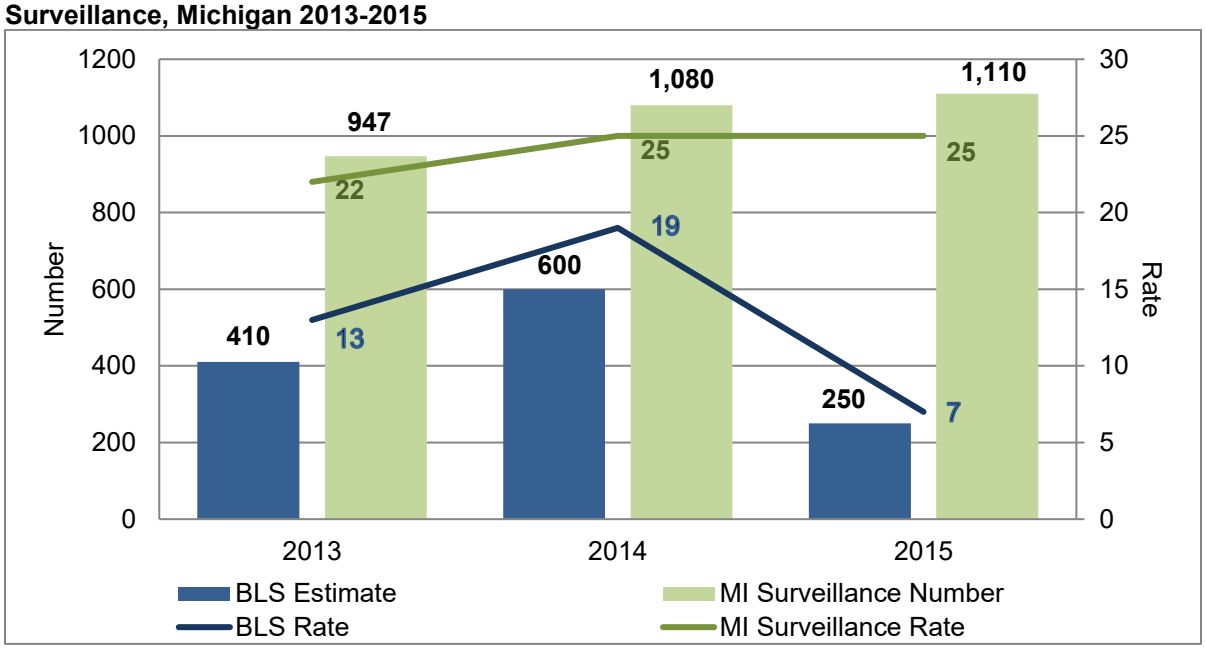
- *Linen Supply*: A female in her late-forties sustained a crushing injury to her right arm after her upper extremity was pulled into an ironing machine. The employee was trying to loosen a piece of clothing that had gotten stuck. MIOSHA cited the company with three serious and one other-than-serious violations, including: 1) One of the following shall be used to gain access to another elevation of more than 16 inches: (a) Flight of stairs, (b) Fixed industrial stairs, (c) Ramp, (d) Fixed ladder (The employee climbed up to 29-inches on to the Omega roll ironer and folder, while attempting to remove the stuck napkin in the roller iron area); 2) Repairs or clean up, where unexpected motion would cause injury, shall be done when power is off and locked out; 3) An employer shall provide training to an employee working on or by a conveyor regarding the hazards and safeguards of such work; 4) You must use MIOSHA 300, 300-A, and 301 forms, or equivalent forms, and shall complete the forms in the detail required by the forms and the instructions contained in the forms for the purpose of recording recordable injuries and illnesses. The company had not corrected the hazard at the time of the inspection.

- *Steel Foundries (except Investment)*: A male in his early forties was running a metal cut off saw when he noticed that some smaller cut pieces had fallen off of the conveyor system onto the floor. He opened one of the four safety gates to the machine, entered and then walked to the rear of the machine. He did not use lockout/tagout to stop the machine. While at the rear of the machine, he bent down to pick up some small ends of roll steel product, that had fallen off the conveyor. While starting to bend, he placed his right hand on a shuttle table to steady himself and the table cycled automatically causing his fingers and hand to be pinched in the closing pinch point. The employee sustained a crushing injury to his right index and middle fingers. MIOSHA found three serious violations, including: 1) No guard for pinch point created by bar stock rolling against metal stop device to change direction; 2) Procedures were not developed, documented and utilized for the control of potentially hazardous energy when employees were engaged in activities covered by Part 85 (The Control of Hazardous Energy Sources); 3) The employer did not conduct an annual or more frequent inspection of the energy control procedure to ensure that the procedures and requirements of Part 85 were followed. The company had not corrected the hazard at the time of the inspection.

DISCUSSION

This is the first report on work-related crushing injuries in Michigan. It covers three calendar years, 2013 through 2015. The Michigan surveillance system for work-related crushing injuries provides a more accurate estimate of the true number of work-related crushing injuries than the employer-based reporting system maintained by BLS, which is the source of official statistics. For years 2013 through 2015, the Michigan system identified 3,137 work-related crushing injuries in comparison to 1,260 estimated by BLS (Figure 6). The employer-based system identified a much smaller estimate (40.2%) than the Michigan system. BLS' rates of crushing injuries per 100,000 full time equivalents are smaller (13 in 2013, 19 in 2014 and 7 in 2015) and show a downward trend in comparison to the upward trend of the rates of crushing injuries identified in the Michigan multi source surveillance system (22 in 2013, 25 in 2014 and 25 in 2015). Workers' Compensation identified a larger number of work-related contusions/crushing injuries than BLS because contusions are given the same code as crushing injuries, and therefore since they cannot be separated in the Michigan Workers' Compensation database from crushing injuries are included in the Workers' Compensation count of crushing injuries. The BLS' estimates differentiate crushing injuries from bruises/contusions.

Figure 6. Number and Rate of Work-Related Crushing Injuries Comparing BLS and MI Surveillance, Michigan 2013-2015



The BLS's undercount of work-related crushing injuries is partially explained by the fact that BLS includes in its statistics only cases with one or more days away from work or with altered work duties, whereas the Michigan multi-source surveillance system counted all work-related crushing injuries. Secondly, the BLS excludes self-employed, household employees and farm workers who work on farms with less than 11 employees. Michigan's crushing injuries surveillance identified only 53 self-employed individuals in 2013 through 2015, and 111 farmers during the three years of surveillance with work-related crushing injuries so the difference in the type of workers covered in the BLS survey would not be an important factor to explain the undercount in the BLS data. Other possible explanations for the BLS undercount may be that employers are not providing complete reporting, or the statistical sampling procedure of BLS, or employers, are not properly identifying employees' injuries as crushing injuries. A factor that will cause small differences in the rates between the Michigan multi-source system and BLS is that the denominator used in the Michigan multi-source system is the number of workers and BLS uses full time equivalents.

Workers' Compensation was identified as the payer for only 76% of the work-related crushing injuries treated at Michigan hospital and emergency department in 2013 through 2015. Another 44 (1.7%) were not covered by workers' compensation (i.e. self-employed). We do not know the reasons why the other 22% of the hospitalizations/ED visits worker compensation was not listed as the payer.

The Workers' Compensation database identified only 725 (23.1%) of the 3,137 work-related crushing injuries. The possible explanations for the Workers' Compensation difference include: 1) The WCA data set only included crushing injuries that caused 7 or more consecutive days away from work, presumably the most severe cases; 2) WCA excluded the self-employed, but again there were only fifty-three self-employed workers in 2013 through 2015 in Michigan' multi source reporting system; 3) Coding or miscoding errors in the WCA data. The matching with hospital records showed that 511 work-related crushing injuries identified from medical records were not classified as crushing injuries in the WCA data. Potentially there were other injuries in the WCA database that were similarly misclassified but for which no medical records were received; 4) Workers' Compensation Condition Type Code combined crush and

contusion injuries into one code with no possibility to differentiate those two injury types; 5) It is possible that some companies are handling crushing injuries unofficially and not reporting them to Workers' Compensation insurance companies or the WCA.

Surveillance of work-related crushing injuries is crucial to the recognition and prevention of these conditions. A large advantage of the Michigan surveillance system is that it not only provides a better count of the total number of work-related crushing injuries but the reports can also be used to identify specific workplaces to perform follow back investigations. Between 2013 and 2015, seventy-seven worksites were identified by the surveillance data with a subsequent intervention by MIOSHA to reduce the hazard of a future work-related crushing injury or other serious injury to other employees. Two-thirds of the inspected companies (57, 74%) were cited, and despite serious injuries at those workplaces, 79% of these companies did not initiate changes to correct the hazardous situation.

We're planning to develop educational materials for distribution to employers and employees where we see patterns in causes for the crushing injuries. Development and distribution of this information will allow employers to work with employees to implement effective prevention strategies for acute crushing injuries at more facilities than where a MIOSHA inspection was performed.

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