Work-Related Crushing Injuries in Michigan: Third Report (January 2019 – December 2020)

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A Joint Report of

Michigan State University

and

Michigan Department of Labor and Economic Opportunity

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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 third report on occupational crushing injuries in Michigan; it covers two years, 2019 and 2020. These are the key findings:

- Work-related crushing injuries were identified through multiple reporting sources
  - In 2019, there were 1,196 work-related crushing injuries, including 12 deaths in 1,193 individuals.
  - In 2020, there were 1,048 work-related crushing injuries, including nine deaths in 1,045 individuals.
  - Over the two years combined, there were 2,244 work-related crushing injuries among 2,233 individuals; six individuals sustained two separate crushing injuries in the same calendar year; six individuals sustained a crushing injury in 2019 and another in 2020; and one individual sustained two separate crushing injuries in 2020 and another crushing injury in 2019
- For 2019 and 2020, the U.S. Bureau of Labor Statistics (BLS) system that relies on employer reporting, estimated 900 work-related crushing injuries in Michigan or only 40.1% of the total of 2,244 crushing injuries identified in our multi-source tracking system that relies on medical records and workers' compensation data (46.0% of our Michigan multi-source total in 2019 and 33.4% of our total for 2020). The U.S. BLS estimated rate was 11 per 100,000 full-time equivalent (FTE) workers in 2019 and 8 per 100,000 FTEs in 2020, which was only 44.0% and 33.3% of the rate of 25 and 24 per 100,000 workers of work-related crushing injuries identified in Michigan's multi-source reporting system.
- The most common type of medical encounter for a crushing injury was an emergency room visit (1,308; 58.3%).
- Seventy-six percent of all work-related crushing injuries were among men and 80.4% were among Caucasians.
- The most common part of the body injured was an upper limb (1,564; 69.7%) followed by a lower limb (572; 25.5%).
- Two National Occupational Research Agenda (NORA) Sector Groups – Manufacturing and Services (except Public Safety) accounted for over a half (53.5%) of all work-related crushing injuries. Wholesale and Retail Trade accounted for another 16.1% of all work-related crushing injuries.
- Agriculture, Forestry & Fishing (except Wildland Firefighting) Sector Group had the highest rate of crushing injuries with 91.1/100,000 workers, followed by the Construction Sector Group with 36.6/100,000 workers.

- “Pinched between” and “Struck by falling object” were the two main causes of work-related crushing injuries with 29.2% and 23.8%, respectively.
- Workers’ Compensation was the expected payer for 73.7% of the 2,244 crushing injuries that were identified in the hospital/ED records and for which the payer type was specified.
- For 2019 and 2020, the Michigan OSHA program completed inspections at 38 worksites identified by the surveillance system as having had a crushing injury. MIOSHA issued 73 violations and assessed $131,700 in fines. In 27 of these 38 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 third report on occupational crushing injuries in Michigan. The report is based on data for 2019 and 2020. A 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.[2] 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.[2] 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 BLS, the official source of work-related injury statistics, estimated 12,140 work-related crushing injuries in 2019 nationwide (incidence rate of 8 workers per 100,000 full-time workers) and 12,140 in 2020 (incidence rate of 8 workers per 100,000 full-time workers).[3,4] 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 550 non-fatal work-related crushing injuries for Michigan in 2019 (incidence rate of 11 workers per 100,000 full-time workers) and 350 in 2020 (incidence rate of 8 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, MIOSHA makes a determination whether or not to conduct a workplace investigation.

DATA SOURCES AND METHODS

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

- Hospitals/Emergency Departments/Hospital Outpatients
- Workers' Disability Compensation Agency (WDCA)
- Michigan Fatality Assessment and Control Evaluation (MIFACE)[5]

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-10 diagnosis code[6] 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-10 Diagnosis Codes

Code	Body part affiliated with code
S07	Head
S17	Neck
S28	Thorax, and Traumatic Amputation of Part of Thorax
S38	Abdomen, Lower Back, Pelvis and External Genitals, Including Amputation
S47	Shoulder and Upper Arm
S57	Elbow and Forearm
S67	Wrist, Hand and Fingers
S77	Hip and Thigh
S87	Lower Leg
S97	Ankle and Foot

The Michigan WDCA provided access to a database of paid 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" (WDCA's Condition Type Code 160) to any part of the body. Crushing injuries in the

WDCA 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 an individual's first and last name, date of birth, date of injury, and social security number when available. 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. NAICS codes were converted to NORA Sector Group.[7]

When employer information was available, MIOSHA potentially conducted an enforcement inspection. The criteria for a MIOSHA inspection were: 1) the individual had to be hospitalized, treated in an emergency department or as an outpatient at a hospital in 2019 or 2020, 2) the injury did not occur to a self-employed individual or an individual employed by an employer not covered by Michigan OSHA (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 inspected by MIOSHA, additional information was obtained about the results of the inspection: inspection date, whether the hazard causing the crushing injury was present at the time of the inspection, number of violations, and total fines assessed.

Data analysis was performed using queries conducted in Microsoft Access. The NIOSH Employment Labor Force (ELF) Query System, which uses BLS Current Population

Survey (CPS) data, provides the estimated number of employed Michigan residents by age group, gender and industry for 2019 and 2020.[8]

The BLS Occupational Injuries and Illnesses and Fatal Injuries Profiles online tool was used to generate the 2019 and 2020 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.[3,4,9,10] Three codes were used to generate the estimates and incidence rates: 1971 (Crushing Injuries) – the code includes crushing injuries to upper and lower extremities – arm, hand, leg; 194 (Internal injuries to organs and blood vessels of the trunk) – the code includes crushing injuries involving internal organs; and 160 (Intracranial injuries, unspecified) – the code includes crushing injuries to the head.

RESULTS

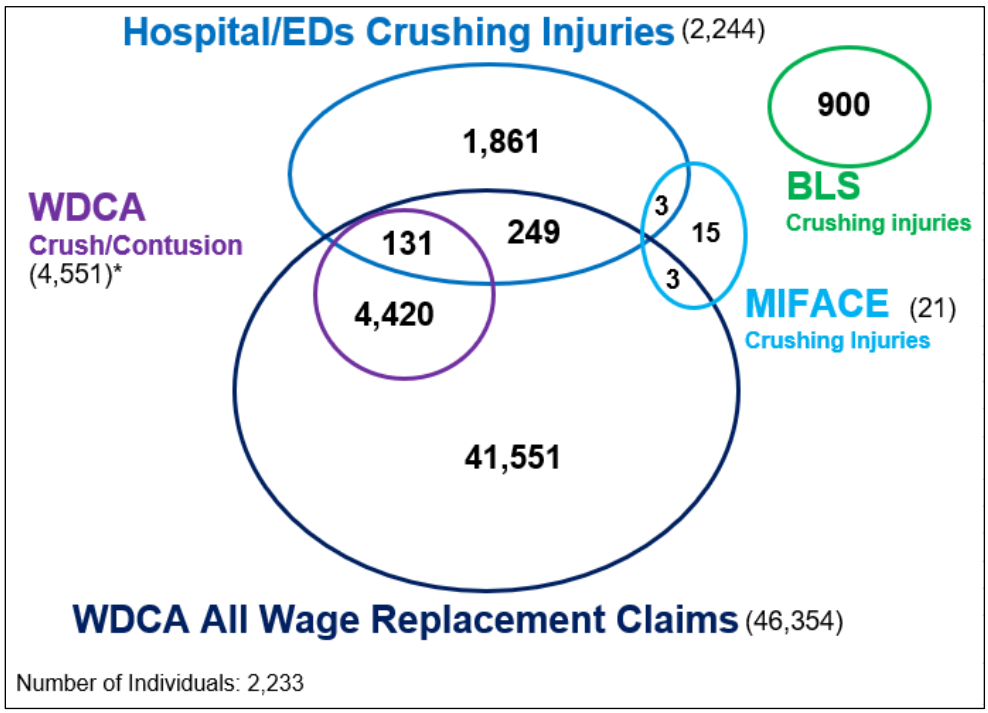
In 2019, there were 1,196 work-related crushing injuries among 1,193 individuals because three individuals sustained two separate crushing injuries in 2019. The hospitals and acute care facilities in Michigan reported for 96.7% of the quarterly reporting periods in 2019. In 2020, there were 1,048 work-related crushing injuries among 1,045 individuals because three individuals sustained two separate crushing injuries in 2020. The hospitals and acute care facilities in Michigan reported for 100% of the quarterly reporting periods in 2020.

2019-2020 Combined: There were 2,244 work-related crushing injuries among 2,233 individuals because six individuals sustained two separate crushing injuries in the same calendar year and six individuals had one crushing injury in 2019 and another in 2020. One individual sustained two separate crushing injuries in 2020 and another crushing injury in 2019.

Reporting Sources

The number of 2019 and 2020 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 2019–2020



*The same condition type (code 160) is used for both crushing injuries and contusions so the two cannot be differentiated in the Workers' Disability Compensation Agency database.

Hospitals/ED reports identified 2,223 cases and the MIFACE program identified 21 cases. Hospital/ED reports matched with 131 WDCA reports of crushing and contusion injuries. Three hospital/ED reports matched with three MIFACE reports and three MIFACE reports matched with three WDCA reports. Fifteen crushing injury cases were 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 380 injuries in the WDCA database that matched with work-related crushing injuries identified by medical records and three WDCA injuries that matched with three crushing injury fatalities identified through the MIFACE program. One hundred and thirty-one hospital/ED reports were matched with the WDCA Crush/Contusion records. Although they had an injury description in the WDCA as something other than "Crush/Contusion" injury, 243 crushing injuries matched with personal identifiers from one or more of the hospital/ED sources. The number of cases and descriptions in WDCA for these 243 were: 93 "Fracture", 55 "Cut/Laceration", 40 "Strains/Sprains", 18 "Multiple Injuries", 6 "Amputation", 2 "Dislocation", 1 "Abrasion/Scratch", 1 "Inflam-Joints", 5 "Other Injury/NEC", 22 "Unclassified". 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 4,420 crush/contusion injuries identified only in the WDCA database.

An emergency room visit was the most common type of medical encounter, 2,556 (75.0%) cases (Table 2).

Table 2. Work-Related Crushing Injuries by the Type of Medical Encounter, Michigan 2019–2020*

Medical Encounter Type	Number	Percent
Hospitalization	231	11.7
Emergency Department	1,308	66.5
Outpatient	430	21.8
Total	**1,969**	**100.0**

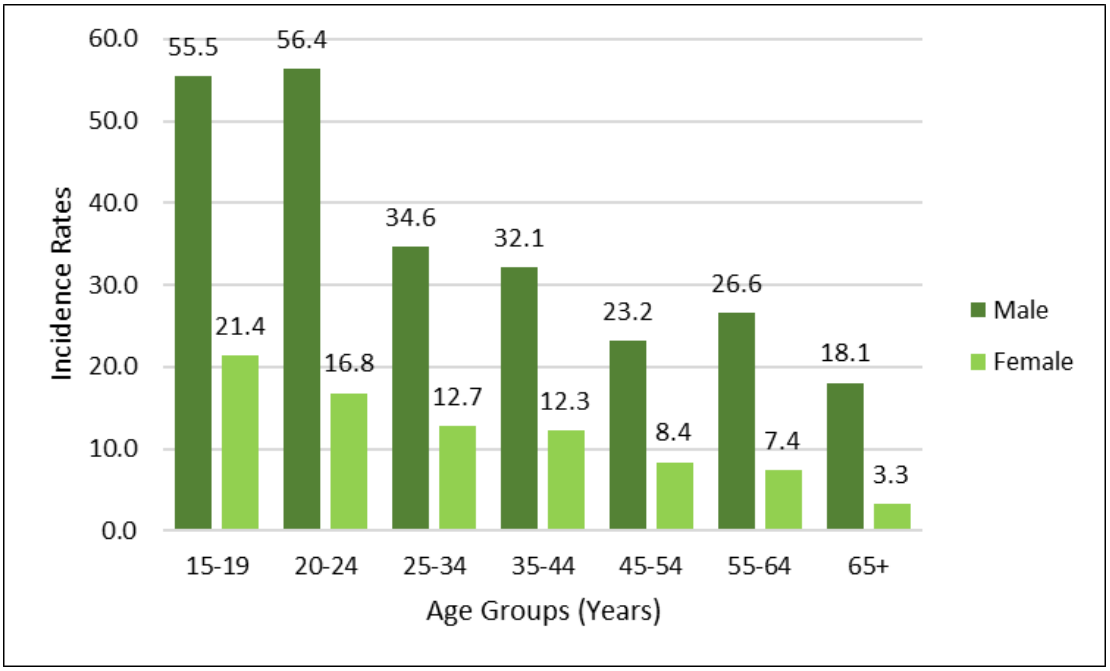
*Information on the type of medical encounter was provided for 2,202 (99.8%) individuals. Medical encounter was listed as "Other" (e.g., occupational disease report from a doctor, specialty office visit, or MIFACE case with no hospital visit) for 270 individuals.

Characteristics of Injured Workers

Age and Gender

Gender was unknown for 23 workers. The age of injured workers varied from 12 to 83 years. The average age was 38 and the median age was 36. One thousand six hundred and ninety (76.1%) 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 15-19 age groups, 56.4/100,000 and 55.5/100,000, respectively. For females, the age groups with the highest rate of crushing injury were 15-19 and 20-24 with 21.4/100,000 and 16.8/100,000, respectively.

Figure 2. Work-Related Crushing Injury Rates by Age Group and Gender, Michigan 2019–2020*



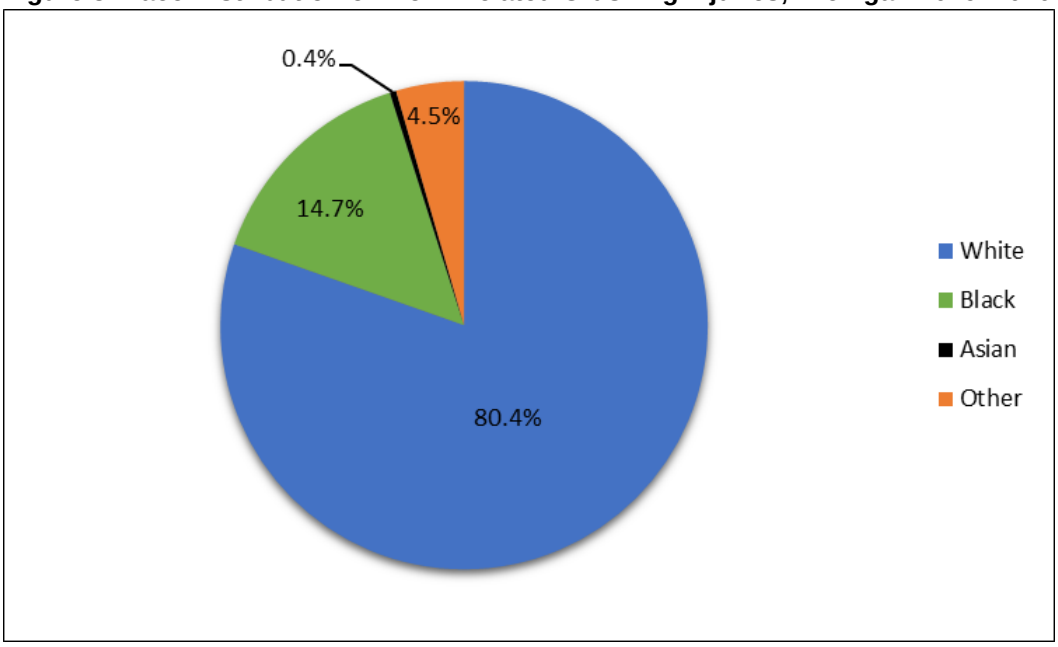
*Data Sources: Number of work-related crushing injuries – Michigan hospital/ED medical records, MIFACE, and WDCA; Total number of workers by age group and sex – NIOSH ELF Query System (BLS CPS).[8]
Note: Rates are the number of workers sustaining a crushing injury per 100,000 workers.

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 (933, 41.6%), 750 (80.4%) were White, 137 (14.7%) were Black, 4 (0.4%) were Asian, and 42 (4.5%) were “Other”.

Information on ethnicity was provided for 577 (25.7%) individuals. Of the 577 individuals, thirty-seven individuals (6.4%) were of Hispanic origin and 540 individuals (93.6%) were not of Hispanic origin.

Figure 3. Race Distribution of Work-Related Crushing Injuries, Michigan 2019–2020*



*Information on race was available for 933 (41.6%) individuals.

Part of Body Injured

Medical records specified the part of body injured and were classified by ICD-10 codes. Table 3 shows the distribution of the part of body injured. Crushing injuries of upper limbs occurred most often (69.7%), followed by crushing injuries of lower limbs (25.5%).

Table 3. Work-Related Crushing Injuries by Part of Body Injured, Michigan 2019–2020

Part of Body Injured	Number	Percent
Face, Scalp, Neck	37	1.6
Trunk	31	1.4
Upper Limb	1,564	69.7
Lower Limb	572	25.5
Multiple and Unspecified Sites	40	1.8
Total	**2,244**	**100.0**

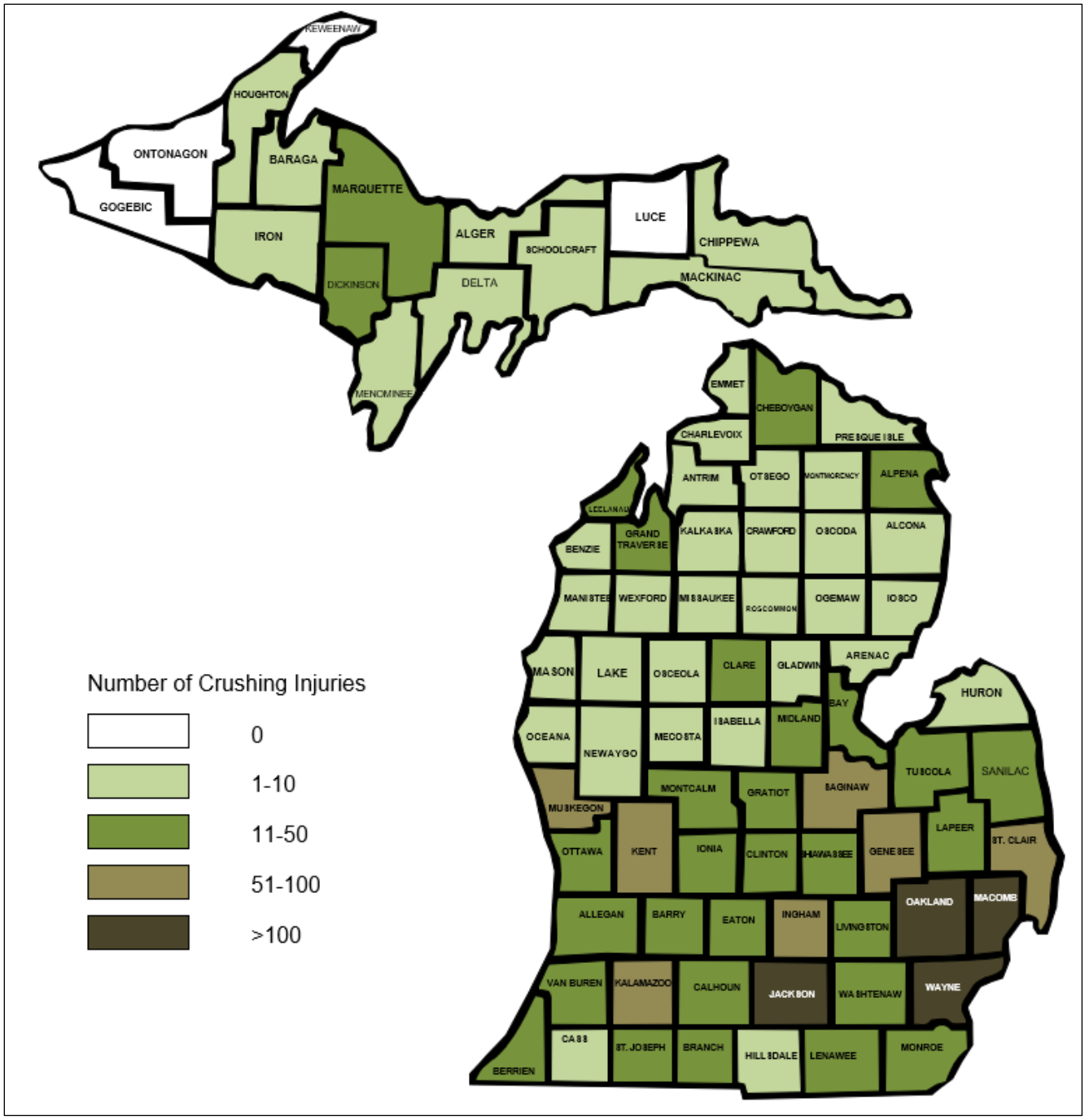
County of Residence

Table 4 and Figure 4 illustrate the worker's county of residence. There were 1,918 Michigan residents with crushing injuries for whom the county of residence was known. There were 38 non-Michigan residents with crushing injuries while working in Michigan, and the county was unknown for 288 Michigan residents with crushing injuries. 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 a work-related crushing injury with 289 (12.9%) cases, followed by Macomb County with 138 (6.1%) cases, and then Jackson County with 129 (5.7%) cases.

Table 4. Work-Related Crushing Injuries by County of Residence, Michigan 2019–2020

County	Number	Percent	County	Number	Percent
Alcona	5	0.2	Leelanau	13	0.6
Alger	3	0.1	Lenawee	22	1.0
Allegan	21	0.9	Livingston	28	1.2
Alpena	22	1.0	Luce	0	0.0
Antrim	6	0.3	Mackinac	7	0.3
Arenac	4	0.2	Macomb	138	6.1
Baraga	7	0.3	Manistee	2	0.1
Barry	11	0.5	Marquette	16	0.7
Bay	20	0.9	Mason	4	0.2
Benzie	3	0.1	Mecosta	5	0.2
Berrien	35	1.6	Menominee	2	0.1
Branch	22	1.0	Midland	13	0.6
Calhoun	39	1.7	Missaukee	8	0.4
Cass	8	0.4	Monroe	31	1.4
Charlevoix	7	0.3	Montcalm	12	0.5
Cheboygan	12	0.5	Montmorency	2	0.1
Chippewa	3	0.1	Muskegon	58	2.6
Clare	12	0.5	Newaygo	5	0.2
Clinton	13	0.6	Oakland	104	4.6
Crawford	5	0.2	Oceana	10	0.4
Delta	9	0.4	Ogemaw	7	0.3
Dickinson	27	1.2	Ontonagon	0	0.0
Eaton	13	0.6	Osceola	5	0.2
Emmet	5	0.2	Oscoda	4	0.2
Genesee	54	2.4	Otsego	5	0.2
Gladwin	4	0.2	Ottawa	50	2.2
Gogebic	0	0.0	Presque Isle	7	0.3
Grand Traverse	12	0.5	Roscommon	1	0.0
Gratiot	17	0.8	Saginaw	52	2.3
Hillsdale	9	0.4	Saint Clair	56	2.5
Houghton	3	0.1	Saint Joseph	30	1.3
Huron	10	0.4	Sanilac	18	0.8
Ingham	51	2.3	Schoolcraft	2	0.1
Ionia	23	1.0	Shiawassee	11	0.5
Iosco	3	0.1	Tuscola	18	0.8
Iron	3	0.1	Van Buren	28	1.2
Isabella	9	0.4	Washtenaw	42	1.9
Jackson	129	5.7	Wayne	289	12.9
Kalamazoo	52	2.3	Wexford	8	0.4
Kalkaska	10	0.4	Out of State	38	1.7
Kent	68	3.0	Unknown	288	12.8
Keweenaw	0	0.0			
Lake	7	0.3	**Instate Total**	**2,206**	
Lapeer	29	1.3	**Total**	**2,244**	**100.0**

Figure 4. Work-Related Crushing Injuries by County of Residnece, Michigan 2019–2020*



*Individuals with two injuries in the same year and individuals with an injury in 2019 and another in 2020 were counted once for each injury. There were 2,244 recorded crushing injuries. Individuals with out of state residence accounted for 38 injuries and there were 288 injuries of which the Michigan county of residence was unknown.

NORA Sector Groups

For 1,741 (77.6%) cases, including 72 self-employed individuals, there was sufficient information to determine their NORA Sector Group classification (Table 5). Manufacturing Sector Group had the highest number of work-related crushing injuries with 571 (32.8%) cases, followed by Services (except Public Safety) Sector Group with 361 (20.7%) cases and then Wholesale and Retail Trade Sector Group with 281 (16.1%) cases. Agriculture, Forestry, and Fishing (except Wildland Firefighting) Sector Group had the highest rate of crushing injuries with 91.1/100,000 workers, followed by Construction Sector Group with 36.6/100,000 workers.

Table 5. Work-Related Crushing Injuries by NORA Sector Groups, Michigan 2019–2020*

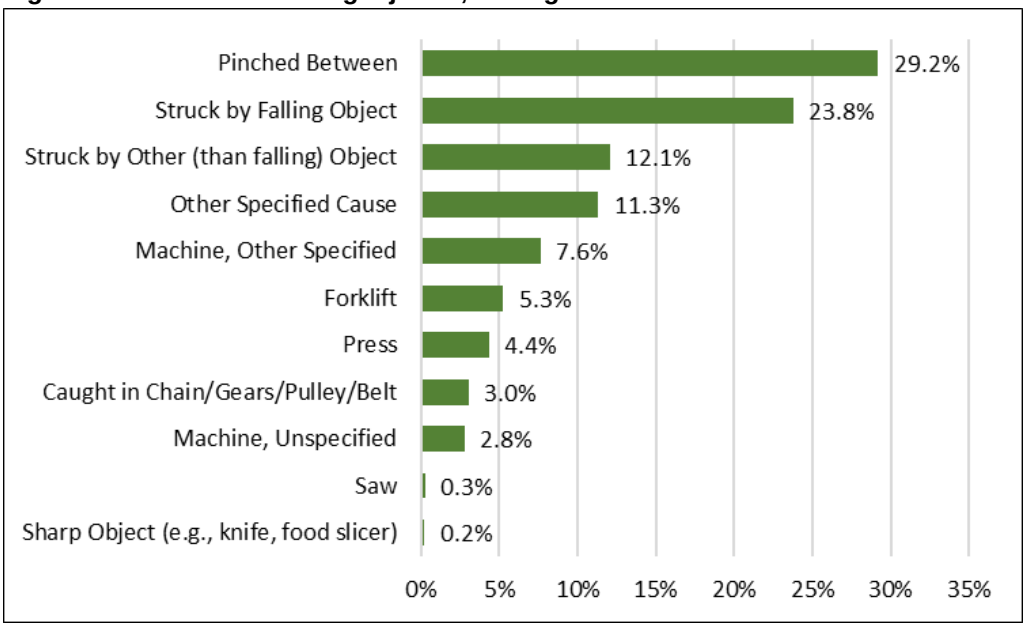
NORA Sector Group	NAICS Code	Number	Percent	Rate[1]
Agriculture, Forestry, & Fishing (except Wildland Firefighting)	11	96	5.5	91.1
Construction	23	185	10.6	36.6
Healthcare & Social Assistance	62, 54194, 81291	103	5.9	7.2
Manufacturing	31-33	571	32.8	33.6
Mining (except Oil & Gas Services)	21	3	0.2	30.8
Oil & Gas Extraction	211, 213111, 213112	5	0.3	N/A[2]
Public Safety (including Wildland Firefighting)	92212, 92214, 92216, 62191	16	0.9	12.7
Services (except Public Safety)	51-56, 61, 71-72, 81, 92	361	20.7	9.7
Transportation, Warehousing & Utilities	48-49, 22	120	6.9	26.7
Wholesale & Retail Trade	42, 44-45	281	16.2	24.6
Total		**1,741**	**100.0**	**24.4**

*Sufficient information for sector groups classification was available for 1,741 (77.6%) cases.
[1]Rates are the number of workers sustaining a crushing injury per 100,000 workers. Number of workers used to calculate rates: NIOSH ELF Query System (BLS CPS)
[2]NIOSH ELF Query System estimated 0 workers in the Oil & Gas Extraction Sector Group for the state of Michigan

Cause of Crushing Injury

Figure 5 illustrates the cause of work-related crushing injuries. For 498 (22.2%) of the 2,224 crushing injuries, the cause of injury was not provided in the medical records. The most common cause among 1,746 crushing injuries where cause was known was “Pinched between” (objects other than door) in 510 (29.2%) cases, followed by “Struck by Falling Object” in 415 (23.8%). These two causes of crushing injuries accounted for more than a half of crushing injures for which a cause was provided in medical records.

Figure 5. Cause of Crushing Injuries, Michigan 2019–2020*



*Cause of Crushing Injuries was provided for 1,746 (77.8%) cases

Source of Payment

Workers’ Compensation was the expected payer in 1,298 (58.3%) of the 2,225 work-related crushing injuries for which there was a medical record (Table 6). For 463 crushing injuries payment source could not be identified. Of the 927 cases for which Workers’ Compensation was not listed as a payment source in medical records, 79 were matched to a case in the Workers’ Compensation claims database. Of those 79 cases, 37 were classified as a crushing injury and 42 had an injury description in the WDCA database as something other than “crushing injury”.

Table 6. Work-Related Crushing Injuries by Payment Source, Michigan 2019–2020*

Expected Source of Payment	All		Non-Self Employed	
	Number	Percent	Number	Percent
Workers' Compensation	1,298	73.7	1,288	76.6
Commercial Insurance	236	13.4	198	11.8
Self-Pay	71	4.0	66	3.9
Medicare/Medicaid	147	8.3	120	7.1
Other Gov't	10	0.6	10	0.6
Total	**1,762**	**100.0**	**1,682**	**100.0**

Data Source: Michigan hospital/ED medical records.
*Payment source was unknown for 463 (20.8%) of all cases with a medical record (n=2,225) and for 453 (21.2%) of non-self-employed cases with a medical record (n=2,135).

MIOSHA Inspections

MIOSHA inspected 38 workplaces where a crushing injury was identified by the surveillance system. Table 7 illustrates the distribution of violations and penalties by the NORA Sector Group. Seventy-nine percent of the workplaces inspected were cited for violations of at least one MIOSHA safety rule. In 27 of the 38 (71.1%) companies, the hazard that caused the crushing injury had not been corrected at the time of the inspection, which was conducted three to six months after the crushing injury occurred.

Table 7. Workplaces Inspected by MIOSHA: Violations and Penalties Assessed by NORA Sector Groups, Michigan 2019–2020

NORA Sector Group	Enforcement Inspections	Companies Cited	Violations	Violations Injury Related	Recom-mendations	Total Penalties Assessed
Manufacturing	18	13	32	31	1	$ 59,300
3Wholesale & Retail Trade	8	7	23	19	3	$ 52,900
Services (except Public Safety)	4	2	5	5	0	$ 3,000
Agriculture, Forestry, & Fishing (except Wildland Firefighting)	3	3	4	1	0	$ 6,300
Construction	3	3	4	3	0	$ 4,500
Oil & Gas Extraction	1	1	2	2	1	$ 3,300
Transportation, Warehousing & Utilities	1	1	3	3	0	$ 2,400
Total	**38**	**30**	**73**	**64**	**5**	**$131,700**

Examples of Work-Related Crushing Injury MIOSHA Enforcement Inspections

- *Metal Component Manufacturing*

A male in his early sixties sustained a crushing injury when his hand got caught in a press while attempting to retrieve a ratchet from the die. This resulted in immediate deformity, including a displaced thumb and fractured fingers, open wounds with exposed tendons, and extruded muscle and soft tissue. MIOSHA found five serious and two other-than serious violations: “There was no means provided to prevent cycling the press with the safety block in place between the upper and lower dies or between the bolster plate and slide face on the 400 ton press; There were no machine specific lockout procedures developed or documented for the control of potentially hazardous energy while the employee was attempting to retrieve a ratchet from inside the die on the 400 ton press resulting in employee injury; The employer did not conduct a periodic inspection of the energy control procedure at least annually; Employees did not receive proper training in the methods and means necessary for energy isolation and control on the specific press; Employees did not receive instruction on the purpose and use of the energy control procedure while operating the 400 ton press; a work-related inpatient hospitalization of an employee was not reported to MIOSHA within the required 24 hours; MIOSHA Form 300 Log of Work-Related Injuries and Illnesses was not complete in the detail required by the forms.” The company had not corrected the hazard at the time of the inspection.

- *Packaging Company*

A female in her early thirties sustained a crushing injury when a high-low ran over her foot. This resulted in bruising, swelling, an avulsion fracture, and a fractured toe. MIOSHA found one serious and two other-than-serious violations: “An employee’s toe was run over by a powered industrial truck in the assembly department; Employee was not provided with a permit to operate a powered industrial truck; There were no daily checks done for the powered industrial truck.” The company had not corrected the hazard at the time of the inspection.

- *Medical Supply Wholesaler*

A male in his late forties sustained a crushing injury when his thumb got stuck in a 3-4-inch-wide rolling device. This tore the end of his thumb off resulting in an avulsion with exposed bone and loss of soft tissue of the thumb tip. MIOSHA found three serious and one other-than-serious violations: “Energy control procedures were not utilized when two employees set up the #2 Delta converting machine; There was an inadequate guard/light curtain device with excessive openings to exposed pinch points between in-running rollers on the #2 Delta converting machine; There was one actuation device being utilized for two employees that placed their hands into the point of operation on the converting machine under a jog and run control system; There was an amputation on the tip of an employee’s right thumb that was not reported to MIOSHA within 24 hours.” The company had not corrected the hazard at the time of the inspection.

- *Semi-truck and trailer repair services and wholesaler*

A 19-year-old male was hospitalized from a crushing injury after a steel beam fell from a hoist onto his foot. He was wearing steel-toed boots and sustained a partial avulsion and open fracture of three toes. MIOSHA found five serious and two other-than-serious violations: “Training did not include that the load becomes an overhead hazard starting at the load block while operating the cranes, located in the molding area; Refresher training was not provided after operators were involved in an accident or a near-miss incident involving the 5-ton crane, located in the used parts bay; Head protection was not utilized when the load block was more than 5 feet in the air while operating the 5-ton crane, located in the used parts bay; The hazard assessment did not include head protection in the molding area while operating the cranes or directing a load when the load block is approximately 5-15 feet in elevation; The alloy steel chain sling was not secured to the frame rail to prevent it from coming off prior to moving the load on the 5-ton crane, located in the used parts bay; Employees were not provided permits to operate the 5-ton overhead crane, located in the used parts bay; A work-related hospitalization was not reported to MIOSHA within 24 hours.” The company had not corrected the hazard at the time of the inspection.

- *Oil Production*

A male in his early thirties sustained a crushing injury when his shirt got caught in the motor of an oil pumpjack and pulled his arm into the jack. The hospital described the injury as a “probable closed degloving,” and the employee was hospitalized. MIOSHA found two serious violations: “The pumpjack that was being serviced had an unguarded belt and pulley to a drive motor; The pumpjack that was being serviced was not locked out or shut down.” The company had not corrected the hazard at the time of the inspection.

- *Agricultural Egg Production*

A male in his mid-twenties was cleaning a conveyor belt that was contaminated with dust and chicken feces when his hand got caught in the moving belt, resulting in a crushing injury, a degloving of part of the hand and some fingers, and other extensive soft tissue damage. MIOSHA found one serious violation: “The egg conveyor did not have power disconnected before cleaning.”

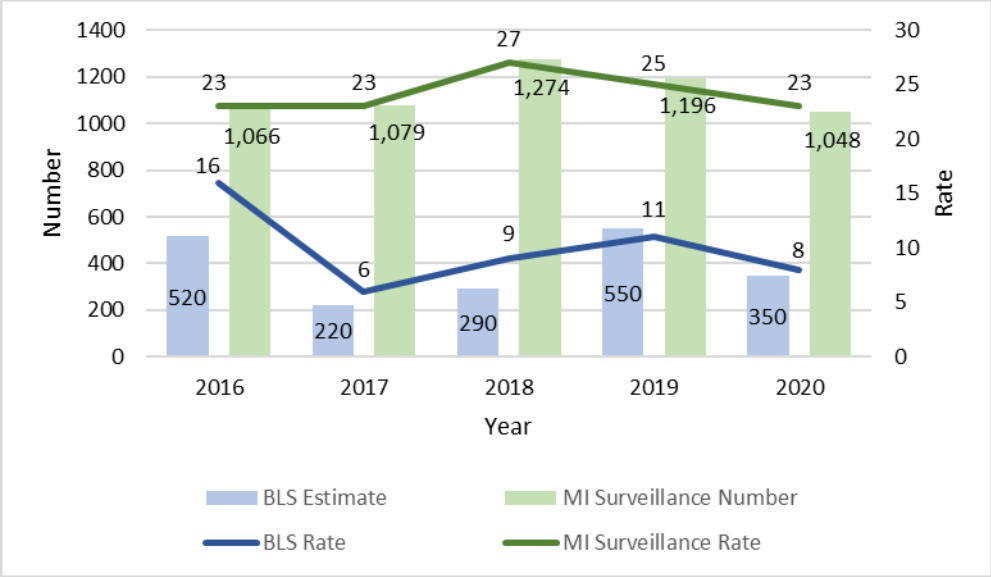
- *Countertop Fabrication, Installation, and Sales*

A male in his early thirties was working as a countertop installer when he sustained a crushing injury after a 1,000-pound granite countertop fell off a cart onto his foot. A co-worker had to free his foot. He was wearing regular shoes, not steel-toed shoes. The injury included severe pain and swelling, lacerations, and multiple fractures to the foot. MIOSHA found one serious and one other-than-serious violation: “Employer did not enforce the use of foot protection when an employee was required to move granite countertops; An employee inpatient hospitalization resulting from a work-related injury was not reported to MIOSHA within 24 hours.”

DISCUSSION

This is the third report on work-related crushing injuries in Michigan. It covers two calendar years, 2019 and 2020. 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 the US BLS, which is the source of official statistics. For years 2019 and 2020, the Michigan system identified 2,244 work-related crushing injuries in comparison to 900 estimated by BLS (Figure 7). The employer-based system identified a much smaller estimate (40.1%) than the Michigan system. BLS' rates of crushing injuries per 100,000 full time equivalents are smaller (11 in 2019 and 8 in 2020) in comparison to the rates of crushing injuries identified in the Michigan multi-source surveillance system (25 in 2019 and 23 in 2020).

Figure 7. Number and Rate of Work-Related Crushing Injuries Comparing BLS and MI Surveillance, Michigan 2016–2020



For 2019 and 2020 BLS estimated only 40.1% of the 2,244 work-related crushing injuries reported in the Michigan's multi-source reporting system. This is a larger estimate than for 2016 through 2018, for which BLS estimated 30.1% of the 3,419 crushing injuries reported in Michigan's multi-source reporting system. The BLS estimate in this report is similar to the estimate in 2013 through 2015, for which BLS estimated 40% of the 3,137 crushing injuries reported in Michigan's multi-source reporting system. The criteria to obtain the estimate were the same for all years.

The BLS's undercount of work-related crushing injuries is partially explained by the fact that BLS only knows the type of injury for 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. 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 95 self-employed individuals in 2019 and 2020, and 96 workers in the Agriculture, Forestry & Fishing NORA Sector Group during the two years of surveillance with work-related crushing injuries so the difference in the type of workers covered in the BLS survey was not 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 73.7% of the 1,762 work-related crushing injuries treated at Michigan hospital and emergency department where source of payment was known. Another 70 (4.0%) were not covered by workers' compensation (i.e., self-employed). Workers' compensation should have paid for 96% of the work-related crushing injuries after excluding the self-employed. We do not know the reasons why workers' compensation was not the payer for the other 22.3% of the hospitalizations/ED visits.

The Workers' Compensation database identified only 383 (17.1%) of the 2,244 work-related crushing injuries. The possible explanations for the Workers' Compensation difference include: 1) The WDCA data set only included crushing injuries that caused seven or more consecutive days away from work, presumably the most severe cases; 2) WDCA excluded the self-employed, but again there were only 95 self-employed workers between 2019 and 2020 in Michigan' multi-source reporting system; 3) Coding or miscoding errors in the WDCA data. The matching with hospital records showed that 249 work-related crushing injuries identified from medical records were not classified as crushing injuries in the WDCA data. Potentially there were other injuries in the WDCA

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 WDCA.

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 2019 and 2020, 38 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. Seventy-nine percent (30) of the inspected companies were cited, and despite a serious injury at those workplaces, 71.1% (27) of the inspected companies had not corrected the hazardous situation months after the injury.

We have developed educational materials for distribution to employers and employees where we see patterns in causes for work-related injuries (https://oem.msu.edu/index.php/work-related-injuries/miface-hazard-alerts).[11] A hazard alert on crushing injuries from presses has been developed (https://oem.msu.edu/images/Alerts/2020/Press_Crush.pdf).[12] Development and distribution of this information allows employers to work with employees to implement effective prevention strategies for injuries at more facilities than where a MIOSHA inspection was performed.

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