Work-Related Skull Fractures in Michigan:
Third Report
(January 2014 – December 2017)

and

Work-Related Hospitalized Intracranial Injuries with Workers' Compensation as the Expected Payer:
First Report
(January 2014 – December 2017)

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Work-Related Skull Fractures in Michigan: Third Report (January 2014 – December 2017)

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Work-Related Hospitalized Intracranial Injuries with Workers' Compensation as the Expected Payer: First Report (January 2014 – December 2017)

A Joint Report of

Michigan State University

and

Michigan Department of Labor and Economic Opportunity

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SKULL FRACTURES

EXECUTIVE SUMMARY

Michigan State University's Occupational and Environmental Medicine Division compiles data on work-related skull fractures in the state of Michigan. This is the third report on occupational skull fractures in Michigan; it covers the years 2014 through 2017. These are the key findings:

- Work-related skull fractures were identified through multiple reporting sources.
    - There were 388 work-related skull fractures, including ten deaths, in 2014.
    - There were 380 work-related skull fractures, including five deaths, in 2015.
    - There were 476 work-related skull fractures, including seven deaths, in 2016.
    - There were 444 work-related skull fractures, including four deaths, in 2017.
- For 2014 through 2017, the Federal reporting system that relies on employer reporting, estimated only 230 work-related skull fractures in Michigan or 13.6% of the 1,688 work-related skull fractures reported in Michigan's multi-source reporting system.
- The most common type of medical encounter was an emergency room visit (60%).
- Seventy-seven percent of all work-related skull fractures were among men.
- Eighty-four percent of all work-related skull fractures were among Caucasians.
- Facial bones were the most common location of the fracture (77.5%).
- The most common type of work-related skull fracture was a depressed skull fracture (broken bone pushed inward) (47.1%).
- Thirty-four percent of individuals lost consciousness due to the head injury.
- Two NORA Sector Groups – Services (except Public Safety) and Manufacturing accounted for almost half (46.9%) of all work-related skull fractures.
- A "fall" was the predominant cause of injury in Construction NORA Sector Group (51.6%). "Struck by" injuries were the leading cause of injuries in the Manufacturing NORA Sector Group (42.3%).
- Workers' Compensation was the expected payer for only 64.6% of the 1,384 cases that were identified in the hospital/ED records.
- The Michigan OSHA program completed inspections at 23 worksites identified by the surveillance system where individuals were injured in 2014 through 2017. MIOSHA issued 40 violations and assessed $134,100 in fines.

BACKGROUND

This is the third report on occupational skull fractures in Michigan. The report is based on data for 2014 through 2017. A skull fracture, which is a crack or break in the cranial (skull) bones, is a small percentage of all traumatic brain injuries (TBI). TBI encompasses a larger category of skull injuries and includes concussions and other conditions without a bone fracture.

Occupational skull fractures are a preventable cause of work-related injury and are among the most severe that can occur in a workplace. A skull fracture is a traumatic injury resulting from exposure to mechanical energy. Mechanical energy injuries include acceleration and deceleration injuries, blunt trauma, and penetrating wound injuries".[1,2] Health professionals and health facilities are required to report individuals with all injuries, including skull fractures, regardless of cause when requested by the Michigan Department of Health and Human Services (MDHHS) or a local health department. The Michigan work-related skull fracture surveillance system, based on mandatory reporting, allows the state to identify causes of work-related skull fractures, target interventions to reduce future skull fractures and evaluate the effectiveness of these interventions.

Nationally, the Bureau of Labor Statistics (BLS), the official source of work-related injury statistics, reported 4,090 work-related skull fractures (excluding fractures to eye(s)) in 2014 (incidence rate of 3 skull fractures per 100,000 full-time workers), 4,170 in 2015 (incidence rate of 4/100,000), 4,650 in 2016 (incidence rate of 4/100,000), and 4,430 in 2017 (incidence rate of 4/100,000).[3-6] The BLS estimates are based on employer reporting. The BLS estimate includes private industry and state and local government workers but not the self-employed. In Michigan, BLS estimated 50 work-related skull fractures in 2014, 50 in 2015, 60 in 2016, and 70 in 2017. This corresponds to a rate in Michigan of 4, 1, 2 and 2 work-related skull fractures per 100,000 full-time workers, respectively.[7-10]

Michigan State University's Occupational and Environmental Medicine Division operates the skull fracture surveillance system as the bona fide agent for the State. Once a work-related diagnosis is confirmed and a case meets designated criteria, Michigan Occupational Safety and Health Administration determines whether to conduct a workplace investigation.

DATA SOURCES AND METHODS

There were three reporting sources of work-related skull fractures in Michigan:

- ➢ Hospitals/Emergency Departments/hospital outpatients
- ➢ Workers' Disability Compensation Agency (WDCA)
- ➢ Michigan Fatality Assessment and Control Evaluation (MIFACE)[11]

All 134 acute care hospitals, including Veterans' Administration Hospitals in Michigan, were required to report work-related skull fractures. Medical records are used to identify work-related skull fractures 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 skull fracture-related ICD-9 diagnosis code was assigned (International Classification of Diseases, Ninth Revision, Clinical Modification)[12]

- ➢ 800.0-.9 – Fracture of vault of skull,
- ➢ 801.0-.9 – Fracture of base of skull,
- ➢ 802.0-.9 – Fracture of face bones,
- ➢ 803.0-.9 – Other and unqualified skull fractures,
- ➢ 804.0-.9 – Multiple fractures involving skull or face with other bones,

or ICD-10-CM diagnostic code[13] was assigned

- ➢ S02 – Fracture of skull and face bones, and

(b) the incident was recorded as having occurred at work.

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

Skull Fracture Injury ICD-9 and ICD-10 Codes:			
ICD-9 CODE		**ICD-10 CODE**	
800.0-.9	Vault of skull	S02	Fracture of skull and face bones
801.0-.9	Base of skull		
802.0-.9	Face bones		
803.0-.9	Other and unqualified skull fractures		
804.0-.9	Multiple fractures involving skull or face with other bones		

*As of October 1, 2015, International Classification of Disease, Clinical Modification (ICD-10-CM), has replaced ICD-9-CM.

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. Cases identified using Michigan's WDCA data were defined as an individual who was in the lost work time wage replacement database with an accepted claim for a fracture ("Nature of Injury" code) to one of the following "Parts of Body": Brain; Cheek/Chin/Jaw; Concussion; Ear(s), unspecified; Ear(s), external; Ear(s), internal; Face, multiple parts; Face, not elsewhere specified; Face, unspecified; Forehead; Head, multiple; Head, unspecified; Mandible; Nasal passages; Nose; Scalp; Sinus; Skull; or Teeth.

Cases identified through the MIFACE program were identified as individuals whose underlying cause of death was from a skull fracture. If the fatality was identified using hospital medical records, it was linked to records in the MIFACE database regardless of the cause of death.

Information from the hospital/ED medical reports and MIFACE reports on each case were abstracted, including: reporting source(s), type of medical care (hospital, ED, outpatient), hospital name, type of visit, date of admission and discharge, patient demographics, city and county of residence, source of payment, employer information (name, address, NAICS code[14]), injury date, cause of injury, type of fracture, loss of consciousness. Once

these skull fracture data were entered into a Microsoft Access database, records were manually linked to records in the WDCA database. Matches were identified using individual's first and last name, date of birth and date of injury. Finally, WDCA cases meeting the work-related skull fracture case definition that did not match with any of the other data sources (i.e. where WDCA was the sole source of the case report) were identified. Information from Workers' Compensation on matched cases and new cases were added to the database. Duplicates identified by more than one reporting source were eliminated, after abstracting all information from every data source. NAICS codes were converted to a NORA Sector Group.[15]

Individuals whose workplaces could not be identified in their medical records and met the criteria for a possible MIOSHA inspection were contacted by telephone to obtain employer information. The criteria for a possible MIOSHA inspection were: 1) the individual had to be hospitalized, treated in an emergency department or as an outpatient at a hospital in 2014, 2015, 2016 or 2017, 2) the injury was not caused by a motor vehicle event or an assault, 3) the injury did not occur to a self-employed individual or an individual employed by an employer not covered by Michigan OSHA (i.e. federal, railroad, merchant marine, dock or mine employees), 4) the circumstances of the injury suggested there was an ongoing hazard and 5) the skull fracture occurred in the last six months.

For cases inspected by MIOSHA, additional information was obtained about the results of the inspection including: inspection date, whether the hazard causing the skull fracture 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 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 2014 through 2017.[16]

The BLS Occupational Injuries and Illnesses and Fatal Injuries Profiles online tool was used to generate the 2014 through 2017 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.[3-10] For 2014 through 2017, code 111XXX (Fractures) and code 183XXX

(Fractures and other injuries) was used. "Head" was selected as the part of body affected to generate the number of fractures to the head. Workers 16 years and older were selected.

RESULTS

In 2014, 388 individuals, in 2015, 380 individuals, in 2016, 476 individuals and in 2017, 444 individuals had a work-related skull fracture.

2014 - 2017 Combined: There were 1,688 work-related skull fractures that represent 1,686 individuals because two individuals sustained two unique skull fractures; one in 2015 and 2016, and one in 2016 and 2017.

Reporting Sources

The number of 2014-2017 work-related skull fractures 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 Skull Fractures, Michigan 2014 - 2017

HOSPITALS/EDs (1,584)

230*

BLS

1,145

420

12   7

7

97

MIFACE (26)

WDCA (524)

Number of Individuals: 1,686
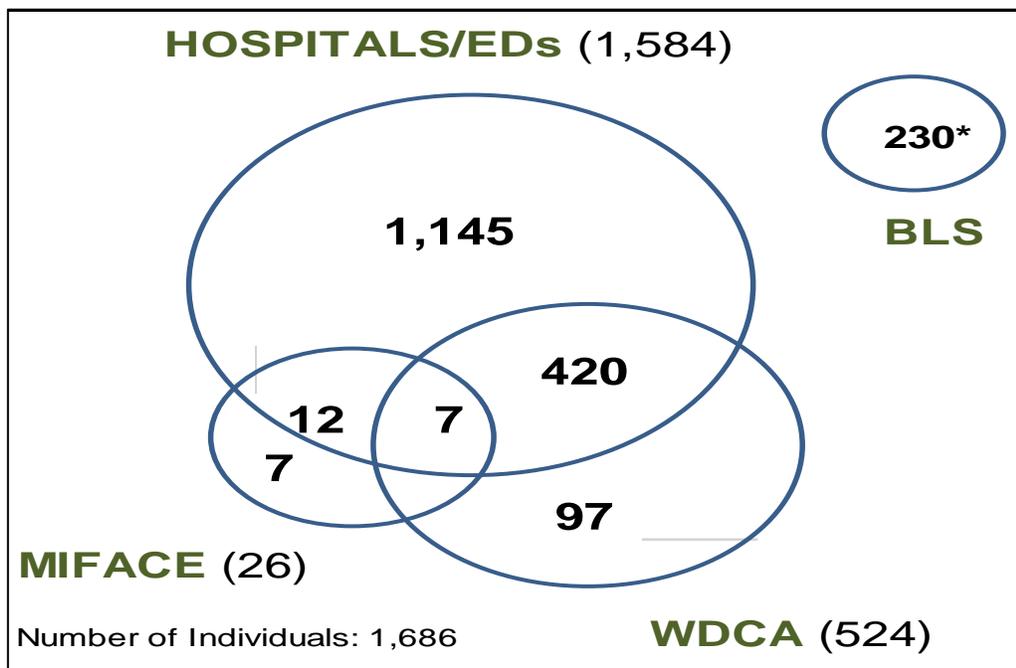
*There is presumably overlap between the 230 estimates of the BLS and the Michigan reporting sources (HDC, MIFACE and WDCA) but BLS does not allow access to their data thus matching to assess the degree of overlap was not possible

2014 - 2017 Reporting Sources

Hospital/ED reports identified 1,584 skull fractures, WDCA 524 skull fractures, and MIFACE 26 fatalities. Hospital/ED reports matched with 420 WDCA reports and 12 MIFACE reports. Another seven skull fractures were identified by all of the reporting sources. Ninety-seven skull fractures were identified by the WDCA data source only. Seven fatalities were identified by the MIFACE source only. Because of confidentiality restrictions, no attempt was made to match the Michigan data set with the BLS data set.

There were 524 WDCA cases identified as work-related skull fractures. Two hundred and four were identified because they had been classified as a fracture to one of the following parts of body: Brain; Cheek/Chin/Jaw; Concussion; Ear(s), external; Ear(s), internal; Ear(s), unspecified; Face, multiple parts; Face, not elsewhere specified; Face, unspecified; Forehead; Head, multiple; Head, unspecified; Mandible; Nasal passages; Nose; Scalp; Sinus; Skull; or Teeth. Of the 204 records, 107 matched with hospital/ED records, and 97 did not match with either hospital/ED or MIFACE records. The other 320 were included because they matched with names from one or more of the other data sources, although they had an injury description in the WDCA database as something other than "Fracture of skull". The descriptions in WDCA for these 320 were: 103 "Multiple Injuries", 56 "Crush/Contusion'", 54 "Fracture" (other than skull), 39 "Unclassified", 28 "Cut/Laceration", 17 "Concussion", 9 Other Injury/Nec, 5 "Strains/Sprains", 4 "Inflam-Joints, 1 "Conjunctivitis", 1 "Eye Diseases", 1 "Ill-Defined", 1 "Suffocation", and 1 "Unknown". Matches were made based on the employee's name, date of birth, date of injury, employee's zip code and employer. An emergency room visit was the most common type of medical encounter, 1,013 (60.0%), followed by hospitalization in 461 (27.3%) cases. The type of medical care that workers received was not available for 97 WDCA cases and seven fatalities.

Table 2. Work-Related Skull Fractures by the Type of Medical Encounter, Michigan 2014 - 2017

Medical Encounter Type	2014-2017	
	Number	Percent
Hospitalization	461	27.3
Emergency Department	1013	60.0
Outpatient	110	6.5
Death Certificate	7	0.4
Unknown	97	5.8
Total	1688	100.0

Characteristics of Injured Workers

Age and Gender

Age and gender were available for all workers with work-related skull fractures. The age of the injured workers ranged from 16 to 93 years. The average age was 41 and median age was 40. One thousand three hundred and fourteen (77.9%) of all work-related skull fractures were among men. Figure 2 displays skull fracture rates by age group and gender. Among males, rates were highest for workers in the 20-24 age group with 18.1/100,000. For females, the age group with the highest rate of skull fractures was 65+ (10.1/100,000).

Figure 2. Work-Related Skull Fracture Rates by Age Group and Gender, Michigan 2014 - 2017*
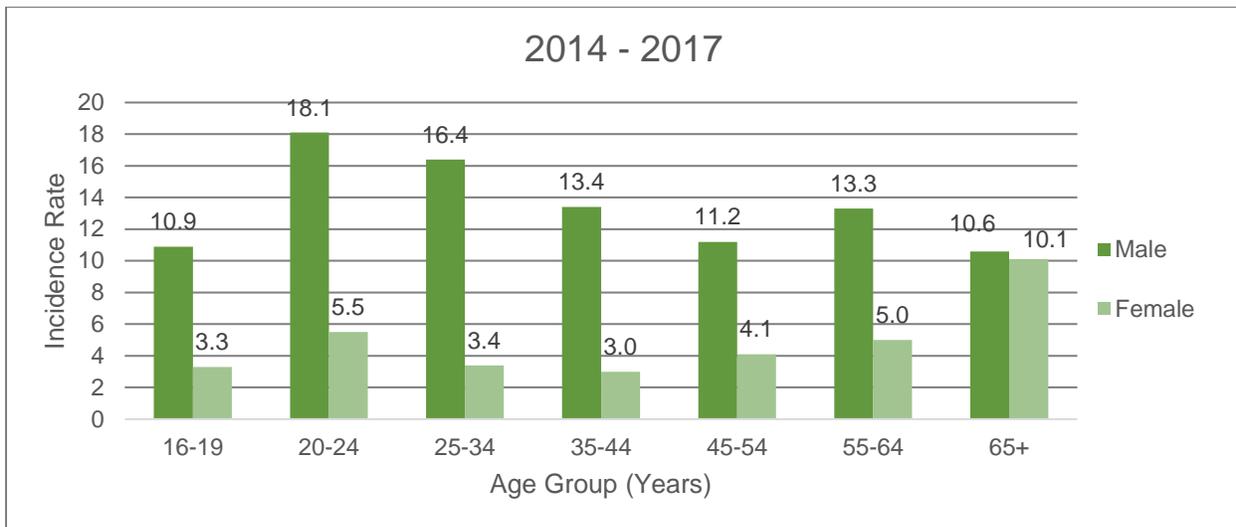
*Data Sources: Number of work-related skull fractures – Michigan hospital/ED medical records and WDCA; Total number of workers – NIOSH Employment Labor Force Query System.
Rates are the number of workers sustaining a skull fracture per 100,000 workers (number of workers employed by age group used to calculate rates: Bureau of Labor Statistics' Current Population Survey).[7,8]

Race and Ethnicity

The race of workers with work-related skull fractures was available for 826 individuals; (49.0%) (Figure 3). Six hundred and ninety-nine (84.6%) were Caucasian, 77 (9.3%) were African-American, 11 (1.4%) were Asian, and 39 (4.7%) were Other.

Information on ethnicity was provided for 525 (31.1%) individuals. Of the 525 individuals, 61 (11.6%) were of Hispanic origin and 464 (88.4%) individuals were not of Hispanic origin.

Figure 3. Race Distribution of Work-Related Skull Fractures, Michigan 2014 - 2017*

2014 - 2017

- Caucasian
- African-American
- Asian
- Other

1.4%
4.7%
9.3%
84.6%
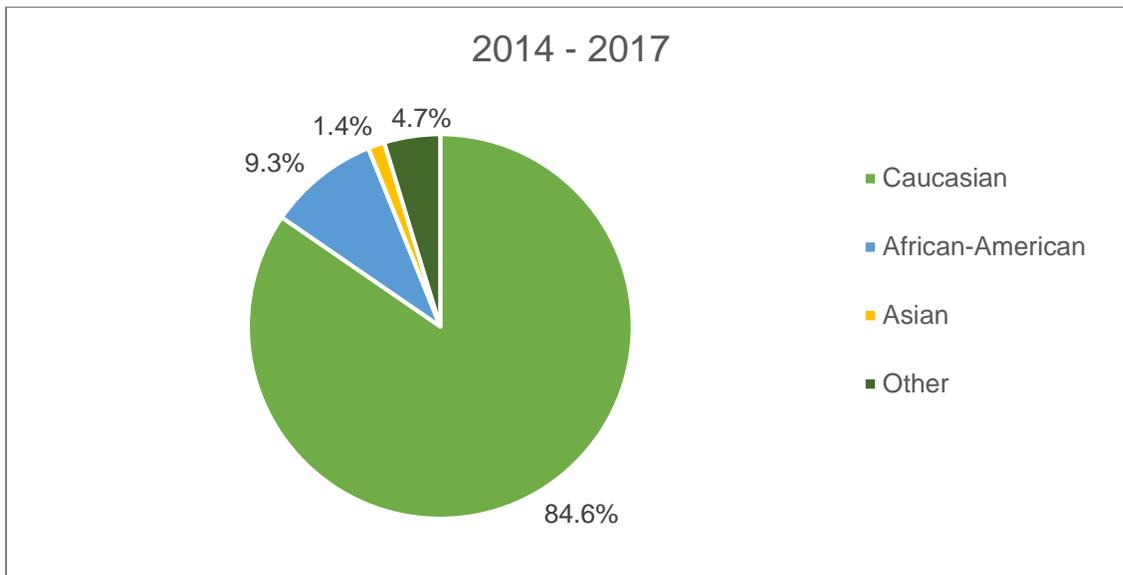
*Race information available for 826 (49.0%) individuals

Part of Skull Injured

Medical records specified the part of skull injured (vault of skull, base of skull, face bones, other and unqualified skull fractures, or multiple fractures involving skull or face with other bones) and were classified by corresponding ICD-9 codes (800.0-.9, 801.0-.9, 802.0-.9, 803.0-.9, 804.0-.9). Since October 1, 2015, the ICD-9-CM classification system has been replaced by the ICD-10-CM system. The ICD-10 diagnosis code S09 (Fracture of skull and face bones) has been used by hospitals to classify and code all skull fracture diagnosis. The discharge summaries of the medical records and emergency department histories and physicals were reviewed to determine the part of skull fractured. Figure 4 illustrates part of skull injured by ICD-9 codes. The WDCA database did not classify injuries by ICD-9/ICD-10 codes but did specify the part of the skull injured, which was then recoded into the ICD-9 codes.

Fractures of facial bones occurred most often (77.5%), followed by fractures of the base of the skull (12.4%), and fractures of the vault of the skull (5.2%) (Table 3).

Figure 4. Part of Skull Injured by ICD-9 Code
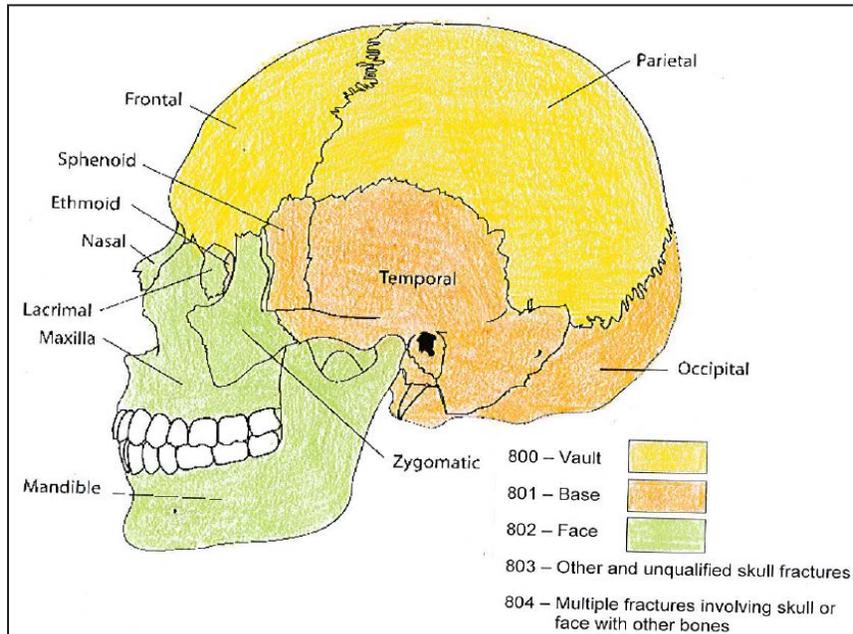
Table 3. Work-Related Skull Fractures by Part of Skull, Michigan 2014 - 2017

Part of Skull Injured	2014 - 2017	
	Number	**Percent**
Vault	87	5.2
Base	210	12.4
Face Bones	1,309	77.5
Other and Unqualified	38	2.3
Multiple	44	2.6
Total	1,688	100.0

Type of Skull Fracture

The severity of a skull fracture depends on its location and the damage done to the bone and surrounding tissue. While there are many types of fractures of the cranial (skull) bones, the main categories are:

➢ Linear (or Hairline) Skull Fracture – a break in a cranial bone resembling a thin line, without splintering or depression of bone,

➢ Depressed Skull Fracture – a break in the cranial bone with depression of the bone in toward the brain,

- Compound Skull Fracture – a break in, or loss of, skin and splintering of the bone,

- Displaced Skull Fracture – a break of the bone into two or more parts and displacement of the bone so that the two ends are not lined up straight,

- Comminuted Skull Fracture – is a fracture in which the bone is in multiple fragments.

The type of skull fracture was only available for 781 (46.3%) of the fractures. There were 368 (47.1%) depressed skull fractures, 242 (31.0%) linear fractures, 81 (10.4%) compound fractures, 60 (7.7%) displaced fractures, and 30 (3.8%) comminuted fractures (Table 4).

Table 4. Work-Related Skull Fractures by Type of Fracture, Michigan 2014 - 2017

Type of Fracture	2014 - 2017	
	Number	Percent
Depressed	368	47.1
Linear	242	31.0
Compound	81	10.4
Displaced	60	7.7
Comminuted	30	3.8
Total	781	100.0

*Type of skull fracture was not specified for 907 (53.7%) cases

Loss of Consciousness

Whether an individual lost consciousness was described for 1,199 (71.0%) cases (Figure 5).

Figure 5. Work-Related Skull Fractures by Loss of Consciousness Status, Michigan 2014 - 2017*
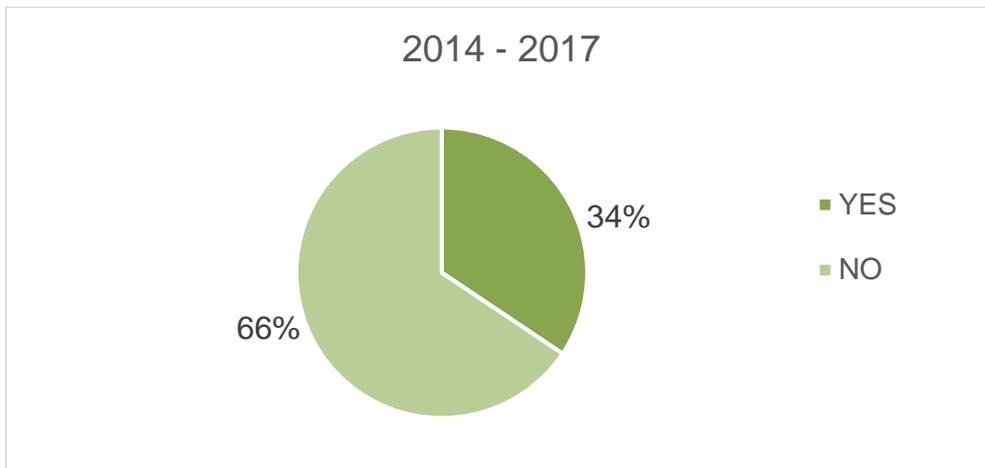
*For 489 (29.0%) cases it was unknown if individuals lost consciousness due to the injury to head

County of Residence

There were 1,539 Michigan residents for whom the county of residence was known (Table 5 and Figure 6). There were 54 out-of-state residents. County of residence was unknown for 93 Michigan residents. 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 skull fracture with 233 (13.8%) cases, followed by 127 (7.5%) cases in Oakland County and 106 (6.3%) cases in Genesee County.

Table 5. Work-Related Skull Fractures by County of Residence, Michigan 2014 - 2017

County	2014 - 2017 Number	Percent	County	2014 - 2017 Number	Percent
Alcona	3	0.2	Leelanau	4	0.2
Alger	6	0.4	Lenawee	20	1.2
Allegan	25	1.5	Livingston	25	1.5
Alpena	5	0.3	Luce	2	0.1
Antrim	0	–	Mackinac	2	0.1
Arenac	4	0.2	Macomb	96	5.7
Baraga	2	0.1	Manistee	7	0.4
Barry	8	0.5	Marquette	10	0.6
Bay	21	1.2	Mason	4	0.2
Benzie	7	0.4	Mecosta	6	0.4
Berrien	23	1.4	Menominee	2	0.1
Branch	12	0.7	Midland	6	0.4
Calhoun	33	2.0	Missaukee	8	0.5
Cass	2	0.1	Monroe	26	1.5
Charlevoix	2	0.1	Montcalm	13	0.8
Cheboygan	6	0.4	Montmorency	2	0.1
Chippewa	4	0.2	Muskegon	22	1.3
Clare	4	0.2	Newaygo	3	0.2
Clinton	22	1.3	Oakland	127	7.5
Crawford	2	0.1	Oceana	8	0.5
Delta	6	0.4	Ogemaw	6	0.4
Dickinson	13	0.8	Ontonagon	2	0.1
Eaton	22	1.3	Osceola	2	0.1
Emmet	6	0.4	Oscoda	0	–
Genesee	106	6.3	Otsego	6	0.4
Gladwin	6	0.4	Ottawa	42	2.5
Gogebic	0	–	Presque Isle	2	0.1
Grand Traverse	16	0.9	Roscommon	2	0.1
Gratiot	11	0.7	Saginaw	21	1.2
Hillsdale	7	0.4	Saint Clair	26	1.5
Houghton	4	0.2	Saint Joseph	7	0.4
Huron	15	0.9	Sanilac	9	0.5
Ingham	48	2.8	Schoolcraft	0	–
Ionia	24	1.4	Shiawassee	10	0.6
Iosco	1	0.1	Tuscola	7	0.4
Iron	3	0.2	Van Buren	14	0.8
Isabella	9	0.5	Washtenaw	40	2.4
Jackson	30	1.8	Wayne	233	13.8
Kalamazoo	48	2.8	Wexford	39	2.3
Kalkaska	3	0.2	Out of State	54	3.2
Kent	87	5.2	Unknown	93	5.5
Keweenaw	0	–			
Lake	2	0.1	**Total**	1686	100.0
Lapeer	20	1.2			

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Figure 6   Work-Related Skull Fractures by County of Residence, Michigan 2014-2017

Number of Skull Fractures

☐	0
▨	1- 3
▦	4 - 9
▨	10 - 29
■	30+
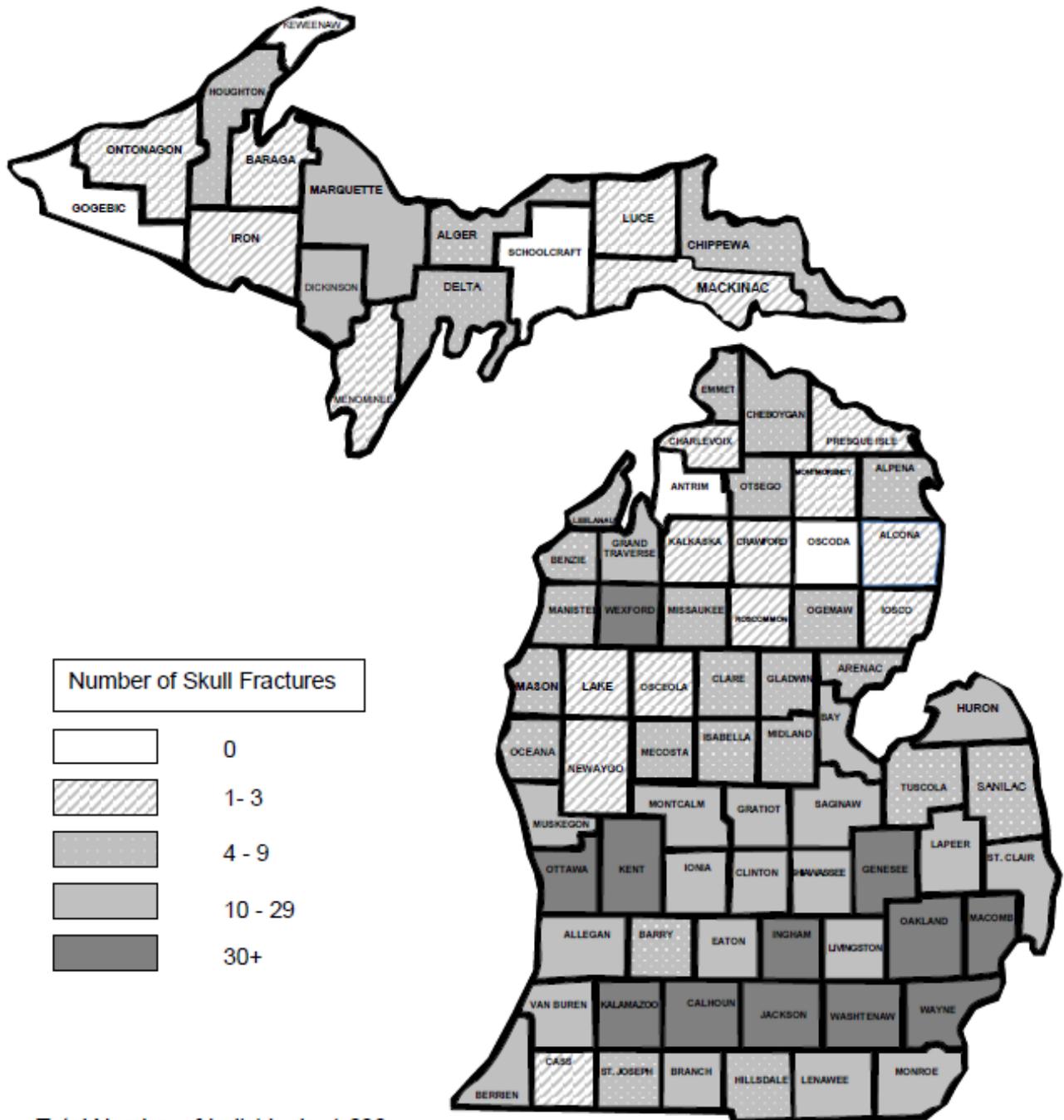
Total Number of Individuals: 1,686
Out of State Individuals: 54
County was unknown for 93 individuals

Cause of Injury

Causes of skull fractures were:

➤ Fall – a fall can be to the same level (i.e. trip while walking on the floor) or to a lower level (e.g. from a ladder, working on a roof or scaffolding).

➤ Struck By – Falling objects, (e.g. while being beneath cranes that move loads or scaffolds); flying objects, (e.g. when power tools may cause objects to become airborne); struck by moving machinery; hit by an animal.

➤ Motor Vehicle Crash (MVC) – a vehicle collides with another vehicle, pedestrian, animal, or some stationery obstruction, e.g. a tree or utility pole.

➤ Assault – A person is intentionally hit in the head (e.g. robbery, teacher by a student, patient in a health care setting).

➤ Machine – Malfunction of a machine or equipment (e.g. being "caught" inside a sanding machine, grinder).

➤ Medical Condition – medical conditions such as syncope or fainting, which lead to a transient loss of consciousness and postural tone.

➤ Other – Includes different types of injury sources that did not fall into the six specific categories (e.g. turning around and walking into an industrial hook, suicide).

The cause of work-related skull fractures was specified for 1,513 (89.6%) cases (Figure 7). It was unknown for 175 cases. The predominant cause of a skull fracture was a struck by incident in 510 (33.7%) cases, followed by a fall in 498 (32.9%) cases, an assault in 225 (14.9%) cases, a motor vehicle crash in 89 (5.9%) cases, medical condition in 79 (5.2%) cases, "other" in 79 (5.2%%) cases, and a machine in 33 (2.2%) cases. Skull fractures due to fall and struck by incidents accounted for two-thirds of all skull fractures. When the NORA Sector was specified, the Construction industry sector had the highest percentage of skull fractures due to a fall with 94 (51.64%) cases, followed by the Healthcare and Social Assistance industry sector with 40 (33.6%) cases (Table 6). Among

hospitalized individuals, fall was the cause of the skull fracture for 217 (48.3%) cases, followed by struck by for 102 (22.7%) cases. Of twenty-six fatalities between 2014 and 2017, fifteen were caused by a fall, five from being struck by an object, three were due to a medical condition, one from an assault, one from a machine, and one from a self-inflicted gunshot wound.

Figure 7. Work-Related Skull Fracture by Cause of Injury, Michigan 2014 - 2017*
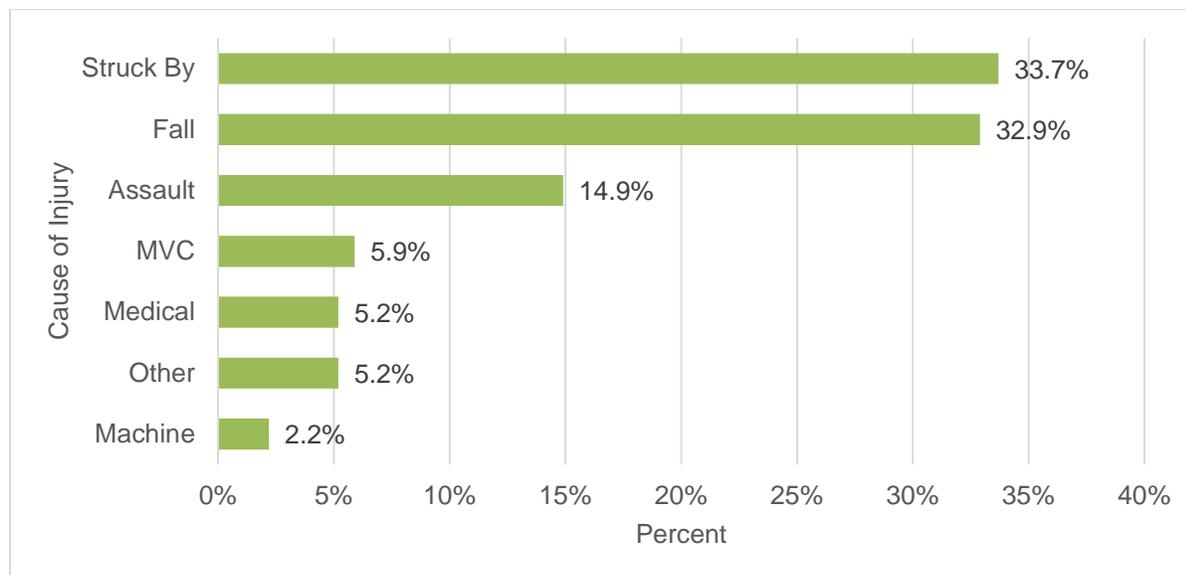
*Cause of injury was specified for 1,513 (89.6%) cases

NORA Sector Groups

For 1,383 (81.9%) cases, including 69 self-employed individuals, there was sufficient information to determine their National Occupational Research Agenda (NORA) Sector Group classification (Table 6). One individual with work-related skull fracture was a prisoner on work details. Services (except Public Safety) Sector Group had the highest number of work-related skull fractures with 436 (31.5%) cases, followed by Manufacturing Sector Group with 213 (15.4%) cases and then Wholesale and Retail Trade Sector Group with 201 (14.5%) cases. Oil and Gas Extraction Sector Group had the highest rate of skull fractures with 195.0/100,000 workers, followed by Agriculture, Forestry and Fishing (except Wildland Firefighting) Sector Group with 34.1/100,000 workers.

Table 6. Work-Related Skull Fractures by Industry, Michigan 2014 - 2017*

NORA Sector Group	NAICS Code	Number	Percent	Rate[1]
Agriculture, Forestry & Fishing (except Wildland Firefighting)	11	78	5.6	34.1
Construction	23	182	13.2	18.7
Healthcare & Social Assistance	62, 54194, 81291	119	8.6	4.4
Manufacturing	31-33	213	15.4	6.2
Mining (except Oil & Gas Services)	21	2	0.1	23.4
Oil & Gas Extraction	211, 213111, 213112	4	0.3	195.0
Public Safety (including Wildland Firefighting)	92212, 92214, 92216, 62191	31	2.2	8.2
Services (except Public Safety)	51, 52, 53, 54, 55, 56, 61, 71, 72, 81, 92	436	31.5	6.0
Transportation, Warehousing & Utilities	48-49, 22	117	8.5	13.8
Wholesale & Retail Trade	42, 44-45	201	14.5	8.4
Total		1,383	100.0	7.6

*Sufficient information for sector groups classification was available for 1,383 (81.9%) cases.
[1]Rates are the number of workers sustaining a skull fracture per 100,000 workers. Number of workers by NORA Group Sectors used to calculate rates: NIOSH Employment Labor Force Query System.

Top Five NORA Sector Groups by Cause of Injury

Table 7 illustrate the top five NORA Sector Groups by cause of injury. "Struck by" was the predominant cause of skull fracture within the Manufacturing (42.3%) and Wholesale and Retail Trade (32.5%) Sector Groups. "Fall" was the predominant cause of a skull fracture in Construction (51.6%), Services (except Public Safety) (28.2%) and Healthcare and Social Assistance (33.6%) Sector Groups.

Table 7. Top Five NORA Sector Groups by Cause of Injury, Michigan 2014 - 2017

NORA SECTOR	Struck By	Fall	Machine	Assault	MVC	Other	Medical Condition	Unknown	TOTAL
Services (except Public Safety)	102	123	4	66	24	28	28	61	436
Manufacturing	90	41	11	18	4	7	16	26	213
Wholesale & Retail Trade	65	60	6	23	7	9	8	23	201
Construction	54	94	1	2	10	5	4	12	182
Healthcare & Social Assistance	15	40	0	30	7	7	5	15	119

Source of Payment

Workers' Compensation was the expected payer in 894 (64.6%) of the 1,384 work-related skull fractures for which source of payment was in the medical record (Table 8). For 200 skull fractures payment source could not be identified. Of the 490 cases for which Workers' Compensation was not listed as a payment source in medical records, 49 were matched to a case in the WDCA database. Of those 49 cases, 17 were classified as a skull fracture and 32 had an injury description in the WDCA database as something other than "skull fracture".

Table 8. Work-Related Skull Fractures by Payment Source, Michigan 2014 - 2017

Expected Source of Payment	2014 - 2017	
	Number	**Percent**
Workers' Compensation	894	64.6
Commercial Insurance	269[1]	19.4
Medicare/Medicaid	126[2]	9.1
Self-Pay	95[3]	6.9
Total	1,384*	100.0

Data Source: Michigan hospital/ED medical records.
*Payment source was unknown for 255 (15.1%) cases
[1]Includes 31 self-employed workers, [2]Includes 20 self-employed workers,
[3]Includes 7 self-employed workers

MIOSHA Inspections

MIOSHA inspected twenty-three workplaces where skull fractures, including eight workplaces where a fatal injury occurred. Table 9 illustrates the distribution of violations and penalties assessed by the NORA Sector Group type of the twenty-three inspected workplaces. In 14 of the 23 (60.9%) companies, the hazard that caused the skull fracture had not been corrected at the time of the inspection, which was conducted three to six months after the skull fracture occurred.

Table 9. Workplaces Inspected by MIOSHA: Violations and Penalties Assessed by Industry, Michigan 2014 - 2017

NORA Sector Group	# of Enforcement Inspections	# of Companies Cited	# of Violations	# of Recom-mendations	Total Penalties Assessed
Construction	12	10	29	0	$118,300
Manufacturing	6	4	7	0	$9,300
Wholesale and Retail Trade	3	3	3	3	$6,150
Services (except Public Safety)	1	1	1	0	$350
Total	23*	18	40	3	$134,100

*Includes eight inspections of fatal injuries

Examples of Work-Related Skull-Fracture MIOSHA Enforcement Inspections

➢ *Roofing Contractors*

A roofer in his early fifties died when he fell 17-20 feet when walking down a purlin to obtain a piece of roof sheeting during the construction of a pole barn. It was the decedent's first day on the job. The decedent and his three coworkers had been assigned to install 4-foot by 8-foot pieces of ½-inch insulation and then cover the insulation with roof steel. The work crew had installed approximately seven pieces of insulation and four sheets of steel. At the time of the incident, two coworkers were walking down the screwed down roof steel to get the next sheet of steel from the ground person. The ground person had walked down the purlins and was in a rough terrain forklift truck with an attached scaffold platform, getting ready to hand up the next sheet of steel. The decedent was walking down the purlins to assist placement of the next sheet of steel when he stepped onto the foam insulation. He fell through the insulation onto the concrete surface. His coworkers called for emergency response. Several workers attended the decedent while one coworker went to the road to direct emergency responders. MIOSHA found three serious violations, including: "An accident prevention program was not developed, maintained, or coordinated with employees at the job site. Employees were exposed to the hazards on the job site while performing roofing/framing activities; Employees were exposed to fall hazards while performing roofing work on a 4 in 12 pitch roof (Work includes installing 4 ft. by 8 ft. by ½ in. sheets of foam insulation and metal roofing materials. Fall protection is up to approximately 30 feet at the peak); Employees who are exposed to fall hazards have no training to minimize

those hazards. Employees doing framing, truss setting, bracing, and roofing work are exposed to falls of up to approximately 30 feet."

Figure 8. Pictures of the roof through which the decedent fell

➢ *Aluminum Die-Casting Foundry*

A male in his mid-fifties, whose job function was production manager, sustained multiple fractures to his head and face while operating an aluminum die cast machine with a cold chamber. The employee was hospitalized for three days. The employee opened the interlocked safety door and leaned into the machine to clean stuck aluminum solder off of the mold with a wand that sprayed a release agent, without locking out or turning off the machine. The die began to close and his head was caught between the water tree and one of the dies. It was later discovered that the interlock switch was stuck and not working. MIOSHA found four (three serious and one other) violations, including: "No equipping die casting machine with interlocked safety door or metal shielding to protect employees from inadvertent metal splash or squirting from the parting line; Not providing interlocked door or barrier to keep employee from reaching into point of operation on automatic die casting machine; The employer has not enforced the following elements of Part 45, Rule 4525(1): A. Employees do not lockout aluminum die cast presses or extractions when cleaning solder off the inside of the molds, while making adjustments to the sensor wires on the extractor. C. There is no employee identification of locks. D. One lock used for multiple employees servicing one die cast press. E. No verification of isolated energy source. F. No periodic inspections of lockout performed; Each recordable injury or illness was not entered on the MIOSHA 300 log and/or an incident report (MIOSHA 301 or equivalent) within seven calendar days of receiving information that a recordable injury or illness had occurred." The company had not corrected the hazard at the time of the inspection.

Figure 9. Pictures of the aluminum die cast machine with a cold chamber

➤ *Motor Vehicle Supplies and New Parts Merchant Wholesaler*

A male in his late fifties, whose job function was production operator, was performing a routine burst test with the hydraulic press and test fixture when a top portion/piece of the tooling flew out and struck the operator in the nose and forehead. The employee was hospitalized for four days for reconstructive surgery fora nasal and other facial fractures. A part is placed between two metal cylindrical blocks and downward pressure is applied hydraulically by means of foot pedal until the part bursts/cracks. When the production manager was performing this test, the top piece of tooling, under pressure from the ram, shot out from the confines of the machine and struck the operator. At the time, there was no guard or shield to contain the tooling within the machine. Full barrier guarding had since been installed with an interlocked door. MIOSHA found one serious violation and cited the company for "having a point of operation guard or device not being as prescribed in a specific standard, or, in the absence of a specific standard, being designed and constructed, when required, to prevent the machine operator exposed to the hazard from having any part of his body in the hazardous area during the operating cycle." MIOSHA has issued a recommendation that "full barrier guarding be installed around the entire perimeter to include an interlocked door on all of the hydraulic burst tester machines." The company corrected the hazard before the inspection.

➤ *Wood Container and Pallet Manufacturing*

A female in her early fifties, sustained a fracture to her nose when a wood cant struck the employee's nose. Cants were removed from a feed conveyor and placed on a resaw conveyor. Cants were moving down the feed conveyor and stopping at the kicker gate prior to being hand placed onto the resaw conveyor. The cants

began to pile up next to the kicker gate as it was having some hydraulic drifting problems. The cants piled up high enough to protrude over the kicker plate. One of the cants became loose and was projected at the employees face approximately 32 inches from the kicker gate. A cant was approximately 4'x4", width and length and approximately 36 inches in length weighting approximately 10 pounds. MIOSHA found one serious violation and cited the company for "not having the hydraulic cylinder on the kicker gate hold pressure to keep cants from being released and not maintaining a hazard-free condition." The company had not corrected the hazard at the time of the inspection.

Figure 10. Pictures of the feed conveyor and the resaw conveyor


➢ *Framing Contractors*

A male in his early forties fell from a second story scaffold. The employee lost consciousness due to the fall and sustained multiple fractures of the pelvis, a fractured vertebrae, a fractured nose, plus various lacerations. The employee was hospitalized for seven days. MIOSHA found three violations (one serious and two other-than-serious), including: "An employer did not have each employee who is involved in erecting, disassembling, moving, operating, repairing, maintaining, or inspecting a scaffold trained by a competent person to recognize any hazards associated with the work in question. The training shall include the following topics, as applicable: A. The nature of scaffold hazards. B. The correct procedures for erecting, disassembly, moving, operating, repairing, inspecting, and maintaining the type scaffold being used. C. The design criteria, minimum intended load-carrying capacity, and intended use of the scaffold. D. Any other pertinent requirements; An employer did not develop, maintain, and coordinate with employees an accident prevention program, a copy of which shall be available at the work site; A person who has a valid certificate in first aid training was not

present at the work site to render first aid." The company had not corrected the hazard at the time of the inspection.

➢ *Machine Shops*

A male in his fifties, was working in an unapproved lift basket that was not secured to the forks of the truck being used for the lift, when he fell to the floor striking his head and sustaining a skull fracture. The employee lost consciousness due to the fall and was hospitalized for 8 days. The employee was in a raised position when he moved, transferring his body weight to an overhanging portion of the basket. The basket tilted and fell off of the forks not being positioned with a restraint engaged to hold it in place. MIOSHA found one serious violation and cited the company for "raising an employee using an inadequate work platform, which was a standard material basket with approximate 32-inch rails, and it was not restrained to prevent it from falling." The company corrected the hazard before the inspection.

Figure 11. Pictures of the parts baskets used as lift baskets
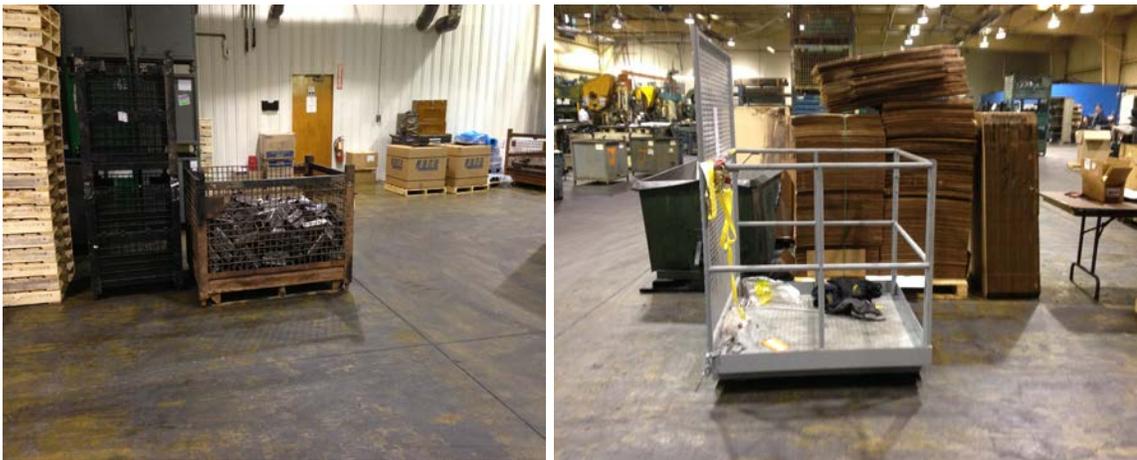
HOSPITALIZED INTRACRANIAL INJURIES WITH WORKERS' COMPENSATION AS THE EXPECTED PAYER

EXECUTIVE SUMMARY

Michigan State University's Occupational and Environmental Medicine Division compiles data on work-related skull fractures in the state of Michigan. This is the first report on occupational hospitalized intracranial injuries (with no fractures of the skull) with Workers' Compensation as the expected payer in Michigan; it covers the years 2014 through 2017 and is based on the hospital medical records only. These are the key findings:

- Work-related intracranial injuries were identified through hospital medical records.
    - ➢ There were 44 work-related intracranial injuries in 2014.
    - ➢ There were 59 work-related intracranial injuries in 2015.
    - ➢ There were 68 work-related intracranial injuries in 2016.
    - ➢ There were 48 work-related intracranial injuries in 2017.
- There were an additional 73 (12 cases in 2014, 19 cases in 2015, 38 cases in 2016 and 4 cases in 2017) hospitalized overnight intracranial injuries with Workers' Compensation as the expected payer that had a skull fracture as an underlying cause of injury and therefore were included in the 2014-2017 skull fractures dataset and not in this intracranial injuries report.

- There were 878 (232 cases in 2014, 183 cases in 2015, 243 cases in 2016 and 220 cases in 2017) WDCA cases in 2014-2017 identified as concussions (brain, cerebral). Of the 878 WDCA cases, 22 matched with hospital medical reports and 856 did not match with hospital reports. There were additional 96 WDCA cases that matched with names from medical records, although they had an injury description in the WDCA database as something other than a "concussion". WDCA data does not include information on whether an individual concussion was hospitalized and therefore this dataset was not included in the total number of work-related hospitalized intracranial injuries.

- MIFACE Program identified 31 fatalities with underlying cause of death from intracranial injuries (i.e. subdural hematoma, craniocerebral trauma, blunt head trauma). None of the 31 fatalities were identified by hospital medical records as hospitalized cases with Workers' Compensation as the expected payer. These cases were not included in the total.

- For 2014 through 2017, the Federal reporting system that relies on employer reporting, estimated 2,190 work-related intracranial injuries; these are all reported intracranial injuries, irrespective of employees' medical encounter type.

- Seventy-nine percent of all work-related intracranial injuries were among men.

- Eighty-four percent of all work-related intracranial injuries were among Caucasians.

- "Fall" was the predominant cause of intracranial injuries and accounted for over half of injuries (53.7%).

- Three NORA Sector Groups– Services (except Public Safety), Construction and Manufacturing Sector Groups accounted for over half (59.7%) of all work-related intracranial injuries.

- The Michigan OSHA program completed inspections at four worksites identified by the surveillance system where individuals were injured in 2014 through 2017. MIOSHA issued four violations and assessed $6,500 in fines.

BACKGROUND

Beginning in 2014, we expanded the work-related skull fracture surveillance to include individuals hospitalized overnight with work-related intracranial injuries, including bleeds and concussions, with Workers' Compensation as the expected payer (Table 10). This is the first report on work-related hospitalized intracranial injuries with Workers' Compensation as the expected payer in Michigan. The report is based on data for 2014 through 2017.

Nationally, the Bureau of Labor Statistics (BLS), the official source of work-related injury statistics, reported 15,810 work-related intracranial injuries in 2014 (incidence rate of 15 workers with intracranial injuries per 100,000 full-time workers), 19,100 in 2015 (incidence rate of 17/100,000), 20,180 in 2016 (incidence rate of 18/100,000), and 19,920 in 2017 (incidence rate of 18/100,000).[17-20] The BLS estimates are based on employer reporting. The BLS estimate includes private industry and state and local government workers but not the self-employed. For Michigan, the BLS reported 490 work-related intracranial injuries in 2014, 410 in 2015, 710 in 2016, and 580 in 2017. This corresponds to a rate of 16, 13, 21 and 17 work-related intracranial injuries per 100,000 full-time workers, respectively.[21-24]

DATA SOURCES AND METHODS

There were three reporting sources of work-related hospitalized intracranial injuries with Workers' Compensation as the expected payer in Michigan:

> ➢ Hospitals/Emergency Departments/hospital outpatients
> ➢ Workers' Disability Compensation Agency (WDCA)
> ➢ Michigan Fatality Assessment and Control Evaluation (MIFACE)[11]

All 134 acute care hospitals, including Veterans' Administration Hospitals in Michigan, were required to report work-related intracranial injuries with workers' compensation as the expected payer and an overnight hospital stay. Cases to be reported were defined as any individual receiving medical treatment at a Michigan hospital for whom:

(a) an intracranial injury-related ICD-9 diagnosis code was assigned (International Classification of Diseases, Ninth Revision, Clinical Modification)[12] (Table 10)

- 850.0-.9 – Concussion,

- 851.0-.9 – Cerebral laceration and contusion,

- 852.0-.5 – Subarachnoid, subdural and extradural hemorrhage,

- 853.0-.1 – Other and unspecified intracranial hemorrhage,

- 854.0-.1 – Other and unspecified nature-intracranial injury,

or ICD-10-CM diagnostic code[13] was assigned

- S04 – Optic nerve and pathways,

- S06 – Intracranial injury,

- S09.8 – Other specified injuries of head,

- S09.9 – Unspecified injury to face and head,

(b) the incident was recorded as having occurred at work, and

(c) Workers' Compensation was the expected payer.

The Michigan WDCA provided access to a database of 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. Cases identified using Michigan's Workers' Compensation system were defined as an individual who was in the lost work time wage replacement database with an accepted claim for a "Concussion (brain, cerebral)" ("Nature of Injury" code) to one of the following "Parts of Body" code: Brain; Head, multiple; Head, unspecified; or Skull.

Cases identified through the MIFACE program were identified as individuals whose underlying cause of death were from an intracranial injury. If the fatality was identified using hospital medical records, it was linked to records in the MIFACE database regardless of the cause of death.

Table 10. Work-Related Hospitalized Intracranial Injury ICD-9 and ICD-10 Diagnosis Codes*

Intracranial Injury ICD-9 and ICD-10 Codes:			
ICD-9 CODE		**ICD-10 CODE**	
850.0-.9	Concussion	S04.0	Optic nerve and pathways
851.0-.9	Cerebral laceration and contusion		
852.0-.5	Subarachnoid, subdural and extradural hemorrhage	S06	Intracranial injury
853.0-.1	Other and unspecified intracranial hemorrhage	S09.8	Other specified injuries of head
854.0-.1	Other and unspecified nature-intracranial injury	S09.9	Unspecified injury to face and head

*As of October 1, 2015, International Classification of Disease, Clinical Modification (ICD-10-CM), has replaced ICD-9-CM.

Information from the hospital medical reports were abstracted, including: type of medical care (hospital, ED, outpatient), hospital name, date of admission and discharge, patient demographics, city and county of residence, employer information (name, address, NAICS[14] code), self-employed status, injury date, cause of injury, ICD-9/ICD-10 code. Once these hospitalized intracranial injury data were entered into a Microsoft Access database, records were manually linked to records in the WDCA database. Matches were identified using individual's first and last name, date of birth and date of injury. Finally, WDCA cases meeting the work-related intracranial injury case definition that did not match with any of the other data sources (i.e. where WDCA was the sole source of the case report) were identified. Information from Workers' Compensation on matched cases were added to the database. NAICS codes were converted to a NORA Sector Group.[15]

Individuals whose workplaces could not be identified in the records and met the criteria for a MIOSHA inspection were contacted by telephone to obtain employer information. The criteria for a MIOSHA inspection were: 1) the individual had to be hospitalized in 2014, 2015, 2016 or 2017, 2) the injury was not caused by a motor vehicle event or an assault, 3) the injury did not occur to a self-employed individual or an individual employed

by an employer not covered by Michigan OSHA (i.e. federal, railroad, merchant marine, dock or mine employees), 4) the circumstances of the injury suggested there was an ongoing hazard and 5) the intracranial injury occurred in the last six months.

For cases whose employers were inspected by MIOSHA, additional information was obtained about the results of the inspection, including: inspection date, number of violations, whether the hazard causing the injury were corrected at the time of the inspection, and total fines assessed.

Data analysis was performed using queries conducted in Microsoft Access. The NIOSH Employment Labor Force 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 2014 through 2017.[16]

The BLS Occupational Injuries and Illnesses and Fatal Injuries Profiles online tool was used to generate the 2014 through 2017 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.[3-10] For 2014 through 2017, code 16XXXX (Intracranial Injuries) was used. All workers, irrespective of their age, were selected.

RESULTS

In 2014, 44 individuals, in 2015 59 individuals, in 2016 68 individuals and, in 2017 48 individuals had a work-related intracranial injury reported from hospital for which Workers' Compensation was the expected payer.

2014 - 2017 Combined: There were 219 work-related hospitalized overnight intracranial injuries with Workers' Compensation as the expected payer.

There were an additional 73 (12 cases in 2014, 19 cases in 2015, 38 cases in 2016 and 4 cases in 2017) hospitalized overnight intracranial injuries with Workers' Compensation as the expected payer that had a skull fracture as an underlying cause of injury and therefore were included in the 2014-2017 skull fractures dataset and not in the intracranial injuries dataset.

Reporting Sources

Michigan hospitals identified 219 work-related hospitalized overnight intracranial injuries with Workers' Compensation as the expected payer.

There were 878 (232 cases in 2014, 183 cases in 2015, 243 cases in 2016 and 220 cases in 2017) WDCA cases identified as concussions (brain, cerebral) to one of the following parts of the body: Brain; Head, multiple; Head, unspecified; or Skull, and only 22 matched with hospital records.

WDCA did not provide information on whether and what type, if any, medical encounter injured individuals had received for their head injuries (e.g. emergency room visit, hospitalization, an outpatient visit at a hospital-based clinic, or individuals may have received medical care at an urgent care or at a primary physician's office). This dataset, except for matches described below, was not included in the total number of work-related hospitalized intracranial injuries. Of the 878 WDCA cases that were identified because they had been classified as concussion, 22 matched with hospital reports and 856 did not match with hospital reports. There were additional 96 WDCA cases that matched with names from medical records, although they had an injury description in the WDCA database as something other than a "concussion". The descriptions in WDCA for these 96 were: 27 "Multiple Injuries", 23 "Crush/Contusion", 14 "Unclassified", 13 "Fracture", 8 "Cut/Laceration", 7 "Strain/Sprain", 1 "Multiple Injuries", 1 "Dislocation", 1 "Electric Shock", and 1 "Other Injury/NEC". Matches were made based on the employee's name, date of birth, date of injury, employee's zip code and employer.

MIFACE Program identified 31 fatalities with underlying cause of death from intracranial injuries (i.e. subdural hematoma, craniocerebral trauma, blunt head trauma). None of the 31 fatalities were identified by hospital medical records as hospitalized cases with Workers' Compensation as the expected payer.

Characteristics of injured workers

Age and Gender

Age and gender were available for all workers with work-related hospitalized intracranial injuries with Workers' Compensation as the expected payer. The age of the injured workers ranged from 16 to 90 years. The average age was 46 and median age was 48. One hundred and seventy-three (79%) of all work-related intracranial injuries were among men. Figure 12 displays intracranial injuries rates by age group and gender. Among males, rates were highest for workers in the 65+ age group with 2.9/100,000. For females, the age group with the highest rate of skull fractures was 55-64 (1.3/100,000).

Figure 12. Work-Related Hospitalized Intracranial Injury with Workers' Compensation as the Expected Payer Rates by Age Group and Gender, Michigan 2014 - 2017*
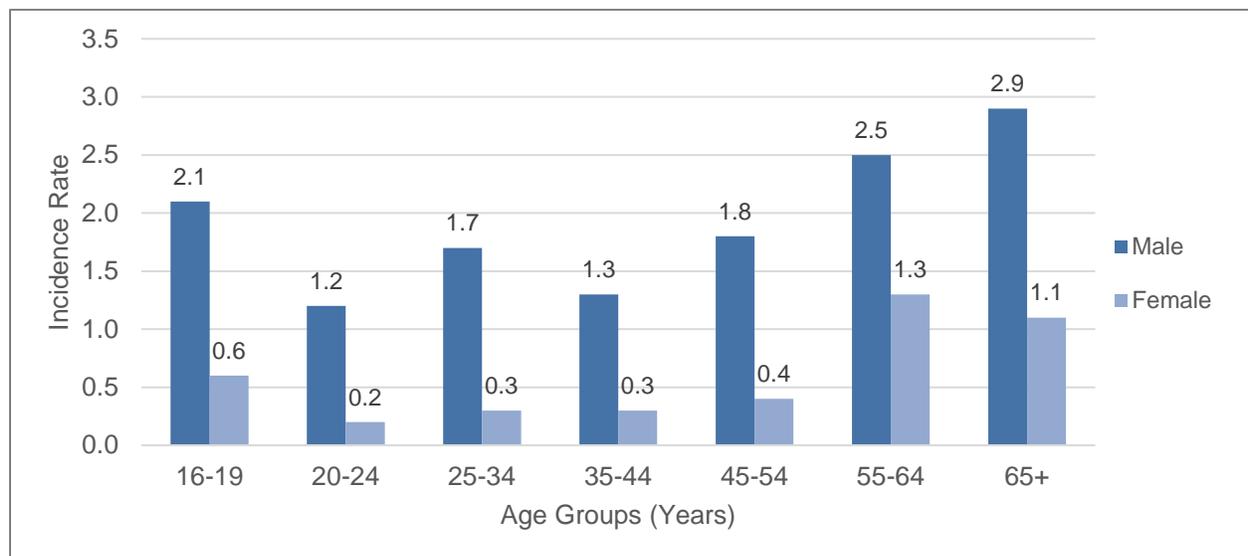
*Data Sources: Number of work-related hospitalized intracranial injuries with Workers' Compensation as the expected payer – Michigan hospital medical records; Total number of workers – NIOSH Employment Labor Force Query System

Race and Ethnicity

Among the workers for whom race was available (140; 63.9%), 118 (84.3%) were Caucasian, 13 (9.3%) were African-American, 1 (0.7%) was Asian, and 8 (5.7%) were Other.

Of the 53 individuals where ethnicity was available; 9 (17%) were of Hispanic origin and 44 (83%) individuals were not of Hispanic origin.

County of Residence

There were 206 Michigan residents for whom the county of residence was known. There were nine out-of-state residents. County of residence was unknown for two Michigan residents. For two workers county and state information was not provided. 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 hospitalized intracranial injury with 42 (19.4%) cases, followed by 22 (10.1%) cases in Oakland County and 16 (7.4%) cases in Macomb County.

Cause of Injury

The categories of the causes of intracranial injuries were the same as in the skull fractures report (See page 16).

The cause of work-related hospitalized intracranial injuries with Workers' Compensation as the payer was specified for 214 (97.7%) cases (Figure 13). It was unknown for five cases. The predominant cause of hospitalized intracranial injuries was a fall in 115 (53.7%) cases, followed by a struck by incident in 43 (20.1%) cases, motor vehicle crash in 42 (19.6%) cases, an assault in six (2.8%) cases, a machine in three (1.4%) cases, medical condition in three (1.4%) cases, and "other" in two (0.9%) cases. Hospitalized intracranial injuries due to fall and struck by incidents accounted for over two-thirds of all hospitalized intracranial injuries. When the NORA Sector Group was specified, the Manufacturing industry sector had the highest percentage of intracranial injuries due to a fall with 20 (58.8%) cases (Table 12).

Figure 13. Work-Related Hospitalized Intracranial Injuries with Workers' Compensation as the Expected Payer by Cause, Michigan 2014 - 2017*
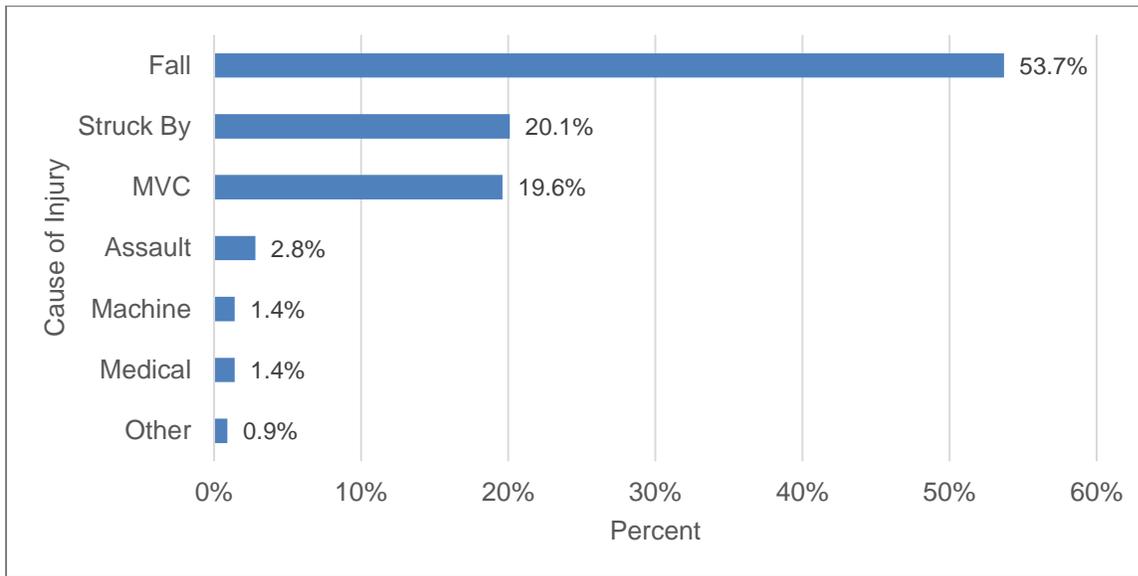
*Cause of work-related hospitalized intracranial injury was not specified for 5 (2.3%) individuals.

NORA Sector Groups

For 196 (89.5%) cases, including six self-employed individuals, there was sufficient information to determine their NORA Sector Group classification (Table 11). Services (except Public Safety) Sector Group had the highest number of hospitalized intracranial injuries with 47 (24%) cases, followed by Construction Sector Group with 36 (18.4%) cases and then Manufacturing with 34 (17.3%) cases. Oil and Gas Extraction Sector Group had the highest rate with 35.1/100,000 workers, followed by Agriculture, Forestry and Fishing (except Wildland Firefighting) Sector Group with 44 /100,000 workers.

Table 11. Work-Related Hospitalized Intracranial Injuries with Workers' Compensation as the expected payer by Industry, Michigan 2014 - 2017*

NORA Sector Group	NAICS Code	Number	Percent	Rate[1]
Agriculture, Forestry & Fishing (except Wildland Firefighting)	11	10	5.1	4.4
Construction	23	36	18.4	3.7
Healthcare & Social Assistance	62, 54194, 81291	10	5.1	0.4
Manufacturing	31-33	34	17.3	1.0
Mining (except Oil & Gas Services)	21	3	1.5	35.1
Oil & Gas Extraction	211, 213111, 213112	0	–	–
Public Safety (including Wildland Firefighting)	92212, 92214, 92216, 62191	7	3.6	1.8
Services (except Public Safety)	51, 52, 53, 54, 55, 56, 61, 71, 72, 81, 92	47	24.0	0.6
Transportation, Warehousing & Utilities	48-49, 22	23	11.7	2.7
Wholesale & Retail Trade	42, 44-45	26	13.3	1.1
Total		196	100.0	1.1

*Sufficient information for sector groups classification was available for 196 (89.5%) cases.

[1]Rates are the number of workers sustaining an intracranial injury per 100,000 workers. Number of workers by NORA Group Sectors used to calculate rates: NIOSH Employment Labor Force Query System.

Top Five NORA Sector Groups by Cause of Injury

Table 12 illustrates the top five NORA Sector Groups by cause of injury. "Fall" was the predominant cause of a hospitalized intracranial injury in Services (except Public Safety) (51.1%), Construction (55.6%), Manufacturing (58.8%) and Wholesale and Retail Trade (57.7%) Sector Groups. Transportation, Warehousing and Utilities Sector Groups had the most motor vehicle crashes (43.5%).

Table 12. Top Five NORA Sector Groups of Work-Related Hospitalized Intracranial Injuries with Workers' Compensation as the Expected Payer by Industry, Michigan 2014 – 2017

NORA SECTOR	Struck By	Fall	Machine	Assault	MVC	Other	Medical Condition	Unknown	TOTAL
Services (except Public Safety)	8	24	1	1	8	2	1	2	47
Construction	11	20	1	0	4	0	0	0	36
Manufacturing	8	20	0	0	6	0	0	0	34
Wholesale and Retail Trade	6	15	0	0	5	0	0	0	26
Transportation, Warehousing and Utilities	1	6	1	1	10	0	1	3	23

MIOSHA Inspections

MIOSHA inspected four workplaces where hospitalized intracranial injuries (Table 13). Three inspections were due to a fall and one due to a struck by incident that caused intracranial injuries. None of the three companies receiving a citation had corrected the hazard that caused the intracranial injury.

Table 13. Workplaces Inspected by MIOSHA: Violations and Penalties Assessed by Industry, Michigan 2014 - 2017

NORA Sector Group	# of Enforcement Inspections	# of Companies Cited	# of Violations	Total Penalties Assessed
Construction	2	2	4	$3,700
Manufacturing	1	1	1	$2,800
Services (except Public Safety)	1	0	0	$0
Total	4	3	5	$6,500

Work-Related Hospitalized Intracranial Injuries with Workers' Compensation as the Expected Payer MIOSHA Enforcement Inspections

> *Other Heavy and Civil Engineering Construction*

A male in his late thirties sustained a concussion, epidural hematoma, laceration of his scalp, fractured vertebra and paresthesia of both arms when a 200-300-pound drill fell on top of his head. The employee was wearing a hard hat. He lost consciousness for about four minutes and was hospitalized for two days. MIOSHA cited the company for one serious violation: "An employee who was engaged in geothermal drilling operations was exposed to a struck-by hazard while standing below a 20-foot drill pipe that was being hoisted above the employee on the jobsite." The company corrected the hazard during the inspection.

> *Asphalt Paving Mixture and Block Manufacturing*

A male in his early sixties was about 10 feet up on a ladder, when the ladder slipped, causing a fall. The employee sustained a concussion, scalp laceration, fractured ribs and vertebrae. The employee was hospitalized for one day. MIOSHA found one serious violation and cited the company for: "Having an employee use the Fly Section [upper portion, that was not equipped with safety feet] of an extension ladder to check on a possible jam in a sand bin at a concrete plant." The company corrected the hazard during the inspection.

> *New Single-Family Housing Construction (except Operative Builders)*

A male in his late twenties sustained frontal and ventricular hemorrhages as a result of falling from a roof. The employee was hospitalized for nine days. MIOSHA found one serious and two other violations and cited the company for: "Each employee engaged in residential construction activities 6 feet (1.8 m) or more above lower levels shall be protected by guardrail systems, safety net system, or personal fall arrest system unless another provision in paragraph (b) of this section provides for an alternative fall protection measure; An employer shall develop, maintain, and coordinate with employees an accident prevention program, a copy of which shall be available, at the worksite; A person who has a valid certificate in first aid training shall be present at the worksite to render first aid."

DISCUSSION

This is the third report on work-related skull fractures in Michigan and first report on hospitalized work-related intracranial injuries with Workers' Compensation as the expected payer in Michigan. Both reports cover four calendar years, 2014 through 2017.

The Michigan surveillance system for work-related skull fractures provides a more accurate estimate of the true number of work-related skull fractures than the employer-based reporting system maintained by BLS, which is the official source of work-related statistics. The Michigan system identified 388 work-related skull fractures in 2014, 380 in 2015, 476 in 2015 and 444 in 2017 in comparison to 50 estimated by BLS in 2014, 50 in 2015, 60 in 2016 and 70 in 2017 (Figure14). The number of fatalities varied each year, with 10 in 2014, five in 2015, seven in 2015 and four in 2017.

Figure 14. Number of Work-Related Skull Fractures by Three Surveillance Systems, Michigan 2014 - 2017
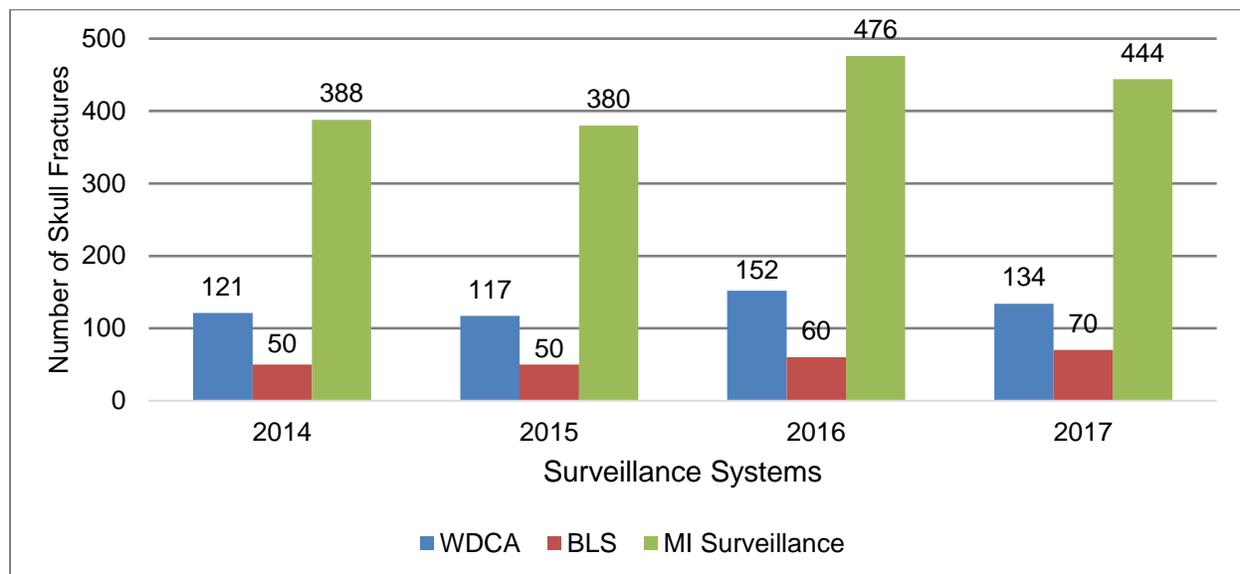
For 2014 through 2017 BLS estimated only 13.6% of the 1,688 work-related skull fractures reported in the Michigan's multi-source reporting system. This is a much smaller estimate compared to previous 2012 and 2013 for which BLS estimated 48% of the 648 skull fractures reported in Michigan's multi-source reporting system. The criteria to obtain

the estimate were the same for all years. The reason for the marked decrease in the BLS estimate of work-related skull fractures for Michigan may be due to a decreased reported number of skull fractures by employers: 50 skull fractures in 2014, 50 in 2015, 60 in 2016, and 70 in 2017, as compared to 170 skull fractures in 2012 and 140 in 2013. We included 14 "Tooth (Teeth)" fractures identified by the WDCA only from the last quarter of 2015 through 2017. BLS included "Tooth (Teeth)" category in the "Face"=>"Mouth" Part of Body classification. This does not explain the difference since the BLS estimate included tooth fractures for all five years.

The BLS's undercount of work-related skull fractures 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 skull fractures treated in a hospital or emergency department. Secondly, the BLS excludes self-employed, household employees and farm workers who work on farms with less than 11 employees. Michigan's skull fracture surveillance identified only sixty-nine self-employed individuals between 2014 and 2017, and seventy-eight farmers with work-related skull fractures so the difference in the type of workers covered in the BLS survey would not explain the undercount in the BLS data. Other possible explanations for the BLS undercount may be that employers are not providing complete reporting, the statistical sampling procedure of BLS, or employers are not properly identifying employees' injuries as skull fractures.

Workers compensation was identified as the payer for only 64% of the work-related skull fractures treated at Michigan hospital and emergency department in 2014 through 2017. Another 58 (4.2%) were not covered by workers compensation (i.e. self-employed). We do not know the reasons why for the other 32% of the hospitalizations/ED visits worker compensation was not listed as the payer.

If one used Michigan's Workers' Disability Compensation Agency data as the sole source of skull fractures, one would identify many fewer cases than the other data sources combined. Reasons contributing to the WDCA undercount include: 1) The WDCA data set only included skull fractures that caused 7 or more consecutive days away from work; 2) WDCA excluded the self-employed, but again there were only sixty-nine self-employed workers; 3) Coding or miscoding errors in the WDCA data. The matching with hospital

records showed that 320 work-related skull fractures between 2014 and 2017 identified from medical records were not classified as skull fractures 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) It is possible that some companies are handling skull fracture injuries unofficially and not reporting them to Workers' Compensation insurance companies or the WDCA.

Surveillance of work-related skull fractures is crucial to the recognition and prevention of these conditions. Between 2014 and 2017, twenty-three worksites were identified by the surveillance data with a subsequent intervention by MIOSHA to reduce the hazard of a future work-related skull fracture or other serious injury to other employees. A large advantage of the Michigan surveillance system is that it not only provides a better count of the total number of work-related skull fractures, but the reports can also be used to identify specific workplaces to perform follow back investigations.

The Michigan surveillance data show patterns in the occurrence of occupational skull fractures. The data has been used in the national campaign to prevent work-related falls and we are in the process of developing hazard alerts where we see patterns in causes for the skull fractures. A hazard alert on assaults in the health care workers has been developed.[25]

Beginning in 2014, we expanded the work-related skull fracture surveillance system to include individuals hospitalized overnight with work-related intracranial injuries including bleeds. This expansion in the number of conditions being tracked has provided a better understanding of the serious work-related head injuries that occur in Michigan. For 2014 through 2017, we have identified 219 work-related hospitalized overnight intracranial injuries with Workers' Compensation as the expected payer from the hospital medical records where there was no skull fracture. There have been additional 73 hospitalized overnight intracranial injuries with Workers' Compensation as the expected payer that had a skull fracture as an underlying cause of injury and therefore those cases were included in the 2014-2017 skull fractures dataset and not in the intracranial injuries report.

There were 878 WDCA cases in 2014-2017 identified as concussions and only 22 (2.5%) matched with hospital records. There were additional 96 WDCA cases that matched with

names from medical records, although they had an injury description in the WDCA database as something other than a "concussion". Due to a lack of the information on what type of medical care workers received (i.e. hospitalization) we did not include those in the total of work-related hospitalized intracranial injuries.

MIFACE Program identified 31 fatalities with underlying cause of death from intracranial injuries (i.e. subdural hematoma, craniocerebral trauma, blunt head trauma). None of the 31 fatalities were identified by hospital medical records as hospitalized cases with Workers' Compensation as the expected payer.

Surveillance of work-related skull fractures and work-related hospitalized overnight intracranial injuries with Workers' Compensation as the expected payer share many similarities. Most of all work-related skull fractures and hospitalized intracranial injuries with Workers' Compensation as the expected payer were among men, both with 77.9%, and among Caucasians, 84% for both types of injuries. Injuries due to a fall and struck by incidents were the top two injury causes, with 66.6% for skull fractures and 73.8% for hospitalized intracranial injuries with Workers' Compensation as the expected payer. Services (except Public Safety) NORA Sector Group had the highest number of work-related skull fractures and hospitalized intracranial injuries with Workers' Compensation as the expected payer, accounting for 31.5% and 24.0% of all injuries, respectively.

The ultimate goal of the skull fracture and hospitalized intracranial injuries with Workers' Compensation as the expected payer surveillance systems is to recognize and prevent work-related injuries and plan interventions to reduce the occurrence of workplace injuries. We plan to continue to collect and monitor data on occupational head injuries in Michigan, identify specific workplaces to perform follow back investigations, and develop educational materials, including hazard alerts.

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