Work-Related Skull Fractures in Michigan: Second Report (January 2012 – December 2013)

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May 4, 2015

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Second Report

(January 2012 – December 2013)

A Joint Report of

Michigan State University

and

Michigan Department of Licensing and Regulatory Affairs

and

Michigan Department of Health and Human Services

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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 second report on occupational skull fractures in Michigan; it covers the years 2012 and 2013. These are the key findings:

- Work-related skull fractures were identified through multiple reporting sources.
  - There were 316 work-related skull fractures, including six deaths, in 2012.
  - There were 332 work-related skull fractures, including five deaths, in 2013.
- For 2012 and 2013, the Federal reporting system that relies on employer reporting, estimated only 310 work-related skull fractures in Michigan or 48% of the 648 work-related skull fractures reported in Michigan's multi-source reporting system.
- The most common type of medical encounter was an emergency room visit (62.3% in 2012 and 53.3% in 2013).
- In 2012, 73.7% of all work-related skull fractures were among men; in 2013, 76.5% of all work-related skull fractures were among men.
- In 2012, 82.8% of all work-related skull fractures were among Caucasians; in 2013, 87.2% were among Caucasians.
- Facial bones were the most common location of the fracture (69.0% in 2012 and 76.2% in 2013).
- The most common type of work-related skull fracture was a depressed (broken bone pushed inward) skull fracture in 2012 (37.5%) and a comminuted (fragmented bone into several pieces) skull fracture in 2013 (31.5%).
- Thirty-one percent of individuals in 2012 and 33.9% in 2013 lost consciousness due to the head injury.
- Three industries – Construction, Primary Metal Manufacturing and Health Care and Social Assistance accounted for a third of all work-related skull fractures in both years of surveillance, 30.4% and 36.2%, respectively.
- A "fall" was the predominant cause of injury in the Educational Services industry (73.7%) in 2012 and in the Construction industry (58.3%) in 2013. "Struck by" injuries were the leading cause of injuries in the Primary Metal Manufacturing industry in 2012 (51.7%) and in 2013 (40.6%).
- Workers' Compensation was the expected payer for only 60.2% of the 299 cases in 2012 and 55.3% of the 300 cases in 2013 that were identified in the hospital/ED records.
- The Michigan OSHA program completed inspections at 17 worksites identified by the surveillance system where individuals were injured in 2012 and 2013. MIOSHA issued 22 violations and assessed $15,500 in fines.

BACKGROUND

This is the second report on occupational skull fractures in Michigan. The report is based on data for 2012 and 2013. 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 traumatic injury is "bodily damage resulting from exposure to physical agents such as mechanical energy, thermal energy, ionizing radiation, or resulting from the deprivation of basic environmental requirements such as oxygen or heat. Mechanical energy injuries include acceleration and deceleration injuries, blunt trauma, and penetrating wound injuries".[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 Community Health (MDCH)[1] 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 4,450 work-related fractures to the head in 2012 (incidence rate of 5 workers per 100,000 full-time workers), and 4,350 in 2013 (incidence rate of 4 workers per 100,000 full-time workers).[3,4] 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. BLS reported 170 work-related skull fractures for Michigan in 2012 and 140 in 2013. This corresponds to a rate of 6 and 5 per 100,000 full-time workers, respectively.

[1] On April 10, 2015 the Michigan Departments of Community Health and Human Services were merged into one Department, the Michigan Department of Health and Human Services. This report is based on work completed prior to the merger, thus the report narrative refers to the Michigan Department of Community Health (MDCH).

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, information about the employer where the skull fracture took place is referred to the Michigan Occupational Safety and Health Administration for a possible workplace investigation.

DATA SOURCES AND METHODS

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

- Hospitals/Emergency Departments/hospital outpatients
- Workers' Compensation Agency (WCA)
- Michigan Fatality Assessment and Control Evaluation (MIFACE)[5]

All 136 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)[6]:

- 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,

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

The Michigan Department of Licensing and Regulatory Affairs (LARA) and WCA 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 fracture ("Nature of Injury" code) to one of the following "Parts of Body": Brain; Cheek/Chin/Jaw; Concussion; Face, multiple parts; Face, not elsewhere specified; Face, unspecified; Forehead; Head, multiple; Head, unspecified; Mandible; Nasal passages; Nose; Scalp; Sinus; or Skull.

Cases identified through the MIFACE program were identified as individuals whose underlying cause of death were 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), 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 Workers' Compensation database. Matches were identified using individual's first and last name, date of birth and date of injury. Finally, WCA cases meeting the work-related skull fracture case definition that did not match with any of the other data sources (i.e. where WCA 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.

Individuals whose workplaces could not be identified in the records and met the criteria for a MIOSHA referral were contacted by telephone to obtain employer information. The criteria for a referral to MIOSHA were: 1) the individual had to be hospitalized, treated in an emergency department or as an outpatient at a hospital in 2012 or 2013, 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 whose employers were referred to MIOSHA, additional information was obtained about the results of the referral, including: date of referral, whether an inspection was performed, inspection date, number of violations, and total fines assessed.

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

The BLS Occupational Injuries and Illnesses and Fatal Injuries Profiles online tool was used to generate the 2012 and 2013 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] For 2012 and 2013, 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.

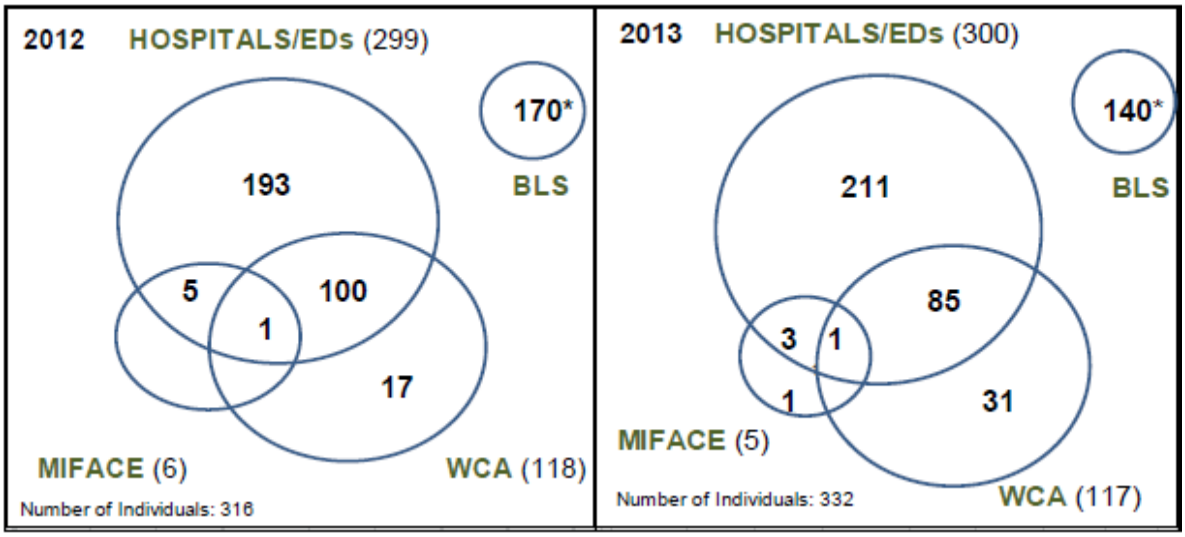
RESULTS

In 2012, 316 individuals had a work-related skull fracture and in 2013, 332 individuals had a work-related skull fracture reported from hospital/ED, WCA, or the MIFACE.

Reporting Sources

The number of 2012 and 2013 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 2012 - 2013



*There is presumably overlap between the 170 (2012) and 140 (2013) estimates of the BLS and the Michigan reporting sources (HDC, MIFACE and WCA) but BLS does not allow access to their data thus matching to assess the degree of overlap was not possible

2012 Reporting Sources

In 2012, Hospital/ED reports identified 299 cases, WCA 118 cases, and MIFACE 6 fatalities. Hospital/ED reports matched with 100 WCA reports and 5 MIFACE reports. One skull fracture case was identified by all of the reporting sources. Seventeen skull fracture cases were identified by the WCA data source only. Because of confidentiality restrictions, no attempt was made to match the Michigan data set with the BLS data set.

There were 118 WCA cases in 2012 identified as work-related skull fractures. Forty-four were identified because they had been classified as a fracture to one of the following parts of body: Brain; Cheek/Chin/Jaw; Concussion; Face, multiple parts; Face, not elsewhere specified; Face, unspecified; Forehead; Head, multiple; Head, unspecified; Mandible; Nasal passages; Nose; Scalp; Sinus; or Skull. Of the 44 records, 27 matched with hospital/ED records, and 17 did not match with either hospital/ED or MIFACE records. The other 74 were included because they matched with names from one or more of the other data sources, although they had an injury description in the WCA database as something other than “Fracture of skull”. The descriptions in WCA for these 74 were: 21 “Multiple Injuries”, 18 “Fracture” (other than skull), 12 “Crush/Contusion”, 9 “Unclassified”, 7 “Cut/Laceration”, 6 “Concussion”, and 1 “Strains/Sprains”. Matches

were made based on the employee's name, date of birth, date of injury, employee's zip code and employer.

2013 Reporting Sources

In 2013, Hospital/ED reports identified 300 cases, WCA 117 cases, and MIFACE 5 fatalities. Thirty-one skull fracture cases were identified by the WCA data source only. Because of confidentiality restrictions, no attempt was made to match Michigan's data set with the BLS data set.

There were 117 WCA cases in 2013 identified as work-related skull fractures. Fifty-six were identified because they had been classified as a fracture to one of the following parts of body: Brain; Cheek/Chin/Jaw; Concussion; Face, multiple parts; Face, not elsewhere specified; Face, unspecified; Forehead; Head, multiple; Head, unspecified; Mandible; Nasal passages; Nose: Scalp; Sinus; or Skull. Of the 56 records, 25 matched with hospital/ED records, and 31 did not match with either hospital/ED or MIFACE records. The other 61 were included because they matched with names from one or more of the other data sources, although they had an injury description in the WCA database as something other than "Fracture of skull". The descriptions in WCA for these 61 were: 21 "Multiple Injuries", 11 "Fracture" (other than skull), 9 "Unclassified", 7 "Crush/Contusion", 5 "Concussion", 5 "Cut/Laceration", 1 "Amputation", 1 "Strains/Sprains", 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.

An emergency room visit was the most common type of medical encounter in 2012 and 2013, 197 (62.3%) and 177 (53.3%) cases, respectively. The type of medical care that workers received was not available for 17 WCA cases in 2012, and for 31 WCA cases in 2013.

Table 1. Work-Related Skull Fractures by the Type of Medical Encounter, Michigan 2012 - 2013

Medical Encounter Type	2012		2013	
	Number	Percent	Number	Percent
Hospitalization	74	23.4	85	25.6
Emergency Department	197	62.3	177	53.3
Outpatient	28	8.9	38	11.5
Other*	0	–	1	0.3
Unknown	17	5.4	31	9.3
Total	316	100.0	332	100.0

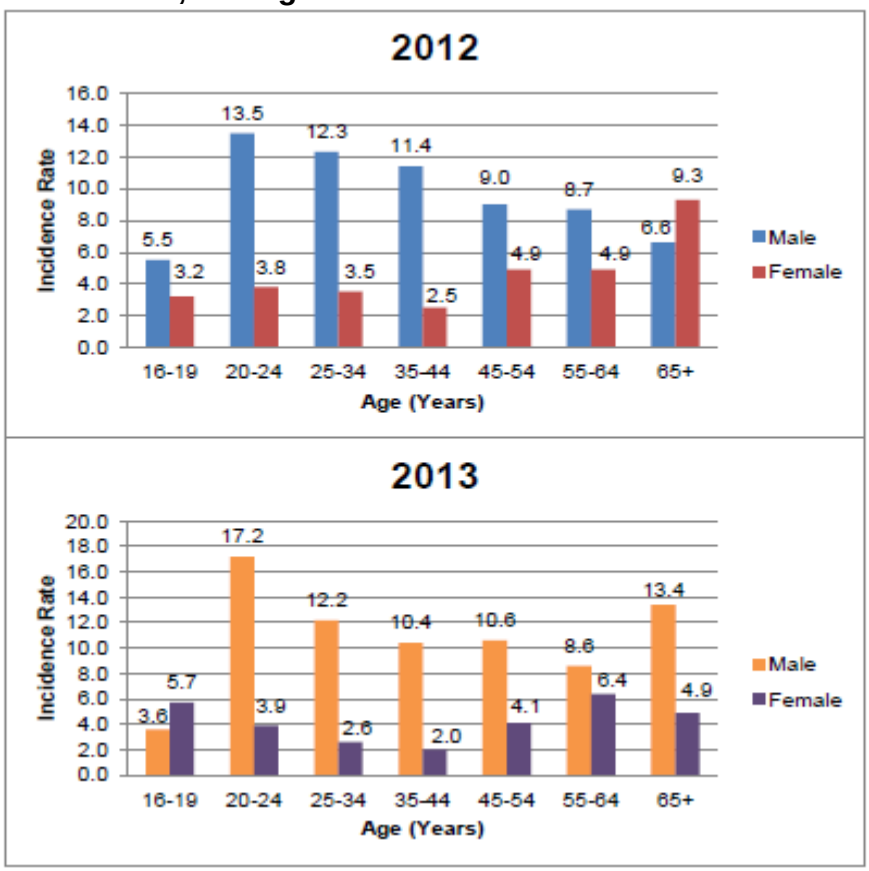
*Autopsy report.

Characteristics of Injured Workers

Age and Gender

Age was available for all workers with work-related skull fractures in 2012 and 2013. The age of the injured workers ranged from 17 to 83 years in 2012 and from 16 to 85 years in 2013. The average and median age was 42 in 2012 and 43 in 2013. Two hundred and thirty-three (73.7 %) of all work-related skull fractures in 2012 and two hundred and fifty-four (76.5 %) of all work-related skull fractures in 2013 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 in both years of surveillance, with 13.5/100,000 and 17.2/100,000, respectively. For females, the age group with the highest rate of skull fractures was 65+ (9.3/100,000) in 2012 and 55-64 (6.4/100,000) in 2013.

Figure 2. Work-Related Skull Fracture Rates by Age Group and Gender, Michigan 2012 - 2013*

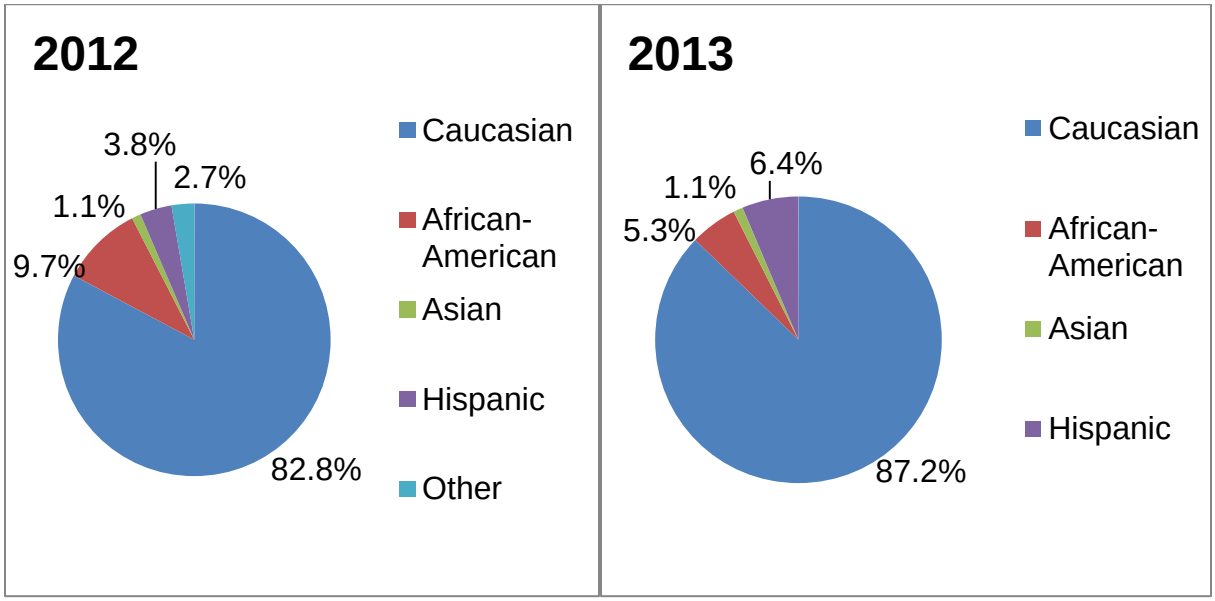


*Rates are the number of workers sustaining a skull fracture per 100,000 workers (number of workers employed by age group used to calculate rates: Bureau of Labor Statistics' Current Population Survey).[7,8]

Race and Ethnicity

The race and ethnicity of workers with work-related skull fractures are shown in Figure 3. Among the workers for whom race was available (186 in 2012 and 187 in 2013), 154 (82.8%) and 163 (87.2%) were Caucasian, 18 (9.7%) and 10 (5.3%) were African-American, 7 (3.8%) and 12 (6.4%) were Hispanic, and 2 (1.1%) and 2 (1.1%) were Asian, respectively for 2012 and 2013.

Figure 3. Race/Ethnicity Distribution of Work-Related Skull Fractures, Michigan 2012 - 2013*



*Race/Ethnicity information available for 186 (58.9%) individuals in 2012 and 187 (56.3%) individuals in 2013.

Part of Skull Injured

Medical records specified the part of skull injured and were classified by ICD-9 codes (800.0-.9, 801.0-.9, 802.0-.9, 803.0-.9, 804.0-.9). Figure 4 illustrates part of skull injured by ICD-9 codes. The Workers' Compensation database did not classify injuries by ICD-9 codes but did specify the part of the skull injured, which was then recoded into the ICD-9 codes.

Table 2 shows the distribution of the part of skull injured. Fractures of facial bones occurred most often (69.0% in 2012 and 76.2% in 2013), followed by fractures of the base of the skull (19.3% in 2012 and 14.2% in 2013), and fractures of the vault of the skull (6.0% in 2012 and 5.4% in 2013).

Figure 4. Part of Skull Injured by ICD-9 Code

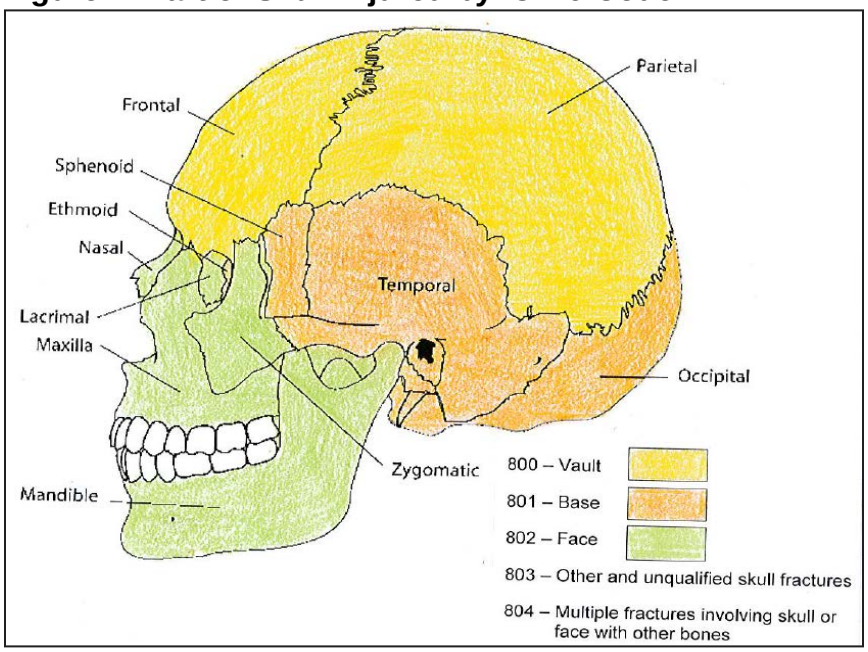


Table 2. Work-Related Skull Fractures by Part of Skull, Michigan 2012 - 2013

Part of Skull Injured (ICD-9 Code)	2012		2013	
	Number	Percent	Number	Percent
Vault (800.0-.9)	19	6.0	18	5.4
Base (801.0-.9)	61	19.3	47	14.2
Face (802.0-.9)	218	69.0	253	76.2
Other and Unqualified (803.0-.9)	10	3.2	13	3.9
Multiple (804.0-.9)	8	2.5	1	0.3
Total	316	100.0	332	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 largely underreported. It was specified for 72 (22.8%) individuals in 2012 and 92 (27.7%) individuals in 2013. Its distribution is illustrated in Table 3. There were 27 (37.5%) and 19 (20.7%) depressed skull fractures, 17 (23.6%) and 25 (27.2%) linear fractures, 15 (20.8%) and 29 (31.5%) comminuted fractures, 9 (12.5%) and 19 (20.7%) displaced fractures, respectively in 2012 and 2013. Only in 2012 were there any compound fractures; 4 (5.6%). Fractures of facial bones accounted for 47.2% of the 2012 cases and for 71.7% of the 2013 cases when the type of facture was known.

Table 3. Work-Related Skull Fractures by Type of Fracture, Michigan 2012 - 2013*

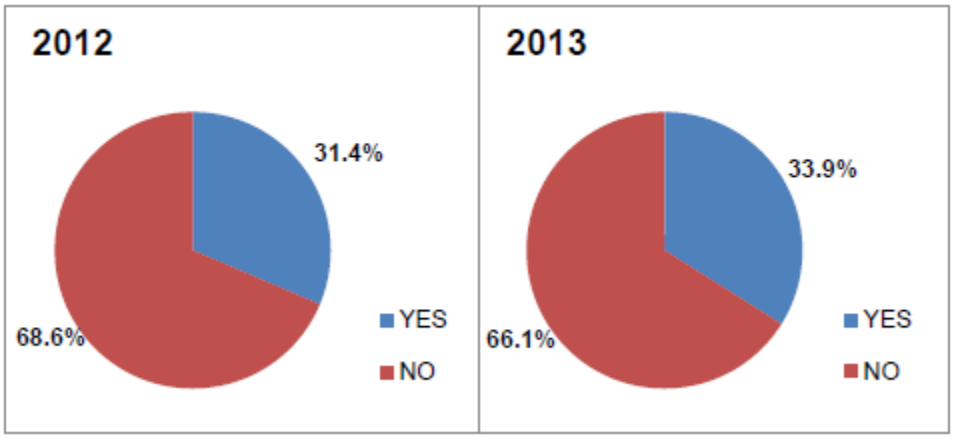
Type of Fracture	2012		2013	
	Number	Percent	Number	Percent
Linear	17	23.6	25	27.2
Depressed	27	37.5	19	20.7
Compound	4	5.6	0	–
Displaced	9	12.5	19	20.7
Comminuted	15	20.8	29	31.5
Total	72	100.0	92	100.0

* Type of skull fracture was not specified for 244 (77.2%) individuals in 2012; type of skull fracture was not specified for 240 (72.3%) individuals in 2013.

Loss of Consciousness

Figure 5 illustrates the 68.6% percent of individuals with work-related skull fractures loss consciousness in 2012 and 66.1% in 2013. The individual's loss of consciousness was described for 258 (81.6%) individuals in 2012 and 224 (67.5%) individuals in 2013.

Figure 5. Work-Related Skull Fractures by Loss of Consciousness Status, Michigan 2012 - 2013*



*For 58 individuals in 2012 and 108 individuals in 2013 it was unknown if they lost consciousness due to the injury to head.

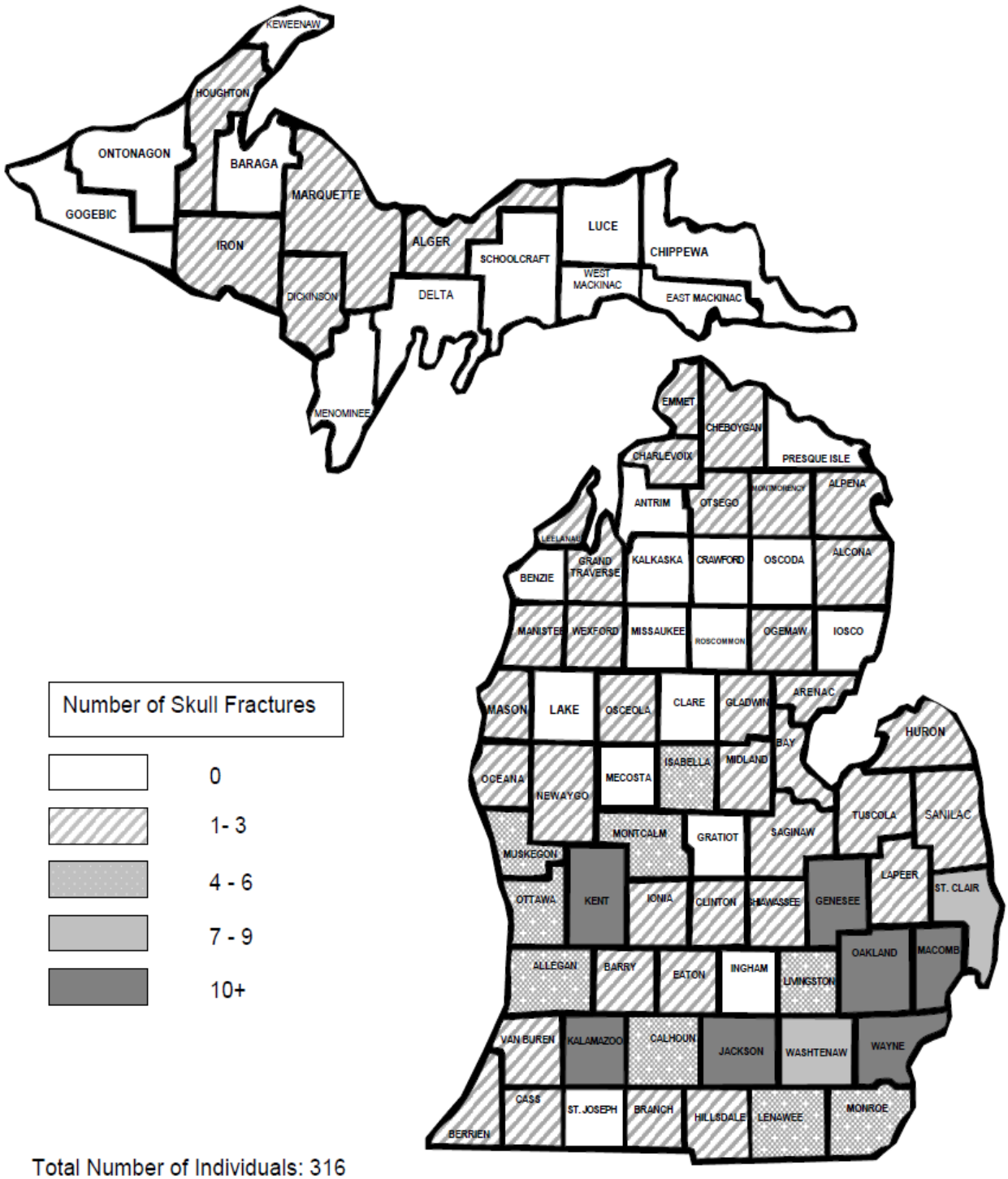
County of Residence

Table 4 and Figures 6 and 7 illustrate the worker's county of residence. There were 303 Michigan residents in 2012 (95.9%) and 315 (94.9%) Michigan residents in 2013 for whom the county of residence was known. There were 10 out-of-state workers in 2012 and 13 out-of-state workers in 2013. County of residence was unknown for three Michigan residents in 2012 and four Michigan residents in 2013. It should be noted that the county of residence would not necessarily be the same county where the individual was injured. In 2012, Wayne County had the highest number of residents with a work-related skull fracture with 60 (19.0%) cases, followed by 37 (11.7%) cases in Oakland County and 23 (7.3%) cases in Kent County. In 2013, Oakland County had the highest number of residents with a work-related skull fracture with 50 (15.1%) cases, followed by Wayne County with 46 (13.9%) cases each and Macomb County with 18 (5.4%) cases.

Table 4. Work-Related Skull Fractures by County of Residence, Michigan 2012 - 2013

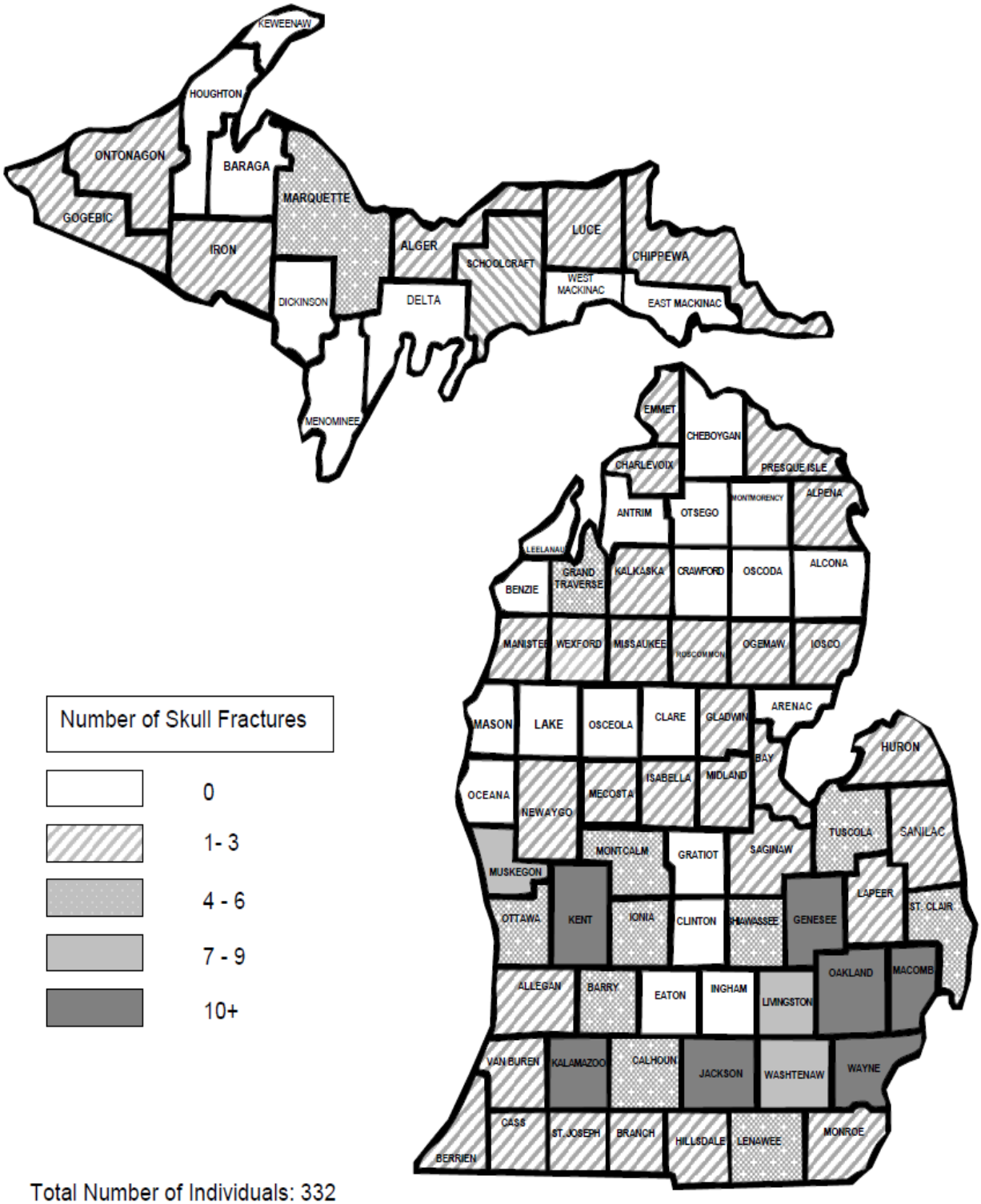
	2012		2013			2012		2013	
County	Number	Percent	Number	Percent	County	Number	Percent	Number	Percent
Alcona	3	0.9	0	-	Leelanau	1	0.3	0	-
Alger	1	0.3	2	0.6	Lenawee	4	1.3	4	1.2
Allegan	4	1.3	3	0.9	Livingston	5	1.6	7	2.1
Alpena	1	0.3	3	0.9	Luce	0	-	1	0.3
Antrim	0	-	0	-	Mackinac	0	-	0	-
Arenac	2	0.6	0	-	Macomb	19	6.0	18	5.4
Baraga	0	-	0	-	Manistee	2	0.6	1	0.3
Barry	1	0.3	5	1.5	Marquette	2	0.6	4	1.2
Bay	3	0.9	3	0.9	Mason	2	0.6	0	-
Benzie	0	-	0	-	Mecosta	0	-	3	0.9
Berrien	2	0.6	4	1.2	Menominee	0	-	0	-
Branch	3	0.9	1	0.3	Midland	3	0.9	2	0.6
Calhoun	5	1.6	5	1.5	Missaukee	0	-	2	0.6
Cass	1	0.3	1	0.3	Monroe	4	1.3	3	0.9
Charlevoix	2	0.6	2	0.6	Montcalm	5	1.6	4	1.2
Cheboygan	1	0.3	0	-	Montmorency	3	0.9	0	-
Chippewa	0	-	2	0.6	Muskegon	5	1.6	7	2.1
Clare	0	-	0	-	Newaygo	2	0.6	1	0.3
Clinton	1	0.3	3	0.9	Oakland	37	11.7	50	15.1
Crawford	0	-	2	0.6	Oceana	1	0.3	0	-
Delta	0	-	0	-	Ogemaw	2	0.6	1	0.3
Dickinson	2	0.6	1	0.3	Ontonagon	0	-	1	0.3
Eaton	2	0.6	3	0.9	Osceola	2	0.6	0	-
Emmet	3	0.9	3	0.9	Oscoda	0	-	0	-
Genesee	15	4.7	17	5.1	Otsego	2	0.6	0	-
Gladwin	1	0.3	1	0.3	Ottawa	4	1.3	5	1.5
Gogebic	0	-	1	0.3	Presque Isle	0	-	2	0.6
Grand Traverse	1	0.3	5	1.5	Roscommon	0	-	1	0.3
Gratiot	0	-	0	-	Saginaw	2	0.6	3	0.9
Hillsdale	3	0.9	1	0.3	Saint Clair	7	2.2	6	1.8
Houghton	1	0.3	0	-	Saint Joseph	0	-	3	0.9
Huron	1	0.3	1	0.3	Sanilac	2	0.6	1	0.3
Ingham	0	-	0	-	Schoolcraft	0	-	1	0.3
Ionia	1	0.3	4	1.2	Shiawassee	1	0.3	5	1.5
Iosco	0	-	1	0.3	Tuscola	2	0.6	4	1.2
Iron	1	0.3	1	0.3	Van Buren	2	0.6	1	0.3
Isabella	5	1.6	2	0.6	Washtenaw	7	2.2	7	2.1
Jackson	11	3.5	10	3.0	Wayne	60	19.0	46	13.9
Kalamazoo	11	3.5	10	3.0	Wexford	3	0.9	3	0.9
Kalkaska	0	-	1	0.3	Out of State	10	3.2	13	3.9
Kent	23	7.3	17	5.1	Unknown	3	0.9	4	1.2
Keweenaw	0	-	0	-					
Lake	0	-	0	-	**Total**	316	100.0	332	100.0
Lapeer	1	0.3	3	0.9					

Figure 6 Work-Related Skull Fractures by County of Residence, Michigan 2012



Total Number of Individuals: 316
Out of State Individuals: 10
County was unknown for three individuals

Figure 7 Work-Related Skull Fractures by County of Residence, Michigan 2013



Total Number of Individuals: 332
Out of State Individuals: 13
County was unknown for four individuals

Cause of Injury

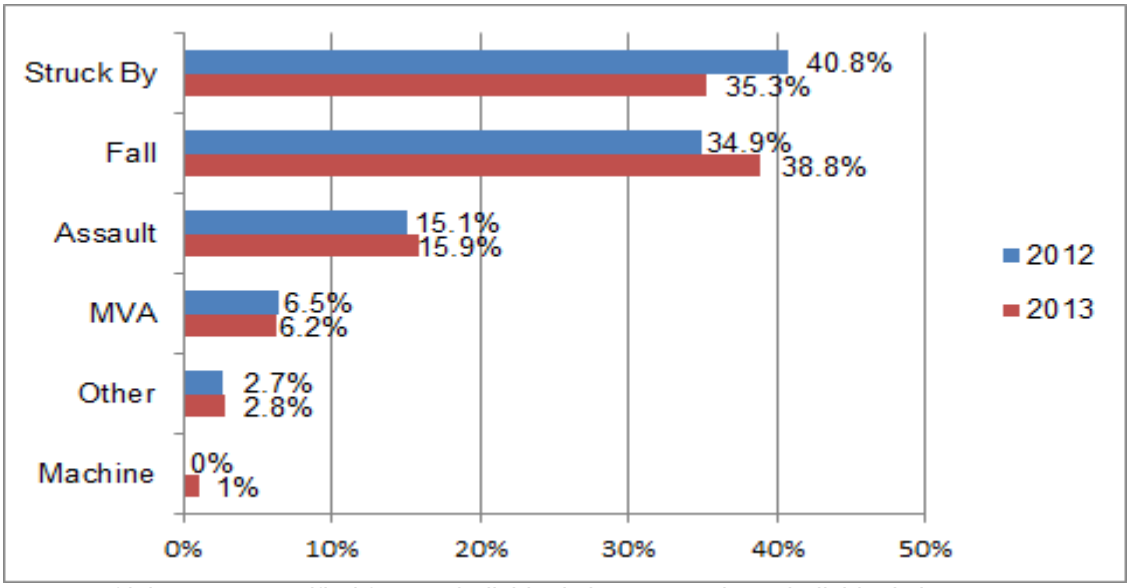
Causes of skull fractures were:

- 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 Accident (MVA) – 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).
- Other – Includes medical conditions such as syncope or fainting, which lead to a transient loss of consciousness and postural tone.
- Machine – Malfunction of a machine or equipment (e.g. being “caught” inside a sanding machine, grinder).

The cause of work-related skull fractures was specified for 292 (92.4%) workers in 2012 and 289 (87.0%) workers in 2013 (Figure 8). It was unknown for 24 workers in 2012 and 43 workers in 2013. The predominant cause of skull fracture was a struck by incident in 119 (40.8%) workers in 2012 and 102 (35.3%) workers in 2013, followed by a fall in 102 (34.9%) workers in 2012 and 112 (38.8%) workers in 2013, an assault in 44 (15.1%) workers in 2012 and 46 (15.9%) workers in 2013, a motor vehicle accident in 19 (6.5%) workers in 2012 and 18 (6.2%) workers in 2013, “other”, in 8 (2.7%; 2.8%) workers in both years of surveillance, and a machine in 3 (1.0%) workers in 2013. Skull fractures due to fall and struck by incidents accounted for 75% of all skull fractures in 2012 and 2013 combined. When the industry was specified, the Educational Services industry had the highest percentage of skull fractures due to a fall with 14 (73.7%) cases in 2012. In 2013, the Construction industry had the most skull fractures due to fall with 28 (58.3%) cases (Tables 6 and 7). Among hospitalized individuals, fall was the cause of

the skull fracture for 35 (47.3%) cases in 2012 and 49 (57.6%) cases in 2013, followed by struck by for 22 (29.7%) cases in 2012 and 20 (23.5%) cases in 2013. Of six fatalities in 2012, three were caused by a fall, two from motor vehicle accidents, and one from being struck by an object. Of five fatalities in 2013, two individuals died from a fall, one from being struck by an object, one from motor vehicle accident, and one from an assault.

Figure 8. Work-Related Skull Fracture by Cause of Injury, Michigan 2012 - 2013*



*Cause of injury was specified for 292 individuals in 2012 and 289 individuals in 2013.

Industry

Table 5 describes work-related skull fractures by industry using 2-digit North American Industry Classification System (NAICS) codes. For 256 (81.0%) individuals in 2012 and 280 (84.3%) individuals in 2013, there was sufficient information to determine their NAICS industry classification. Twelve workers in 2012 and thirteen workers in 2013 were self-employed. In 2013, two of the individuals with work-related skull fractures were prisoners on work details. In 2012, Primary Metal Manufacturing (NAICS: 33) had the highest number of work-related skull fractures with 29 (11.3%) cases, followed by the Health Care and Social Assistance (NAICS: 62) with 27 (10.5%) cases and then Construction (NAICS: 23) with 22 (8.6%) cases. In 2013, the Construction industry had the highest number of work-related skull fractures (48, 17.2%), followed by the Primary

Metal Manufacturing with 32 (11.5%) cases and Health Care and Social Assistance with 21 (7.5%) cases. These three sectors combined accounted for one-third of all work-related skull fractures for both years of surveillance, representing 30.4% and 36.2% of skull fractures cases, respectively. Agriculture, Forestry, Fishing and Hunting (NAICS: 11) had the highest rate of skull fractures in 2012 with 19.5 per 100,000 workers, and in 2013 with 29.1 per 100,000.

Table 5. Work-Related Skull Fractures by Industry, Michigan 2012 - 2013

Industry Classification (NAICS)	2012			2013		
	Number	Percent	Rate*	Number	Percent	Rate*
Primary Metal Manufacturing (33)	29	11.3	5.8[1]	32	11.4	5.2[1]
Health Care and Social Assistance (62)	27	10.5	4.3	21	7.5	3.2
Construction (23)	22	8.6	10.9	48	17.2	23.1
Educational Services (61)	19	7.4	4.0	15	5.4	4.2
Public Administration (92)	18	7.0	13.6	13	4.6	9.9
Wholesale Trade (42)	17	6.6	15.4	17	6.1	16.9
Transportation and Warehousing (48)	16	6.3	16.4	11	3.9	9.7
Admin. and Support and Waste Management and Remediation Services (56)	17	6.6	11.8	18	6.4	11.0
Retail Trade (44)	15	5.9	4.7[2]	17	6.1	5.1[2]
Accommodation and Food Services (72)	16	6.3	5.5	19	6.8	6.6
Agriculture, Forestry, Fishing and Hunting (11)	12	4.7	19.5	16	5.7	19.1
Professional, Scientific and Technical Services (54)	11	4.3	4.7	11	3.9	4.4
Wood Product Manufacturing (32)	8	3.1	6.6[1]	5	1.8	4.0[1]
Real Estate and Rental and Leasing (53)	5	2.0	7.1	2	0.7	3.0
Other Services (except Public Administration) (81)	5	2.0	2.6	7	2.5	3.2
Sporting Goods, Hobby, Book and Music Stores (45)	4	1.6	3.0[2]	6	2.1	4.7[2]
General Warehousing and Storage (49)	4	1.6	8.7	3	1.1	6.6
Utilities (22)	3	1.2	6.4	3	1.1	7.5
Food Manufacturing (31)	3	1.2	5.8[1]	3	1.1	5.2[1]
Finance and Insurance (52)	3	1.2	1.8	1	0.4	0.5
Information (51)	1	0.4	1.4	0	_	_
Arts, Entertainment, and Recreation (71)	1	0.4	1.1	11	3.9	10.9
Mining, Quarrying, and Oil and Gas Extraction (21)	0	–	–	1	0.4	21.1
Total of All Skull Fractures	316**	100.0	7.5	332**	100.0	7.7

*Rates are the number of workers sustaining a skull fracture per 100,000 workers (number of workers by industry used to calculate rates: Bureau of Labor Statistics' Current Population Survey).[9, 10]

**Sufficient information for industry classification was available for 256 individuals in 2012 and for 280 individuals in 2013.

[1]The denominator for this rate does not include 14,209 individuals in 2012 and 11,777 individuals in 2013 from "Not specified manufacturing industries (Part of 31, 32, and 33)" because the rate of skull fractures was calculated separately for NAICS 31, 32, and 33. This is 2.1% and 1.5%, respectively of workforce with NAICS 31, 32, and 33.

[2] The denominator for this rate does not include 9,344 individuals in 2012 and 7,679 individuals in 2013 from "Not specified retail trade (Part of 44, 45)" because the rate of skull fractures was calculated separately for NAICS 44 and 45. This is 2.0% and 1.6%, respectively of workforce with NAICS 44 and 45.

Top Five Industries by Cause of Injury

Tables 6 and 7 illustrate the top five industries separately for 2012 and 2013 by cause of injury. Of the five, the top three industries, Primary Metal Manufacturing, Health Care and Social Assistance, and Construction, were common to both years and had the highest number of skull fractures which cause had been identified in both years of surveillance. “Fall” was the predominant cause of skull fracture within the Educational Services industry (73.7%) in 2012. The Construction industry had the highest number of falls (58.3%) in 2013. “Struck by” incidents in the Primary Metal Manufacturing sector accounted for 13 (51.7%) cases of all skull fractures in 2012, and the Construction sector had the most “struck by” cases (14, 29.2%) in 2013. The “other” category includes mostly individuals who sustained a skull fracture due to syncope at work - 8 (100%) individuals in 2012 and 5 (62.5%) individuals in 2013.

Table 6. Top Five Industries by Cause of Injury, Michigan 2012

INDUSTRY (NAICS code)	Fall	Struck By	Assault	MVA	Other	Unknown	Total
Primary Metal Manufacturing (33)	7	15	1	0	2	4	29
Health Care and Social Assistance (62)	8	8	7	0	0	4	27
Construction (23)	12	8	0	1	0	1	22
Educational Services (61)	14	3	2	0	0	0	19
Public Administration (92)	3	4	7	3	0	1	18

Table 7. Top Five Industries by Cause of Injury, Michigan 2013

INDUSTRY (NAICS code)	Fall	Struck By	Assault	MVA	Other	Machine	Unknown	TOTAL
Construction (23)	28	14	0	3	1	0	2	48
Primary Metal Manufacturing (33)	10	13	0	0	1	2	6	32
Health Care and Social Assistance (62)	8	2	6	1	1	0	3	21
Accommodation and Food Services (72)	8	2	5	0	1	0	3	19
Admin. and Support and Waste Mgt and Remed. Services (56)	4	6	1	1	0	0	6	18

Source of Payment

Workers' Compensation was the expected payer in 180 (60.2%) of the 299 work-related skull fractures for which there was a medical record in 2012 and in 166 (55.3%) of the 300 work-relates skull fractures for which there was a medical record in 2013 (Table 8). For 33 skull fractures in 2012 and 29 skull fractures in 2013, payment source could not be identified. Of the 86 cases for which Workers' Compensation was not listed as a payment source in medical records in 2012, 16 were matched to a case in the Workers' Compensation claims database. Of those 16 cases, 5 were classified as a skull fracture and 11 had an injury description in the WCA database as something other than "skull fracture". Of the 105 cases for which Workers' Compensation was not listed as a payment source in medical records in 2013, 17 were matched to a case in the Workers' Compensation claims database. Of those 17 cases, 2 were classified as a skull fracture and 15 had an injury description in the WCA database as something other than "skull fracture".

Table 8. Work-Related Skull Fractures by Payment Source, Michigan 2012 - 2013*

Expected Source of Payment	2012		2013	
	Number	Percent	Number	Percent
Workers' Compensation	180	67.7	166	61.2
Commercial Insurance	25[1]	9.4	54[2]	19.9
Self Pay	38[3]	14.3	27[4]	10.0
Medicare/Medicaid	23[5]	8.6	24[6]	8.9
Total	266	100.0	271	100.0

Data Source: Michigan hospital/ED medical records.
*Payment source was unknown for 33 (11.0%) cases in 2012 and 29 (9.7%) cases in 2013.
[1]Includes 2 self-employed workers, [2]Includes 4 self-employed workers, [3]Includes 4 self-employed workers, [4]Includes 1 self-employed worker, [5]Includes 6 self-employed workers, [6]Includes 4 self-employed workers.

Referrals to MIOSHA

MIOSHA inspected seventeen workplaces where skull fracture injuries occurred in 2012 and 2013. Table 9 illustrates the distribution of violations and penalties assessed by the industry type of the seventeen inspected workplaces.

Table 9. Workplaces Inspected by MIOSHA: Violations and Penalties Assessed by Industry, Michigan 2012 - 2013

INDUSTRY TYPE (NAICS)	# OF ENFORCEMENT INSPECTIONS	# OF VIOLATIONS	TOTAL PENALTIES ASSESSED
Agriculture, Forestry, Fishing and Hunting (11)	2	1	$1,050.00
Wood Product Manufacturing (32)	1	1	$250.00
Primary Metal Manufacturing (33)	6	13	$9,200
Wholesale Trade (42)	2	7	$5,000.00
Retail Trade (44)	1	0	––
Transportation and Warehousing (48)	1	0	––
Professional, Scientific and Technical Services (54)	2	0	––
Administrative and Support and Waste Management and Remediation Services (56)	2	0	––

Examples of Work-Related Skull-Fracture MIOSHA Enforcement Inspections

- *Other Millwork (including Flooring):* A male in his early forties, was operating a Hydromat 22B Molder and went to make an adjustment to one of the cutters. He pushed a stop control on the machine and then opened the guard exposing an approximately 40-inch high 1½ inch diameter shaft of the cutter that was still winding down. When he reached over the top of the machine to rotate an adjustment crank, the front of his T-shirt became caught in the rotating shaft and pulled his body into the machine frame. The employee's face hit the frame causing a broken upper jaw and teeth. The employee had been trained by employer on lockout procedures. MIOSHA found 1 serious violation and cited the company for not enforcing the use of lockout procedures.

- *Floriculture Production:* A male in his late thirties was engaged with a replacement of a solar heat blanket in a greenhouse. He was using a Little Giant ladder set as an extension ladder. He placed the ladder up against the truss of the roof near the wall. The ladder was in contact with the truss with both side rails and sections of the ladder partially over the contact point of the truss. He was at the shoulder height of the truss when the ladder "slid out" and he fell approximately 12-15 feet to the floor. He sustained depressed skull fractures. MIOSHA found 1 serious violation and cited the company for not ensuring that the side rails were firmly set to the upper anchoring of the Little Giant ladder.

- *Farm Supplies Merchant Wholesaler:* A male in his late thirties was working with three other employees in the removal and replacement of a broken conveyor belt on a Terragator 8300 Applicator tractor. The broken belt had been removed and they were attempting to install the new belt by pulling it through the guides using a forklift. Two 11-inch welding clamps were fastened to the belt, a ½-inch polypropylene rope was tied to each clamp and the ropes were then tied to the mast cage of the forklift. The injured employee had the forklift in reverse attempting to pull the belt into place when one of the clamps released and struck the employee in the head. He lost consciousness and the forklift continued in

reverse until it struck a storage rack and stopped. He then fell off of the forklift and landed on the floor. The employee was not trained to perform the new task, was not wearing any form of personal protective equipment and had not been trained in forklift operation. He was hospitalized for five days. MIOSHA found 7 violations (6 serious and 1 other), including: “The employee was not provided with a valid operator permit to operate powered industrial trucks; There was no assessment of the workplace to determine if hazards that necessitated the use of personal protective equipment were present, or were likely to be present; (b) There was no verification through a written certification that the required workplace hazard assessment had been performed; (c) An employer shall provide and an employee shall wear eye protection; An employee shall do all of the following: Not use a tool for other than its designated or approved use; An employer shall: Provide training to an employee as to the hazards, safe operations of the assigned job and applicable rules; A log of all work-related injuries and illnesses (MIOSHA 300), and/or the summary of work-related injuries and illnesses (MIOSHA 300-A), and/or the injury and illnesses incident report (MIOSHA 301), or equivalent forms were not kept by establishment.”

- *Aluminum Die-Casting Foundries:* A male in his late twenties was trapped in a high pressure sanding machine. He lost consciousness, sustained comminuted skull fractures and was hospitalized for eight days. MIOSHA found 2 violations (1 serious and 1 repeat other), including: “A polishing, buffing, or wire brush wheel on a hand jack, automatic machine or coated abrasive machine did not have guards designated to cover at least half of the sides of the working wheel, and designated to extend at least one inch beyond the spindles; A valid operator permit was not provided to a crane operator.”

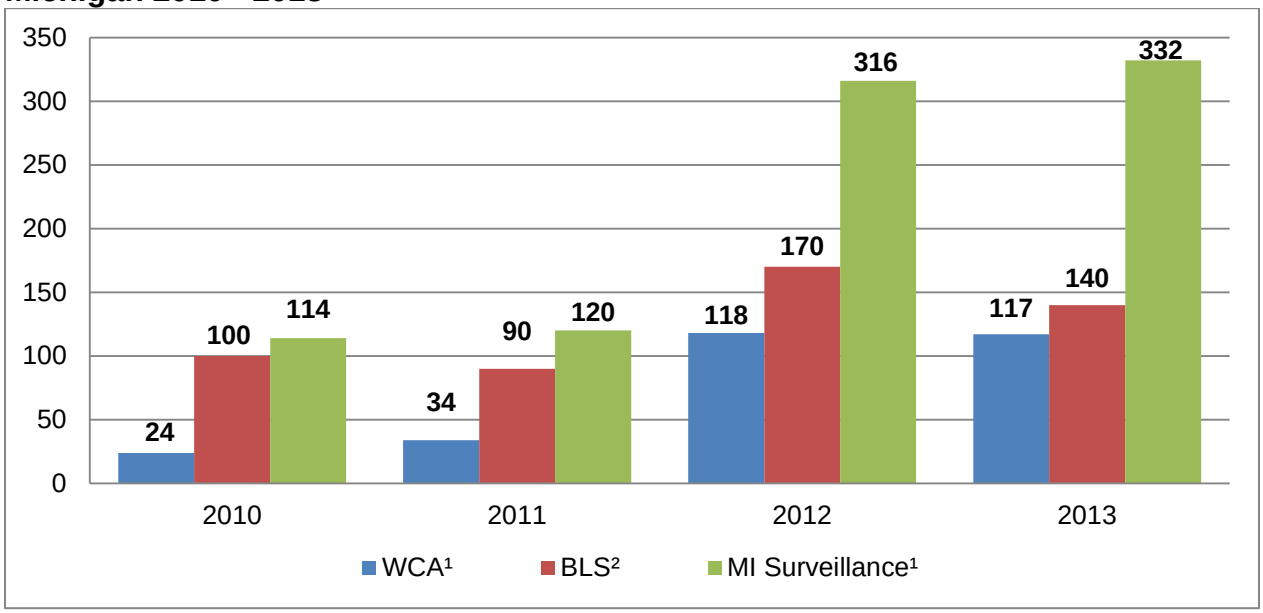
- *Motor Vehicle Steering and Suspension Components (except Spring) Manufacturing:* A female in her mid-forties was working on a production line for car parts when a spring-loaded device snapped back up into her face. She was wearing protective eye wear, but the spring hit her nose. The employee sustained depressed fracture of her nasal bone. MIOSHA found 7 violations (2 serious and 5 other), including: “A point of operation guard or device was not

designed and constructed to prevent machine operator exposed to the hazard from having any part of her body in the hazardous area during the operating cycle; The band wheels and all portions of the blade of a vertical metal band saw were not guarded; There was no assessment of the workplace to determine if hazards that necessitated the use of personal protective equipment were present, or were likely to be present."

DISCUSSION

This is the second report on work-related skull fractures in Michigan. It covers two calendar years, 2012 and 2013. 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 316 work-related skull fractures in 2012 in comparison to 170 estimated by BLS and 332 in 2013 in comparison to 140 estimated by BLS (Figure 9). Inclusion of fractures of facial bones in 2012 and 2013 led to the large increase in the number of work-related skull fractures identified by the WCA and MI surveillance system, as compared to the number of work-related skull fractures identified in 2010 and 2011 when fractures of the facial bones were excluded. Despite the exclusion of facial fractures in 2010 and 2011 in the Michigan system, there were still more skull fractures identified in the Michigan system in 2010 and 2011 than in the BLS estimates, which included facial fractures for all four years, 2010-2013.The number of fatalities increased from two in 2011 to six in 2012 and five in 2013.

Figure 9. Number of Work-Related Skull Fractures by Three Surveillance Systems, Michigan 2010 - 2013



[1] 2010 and 2011 WCA and MI Surveillance estimates do not include nasal fractures. In 2010, there were additional 19 nasal fractures and in 2011 there were additional 22 nasal fractures identified by the WCA.
[2] 2010 – 2013 BLS estimates include nasal fractures, however it is unknown how many nasal fractures are included in the BLS estimates.

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. 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 twelve self-employed individuals in 2012 and thirteen in 2013, and twelve farmers in 2012 and sixteen farmers in 2013 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 2012 and 2013. Another 27 (5.0%) were not covered by workers compensation (i.e. self-

employed). We do not know the reasons why for the other 31% of the hospitalizations/ED visits worker compensation was not listed as the payer.

If one used Michigan's Workers' 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 Workers' Compensation Agency undercount include: 1) The WCA data set only included skull fractures that caused 7 or more consecutive days away from work; 2) WCA excluded the self-employed, but again there were only twelve self-employed workers in 2012 and fifteen self-employed workers in 2013 in Michigan' multi source reporting system; 3) Coding or miscoding errors in the WCA data. The matching with hospital records showed that 74 work-related skull fractures in 2012 and 61 work-related skull fractures in 2013 identified from medical records were not classified as skull fractures in the WCA data. Potentially there were other injuries in the WCA database that were similarly misclassified but for which no medical records were received; 4) It is possible that some companies are handling skull fracture injuries unofficially and not reporting them to Workers' Compensation insurance companies or the WCA.

Surveillance of work-related skull fractures is crucial to the recognition and prevention of these conditions. In 2012 and 2013, seventeen 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.[11] Beginning in 2014, we expanded the work-related skull fracture surveillance system to include individuals hospitalized overnight with work-related intracranial injuries including bleeds and concussions (ICD-9 codes: 850.0-.9, ICD 851.0-.9, 852.-.5, 835.0-.1 and 854.0-.1). This expansion in the number of conditions

being tracked will provide an even better understanding of the serious work-related head injuries that occur in Michigan.

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