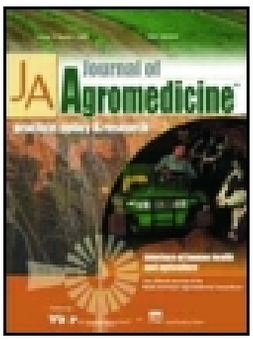

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Multisource surveillance for non-fatal work-related agricultural injuries

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ABSTRACT

Objectives: Development of a state-wide comprehensive surveillance system for non-fatal work-related farm injuries, since non-fatal injuries that occur to the self-employed (i.e., many farm owners/operators), family workers, federal government workers and small farms with fewer than 11 employees are not included in the Bureau of Labor Statistics employer-based survey used to produce the U.S. National statistics of work-related injuries.

Methods: In 2015 and 2016, inpatient discharge summaries, emergency department, and hospital-based outpatient clinic records from all 134 of Michigan's hospitals with ICD-9 codes 989.0-.1, E827.0-.9, E849.1, E906.8, E919.0 or ICD-10 codesT65.0-.1, V80, Y92.7, W55.1-.4, W30 were reviewed to identify non-fatal work-related farm injuries.

Results: We identified 1,559 non-fatal work-related farm injury incidents that occurred in 1,525 individuals, with 74% being among men. The most common parts of the body injured were an upper limb (38.2%) and a lower limb (23.7%). The most common types of injury were contusions (26.4%) and fractures (19.9%). Owners/operators accounted for 44.1% and hired hands for 42.9% of individuals injured. Injuries caused by cows were the predominant cause: 472 (31.5%) of all the injuries. Dairy farms accounted for 39.6% of all cases for which the farm type was recorded.

Conclusion: A comprehensive system to identify non-fatal work-related farm injuries among all individuals who work on a farm, including owner/operators, family members and migrant and seasonal farm laborers, was implemented using hospital, emergency department and hospital-based outpatient clinic medical records. Such a system is important to be able to identify hazards and target prevention.

KEYWORDS
Agriculture; dairy industry; non-fatal agricultural injury; surveillance; work-related farm injury

Introduction

The agriculture industry is one of the most hazardous industries, where farm operators and workers have a high rate of farm-related fatalities.[1] In addition, the U.S. Bureau of Labor Statistics (BLS), the official source of work-related injury statistics, estimated nationwide in 2015 there were 37,400 work-related agricultural injuries (excluding injuries in Forestry, Fishing and Hunting), an incidence rate of 6.1 per 100 full-time equivalents (FTEs).[2] There were 22,800 of the injuries that led to days away from work, job transfer or restriction–an incidence rate of 3.7/100 FTEs. In 2016, BLS estimated there were 34,400 (5.8 per 100 FTEs) farm-related work injuries of which 19,000 (3.2 per 100,000 FTEs) had days away from work, job transfer or restriction.[2] For Michigan in 2015, BLS estimated there were 1,000 (5.2 per 100 FTEs) work-related agricultural injuries, of which 500 (2.6 per 100 FTEs) had days away from work, job transfer, or restriction, and there were 700 (4.1 per 100 FTEs) in 2016, of which 500 (2.8 per 100 FTEs) had days away from work, job transfer, or restriction.[3] In contrast to the BLS surveillance system for fatal work-related injuries (Census of Fatal Occupational Injuries [CFOI]), which uses multiple-sources and includes all individuals in the agricultural sector regardless of their work status and number of employees, the BLS estimates for non-fatal injuries are based on employer reporting through the Survey of Occupational Injuries and Illnesses (SOII).[4] The BLS non-fatal injury estimate has substantial limitations and does not present a true estimate of agricultural injuries, missing about 77.6% of occupational injuries and illnesses in agriculture.[5] The BLS estimate for agriculture does not include self-employed owner/operators, family workers, federal government employees, or farms with fewer than 11 employees. In Michigan, an estimated 3% of farms are large farms (10+ employees) which

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employ 60% of farm workers in the state.[6] Several national studies and surveys have reported the health and safety hazards and measured the magnitude and characteristics of agricultural injuries in specific geographic areas or populations.[7–15] A few international retrospective studies analyzed farming injuries treated in emergency departments.[16,17]

In 2015, Michigan initiated surveillance for non-fatal work-related farm injuries, adding farm injuries to existing multi-source surveillance for non-fatal work-related amputations, crushing injuries, burns, skull fractures, and hospitalized injuries.[18] Michigan's surveillance system tracks all work-related farm injuries, irrespective of the number of farm workers on the farm, the individual's age, or whether self-employed or family worker that are treated at Michigan's hospitals, emergency departments or hospital-based outpatient clinics. This article describes Michigan's surveillance system and the non-fatal work-related farm injuries identified in the first two years of the system.

Methods

Case definition

A farm-related injury case was defined as an individual (any age) examined at a Michigan hospital, Emergency Department (ED), or hospital-based outpatient clinic for whom: 1) a farm injury-related ICD-9 or -10 code was assigned (see specific ICD-9 and -10 codes below); and 2) review of the medical records indicated the individual's medical condition occurred because of work on a farm.

"Work" has been defined as any form of agricultural activity carried out on the farm. However, injuries related to activity around the home, even though the home was typically on the farm, were not included. Children, who were injured while performing chores on a farm, were included. "Chores" have been defined as regular daily light work on a farm.

Non-fatal work-related farm injuries were identified for the two-year period from January 1, 2015, to December 31, 2016.

Data sources

Hospital/emergency department

All 134 of Michigan's acute care hospitals, including Veterans' Administration hospitals, are required by state regulation to identify and report work-related farm injuries as part of the state's traumatic injuries reporting requirement.[19] Hospitals submitted discharge summaries and ED and hospital-based outpatient clinic records of individuals (any age) where one of the following ICD-9 diagnostic codes[20] were assigned for a medical encounter between January 1, 2015 and September 30, 2015:

- 989.0-.1 (toxic effect cyanides, strychnine),
- E827.0-.9 (animal-drawn vehicle accidents),
- E849.1 (place of occurrence – farm),
- E906.8 (other injury caused by animal),
- E919.0 (accidents caused by agricultural machinery)

or ICD-10 diagnostic codes[21] for medical encounters from October 1, 2015 to December 31, 2016:

- T65.0-.1 (toxic effect cyanides, strychnine),
- V80 (animal-drawn vehicle accidents),
- Y92.7 (place of occurrence – farm),
- W55.1-.4 (other injury caused by animal),
- W30 (accidents caused by agricultural machinery).

Workers' compensation agency

The Michigan Workers' Compensation Agency (WCA) provided access to a database of all paid claims for wage replacement due to lost work time in 2015 and 2016. Individuals are eligible for wage replacement when they have had at least seven consecutive days away from work (five workdays and two weekend days).

Analysis

To differentiate work and non-work-related farm injuries a single staff person reviewed the discharge summary diagnosis for hospital admissions,

and the medical records for ED and hospital-based outpatient clinic visits. In case of uncertainty whether the injury was work- or non-work -related, which occurred in approximately 5% of the records, the medical record was reviewed by a second staff person. Information from the hospital, ED, and hospital-based clinic visit medical reports on each case were abstracted, including: type of medical care (hospital overnight, ED, outpatient), hospital name, date of admission and discharge, patient demographics, city and county of residence, source of payment, information on whether the worker was a migrant worker, occupation type, farm information (type, name, address), injury date, part of body injured, injury source, nature of injury.

Occupation type was classified as owner/operator, hired hand, family member and migrant worker. We could not determine whether the family member was paid. Injury source was classified as cattle, horse, poultry, livestock (other than cattle or horse), chemical, tractor, non-tractor machine, fall from height, fall at ground level, tool and other. Nature of injury was classified as contusion/bruise, fracture, laceration/cut/puncture, sprain/strain, head injury (with no fractures), crushing injury, amputation, abrasion, concussion, burn, dislocation, animal bite/sting and open wound. Occupation, injury source and type were obtained from reading the health care providers' medical notes.

The hospital/ED/hospital-based outpatient clinic visit farm injury data were entered into a Microsoft Access database and records were manually linked to records in the workers' compensation database. The Michigan WCA database was matched with the Access database using an individual's first and last name, date of birth and date of injury. Information from workers' compensation on matched cases was added to the database.

The data for 2015 and 2016 were combined. Individuals, who sustained two unique farm injuries in the same calendar year and/or in two different calendar years, were counted only once. The total number of injuries included multiple injuries that occurred at different times to the same person.

Data analysis was performed using queries conducted in Microsoft Access. Numbers and incidence rates of non-fatal occupational injuries and illnesses by industry and case types were available from the BLS SOII.[22] SOII provides counts and incidence rates for non-fatal cases of work-related injuries and illnesses from participating states, including Michigan, that are recorded by employers under the Occupational Safety and Health Administration's (OSHA's) recordkeeping guidelines.

The BLS Occupational Injuries, Illnesses and Fatal Injuries Profiles online tool was used to generate the 2015 and 2016 BLS counts and incidence rates of non-fatal occupational injuries and illnesses involving days away from work by selected worker and case characteristics and occupation for both private and public ownerships.[23,24] Code 452000 (Agricultural Workers) was used to generate the estimates and incidence rates. The BLS employer survey of employers does not count injuries in self-employed farm owners/operators, family workers, federal government employees, and farm workers who work on farms with less than 11 employees nor does the denominator BLS used to calculate the rates include these type of individuals. These types of individuals were included in both the numerator and the denominator for injuries identified in the Michigan surveillance system.

Categories of farm labor

The U.S. Department of Agriculture 2012 Census of Agriculture for Michigan and the Michigan Migrant and Seasonal Farmworker Enumeration Profiles Study (Update June 2013) was used for denominators to calculate rates.[6,25] Due to a number of issues associated with summing up the counts of hired labor, unpaid workers, and migrant/seasonal workers in the denominator, two incidence rates were calculated. The first incidence rate utilized the number of operators, hired farm labor, unpaid workers and migrant/seasonal laborers; the second incidence rate was based on a smaller denominator because it assumed that both hired farm labor and migrant/seasonal laborers were included in the hired hand category. Rates were presented as a range using these two denominators, 217,552 and 266,687, respectively. According to the U.S. Department of Agriculture 2012 Census of Agriculture for Michigan, there were 52,194 farms in Michigan with 80,304 operators, 83,451 hired farm labor,

53,797 unpaid workers and 49,135 migrant and seasonal laborers.[6] Farm operators are people who own or control the operations on the farm and are usually self-employed. Hired labor includes paid family members, bookkeepers, office workers, maintenance workers, etc., if their work was primarily associated with agricultural production. Hired farm workers excluded contract (migrant) workers and operators identified as a hired manager. The Census divides hired farm workers into two categories based on the duration of work in a calendar year: working 150 days or more (25,710 workers) or less than 150 days (57,741 workers). Unpaid workers include agricultural workers not on the payroll who perform activities or work on a farm or ranch (family members). The number of migrant workers was not noted on the 2012 Agricultural Census, only the number of farms utilizing migrant labor. The Michigan Migrant and Seasonal Farmworker Enumeration Profiles Study (Update June 2013) estimated 49,135 migrant and seasonal farm laborers.[25]

Results

We identified 1,559 work-related farm injuries (677 in 2015 and 882 in 2016) in 1,525 individuals (668 in 2015 and 871 in 2016). To identify these 1,559 work-related farm injuries, we reviewed 4,467 medical records with the selected ICD codes and determined that 2,908 (65.1%) were not work-related.

Twenty individuals sustained two unique farm injuries in the same calendar year, 13 individuals had a farm injury in 2015 and another in 2016, and one individual had three unique farm injuries; two in 2015 and another in 2016. The rate was between 2.53 and 3.11 per 100 workers in 2015 and between 3.3 and 4.05 per 100 workers in 2016.

The employer-based system estimated 1,700 farm injuries for Michigan with a rate of 5.2 per 100 FTEs in 2015 and 4.1 per 100 FTEs in 2016.[22]

BLS reported 680 (390 in 2015 and 290 in 2016) non-fatal work-related farm injuries involving days away from work by selected worker and case characteristics for Michigan.[23,24] Because of confidentiality restrictions, we were unable to match our data set with the BLS set.

Table 1. Summary characteristics of non-fatal work-related farm injuries, Michigan 2015–2016.

	Number	(Percent)
Gender		
Male	1131	(74.2)
Female	394	(25.8)
Total	1525	(100.0)
Age group, yr		
<6	4	(0.3)
6–10	10	(0.7)
11–15	52	(3.4)
16–19	121	(7.9)
20–24	190	(12.5)
25–34	285	(18.7)
35–44	231	(15.1)
45–54	205	(13.4)
55–64	199	(13.0)
≥65	228	(15.0)
Total	1525	(100.0)
Race		
Caucasian	671	(89.5)
African-American	8	(1.1)
Asian	4	(0.5)
Other	67	(8.9)
Total	750[a]	(100.0)
Hispanic ethnicity		
Yes	181	(41.2)
No	258	(58.8)
Total	439[b]	(100.0)
Medical encounter		
Overnight	171	(11.0)
Emergency only	1347	(86.4)
Outpatient	41	(2.6)
Total	1559	(100.0)
Part of body injured		
Upper extremity	595	(38.2)
Lower extremity	370	(23.7)
Head	230	(14.8)
Back	160	(10.3)
Vision	44	(2.8)
Respiratory	18	(1.1)
Other	142	(9.1)
Total	1559	(100.0)
Source of payment		
Commercial	557	(41.7)
Workers' compensation	323	(24.2)
Medicare/Medicaid	321	(24.1)
Self pay	133	(10.0)
Total	1334[c]	(100.0)

[a]Information for race classification was missing for 775 individuals
[b]Information for hispanic ethnicity classification was missing for 1,086 individuals
[c]Information for payment classification was missing for 225 cases

Demographics

The age of injured farm operators and workers varied from 4 to 86 years, with an average age of 41.4 years (Table 1). The 25–34 and 35–44 age groups, 285 (18.7%) and 231 (15.1%), respectively had the largest number of injuries. There were 66 children, aged 15-years and younger, including 14

aged 10-years and younger, who performed chores on a farm. Of all work-related farm injuries, 1,131 (74.2%) were among men (Table 1).

Among the 750 (49.2%) individuals where race was available, 671 (89.5%) were Caucasian, 8 (1.1%) were African-American, 4 (0.5%) were Asian, and 67 (8.9%) were "Other" (Table 1). Information on ethnicity was only available in the medical record for 439 (28.8%) individuals. Of the 439 individuals, 181 individuals (41.2%) were of Hispanic origin. Hispanic workers were more likely to be a hired hand (96.8%) than non-Hispanic workers, who were more likely to be owner/operators (52.6%). Dairy farms were the most common location of injuries for both Hispanic and non-Hispanic individuals, with 63 (42.9%) and 42 (30.5%) cases, respectively.

Type of medical encounter

There were 171 (11.0%) individuals hospitalized overnight, 1,347 (86.4%) individuals were only seen in the ED, and 41 (2.6%) individuals were seen in a hospital-based outpatient clinic (Table 1). For all farm injuries that required hospitalization, males (86.5%) were more likely than females (13.5%) to be hospitalized. Of hospitalized individuals, 51% were owner/operators. Among those hospitalized because of fractures (70.2%), fractures to lower extremities (33.3%) were the most common, followed by fractures to upper extremities and back, each with 19.2%. Fall from a height (21.6%) was the predominant cause of hospitalization, followed by injury caused by a machine other than tractor (16.4%).

Part of body injured

The part of body injured was specified in the medical records for all farm injuries. Farm injuries of upper limbs occurred most often (38.2%), followed by injuries of lower limbs (23.7%) (Table 1).

Source of payment

Commercial insurance was the expected payer in 557 (41.7%) cases, followed by workers' compensation insurance in 323 (24.2%) cases, Medicare or Medicaid insurance in 321 (24.1%) cases and self-pay in 133 (10.0%) of cases (Table 1). For 225 farm injuries, payment source was not available in the medical record.

Injury source

The cause of injury was available in 96.2% of the medical records. Injuries caused by cows were the most common and accounted for almost a third of all injuries (31.5%) (Table 2). The next most common sources were injuries from machines other than a tractor (e.g., combine, corn husker, auger, hay baler) (10.4%), falls from height (8.6%), and falls at ground level (7.6%) (Table 2). Category "Other" (19.7%) includes different types of injury sources (i.e., being struck by barn door, dropping a heavy object on a hand, being cut by a tree branch, running into a pole while going after a cow) that did not fall into the ten defined categories.

Nature of injury

The most common type of injury was contusion in 412 (26.4%) individuals, followed by fractures in 311 (19.9%) individuals, and lacerations in 231 (14.8%) individuals (Table 2). For all injuries involving contusions, fractures, and lacerations, the most often injured parts of the body were upper and lower extremities, with 70.4%, 60.6%, and 69.7%, respectively.

Occupation type

The occupation type was specified for 77.8% of all medical records. Owner/operators accounted for 44.1% of all the individuals injured, followed by hired farm labor with 42.9%, family members with 11.6%, and migrant workers with 1.4%. There were additional 10 individuals, who were not family members and were not paid for their work but assisted on a farm.

Farm type

The type of farm was recorded by a health care provider for only 903 (57.9%) cases (Table 2). Dairy farms accounted for over a third (358; 39.6%) of all cases, followed by livestock farms with almost a quarter (213; 23.6%) of all cases (Table 2). Category "Other" includes farms, such

Table 2. Summary characteristics of non-fatal work-related farm injuries, Michigan 2015–2016.

	Number	(Percent)
Injury Source		
Cattle	472	(31.5)
Other	296	(19.7)
Non-Tractor Machine	156	(10.4)
Fall from Height	129	(8.6)
Fall at Ground Level	114	(7.6)
Livestock (other than cattle or horse)	102	(6.8)
Tractor	99	(6.6)
Horse	59	(3.9)
Tool	58	(3.9)
Chemical	11	(0.7)
Poultry	4	(0.3)
Total	1500[a]	(100.0)
Nature of Injury		
Contusion/Bruise	412	(26.4)
Fracture	311	(19.9)
Laceration/Cut/Puncture	231	(14.8)
Other	172	(11.0)
Sprain/Strain	153	(9.8)
Head Injury (no fractures)	78	(5.0)
Crushing Injury	66	(4.2)
Abrasion	32	(2.1)
Amputation	27	(1.7)
Concussion	22	(1.4)
Burn	20	(1.3)
Dislocation	17	(1.1)
Animal Bite/Sting	14	(1.0)
Open Wound	4	(0.3)
Total	1,559	(100.0)
Farm Type		
Dairy	358	(39.6)
Livestock	213	(23.6)
Other	98	(10.9)
Grain	80	(8.9)
Vegetable	65	(7.2)
Fruit	62	(6.9)
Poultry	27	(2.9)
Total	903[b]	(100.0)
Seasonality		
Spring	367	(23.6)
Summer	490	(31.4)
Fall	432	(27.7)
Winter	270	(17.3)
Total	1559	(100.0)

[a]Information for injury source classification was missing for 59 cases
[b]Information for farm type classification was missing for 656 cases

as a tree nursery or a fish farm, which were not included in the six specific farm categories (98; 10.9%) (Table 2). A comparison of injuries by farm type to the distribution of types of farms in Michigan is shown in Figure 1.

Seasonality

Consistent increased time spent working and hiring of seasonal workers, farm injuries occurred

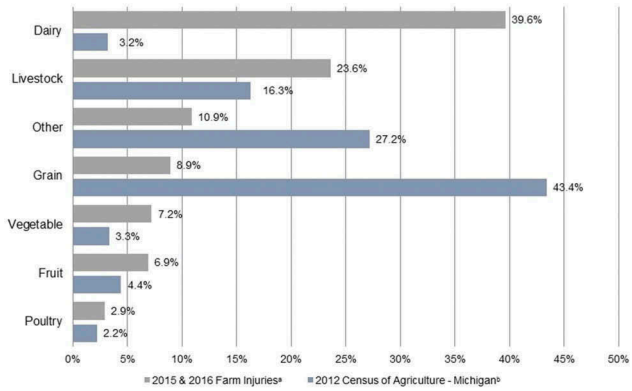

Figure 1. Injuries by farm type compared to distribution of types of farms, Michigan. [a]Information on farm type among 903 injuries identified in medical records. [b]Information of type of farm on 52,194 farms in Michigan, 2012 Census of Agriculture[6].

significantly more often in the summer (31.4%) than in the winter (17.3%) ($p < 0.0001$) (Table 2).

Michigan OSHA intervention

One form of intervention used in all the Michigan surveillance systems for work-related injuries such as amputations, burns, and crushing injuries, including the farm injury system, is for the Michigan OSHA (MIOSHA) program to investigate the worksite after an injury. MIOSHA inspected one workplace where a farm injury occurred in 2015. A male employee in his mid-50s was brushing the last hops from the mixing chamber into the pellet delivery conveyor with a hand brush when his rubber glove became caught in the revolving mixing arms of the hopper. The employee sustained multiple right forearm fractures with displacement. The equipment's e-stop button had not been pushed before the employee began sweeping out the hopper. MIOSHA's enforcement inspection found one serious violation of MIOSHA safety rules: "A point of operation guard or device shall be as prescribed in a specific standard, or, in the absence of a specific standard, shall be 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." The citation was directly related to the injury. The company had not corrected the hazard at the

time of the inspection, which was performed six months after the injury.

Discussion

Michigan's farm-related injury surveillance system identified 1,559 non-fatal work-related farm injuries in 1,525 individuals over a 2-year period. These non-fatal injuries were in addition to 49 agricultural fatalities (21 in 2015 and 28 in 2016) identified during the same time period in a separate system by the Michigan Fatality Assessment and Control Evaluation (MIFACE) Program.[26] Given the exclusions of the BLS employer-based system, we were surprised that the BLS estimate of 1,700 farm injuries for Michigan during this same time period was greater than the number of injuries identified in our medical record based system. In all the other conditions we have under surveillance, the BLS estimates were only 30–40% of what was identified in medical records.[27] Why this is different for farm-related injuries may be based on where farmers seek care, primary care offices, migrant health clinics or urgent care facilities – facilities that were not included in the Michigan surveillance system.

Similar to other reports, farm injuries in male workers were the most common in Michigan (1,131; 74.2%).[8–10,12,13,16,17] The most common part of body injured identified by the Michigan surveillance system were upper extremities (595; 38.2%), similar to results from Switzerland[16] (45.2%) Eastern Ontario[12] (43.9%), Alabama[7] (21.4%), and central New York[8] (27%). Animal-related injuries were more common in Michigan (42.5%), New York[9] (24%), and in the central United States[10] (38.3%), while machinery injuries were more common in Alabama[7] (28.6%), central New York[8] (35%), Iowa[13] (22.9%), Switzerland[16] (39.5%), and Poland[17] (28.2%). Sources of the injury data and the time frame the data were collected varied in previous studies. The Iowa agricultural data were derived from the Iowa Trauma Registry, which is a data repository managed by the Iowa Department of Health of reports from acute care hospitals accredited as Level I, II, and III Trauma Care Facilities (2005–2013).[13] The Maine agricultural and logging data were derived from administrative data for ambulance runs and hospitalizations and did not distinguish work and non-work related injuries (2008).[14] The Minnesota data were derived from an administrative hospital discharge database and did not distinguish work and non-work related injuries (2000–2011).[15] We found that the use of administrative data without the review of medical records would lead to a 65% over count. The Swiss data were derived from patients admitted to the only Level I ED center in a mainly rural and agricultural catchment area in Switzerland (2000–2011),[15] and the Polish data were from agricultural and forestry related injury cases admitted to an ED of a single hospital (2004–2005).[17]

The sources for the other data were population-based cross-sectional surveys; farmers listed in the Alabama Agricultural Statistics Service (AASS) maintained and used by U.S. Department of Agriculture (USDA) (1990–1991);[7] a mailed and telephone interview of farm operators selected from the USDA list of all farms in Otsego County, New York (1984–1986);[8] a telephone interview as part of the New York State Farm Family Health and Hazard Surveillance (1994–1997);[9] surveys mailed by the Central States Center for Agricultural Safety and Health in collaboration with the National Agricultural Statistics Service to farm and ranch operators in seven Midwestern states (2011–2013);[10] a survey using the National Safety Council Farm Accident Survey forms and sampling strategy (1978);[11] and a personal interview with a representative from each participating farm identified by the Agricultural Census Division of Statistics Canada (1986).[12] None of these reports involved development of an ongoing system, and all the surveys depended on the farmer's participation in an interview and self-reports of the injury. These surveys contrast with our ongoing statewide system, which uses medical records of individuals treated in hospitals across the state, includes all individuals working on farms, and is not dependent on participation rates nor self-reporting by individuals. However, one advantage of the surveys is that they capture injuries that either the farmer did not seek treatment for or treatment was provided in a non-hospital based setting.

In contrast to farm-related work fatalities, which are predominately machine related (i.e., tractors), livestock were the most common source of non-fatal injuries in Michigan. Differences like these reinforce the need for a comprehensive surveillance

system that can identify both fatal and non-fatal farm injuries.

In 2015, the rate of farm-related injury was 2.53–3.11 per 100 workers, and in 2016 it was 3.3–4.05 per 100 workers. We have presented the rate as a range, because of uncertainty about the denominator and whether or not migrant/seasonal laborers are included or not as a separate category of farm labor.[4] BLS reported that the non-fatal farm-related injury rate in Michigan in 2015 was 5.2 per 100 FTEs and 4.1 per 100 FTEs in 2016.[3] The BLS rates were higher in 2015 but not in 2016. Differences between the rates we calculated and those calculated by BLS are partially because BLS calculates FTEs while our denominator is the number of workers. We attribute the higher rate in 2015 to not only having more injuries reported to BLS despite the exclusions of the SOII and that BLS used a smaller denominator with the same exclusions as in the numerator to calculate the rates. The lower BLS rate in 2016 is unexplained. Variations in the relatively small number of employer reports, which are then extrapolated to derive the BLS estimate, may be the explanation, and further years of data are needed to explain the variation. This can also be true for our hospital/ED data, where the number of injuries increased from 677 in 2015 to 882 in 2016. The higher BLS estimate suggests that at least for 2015, injuries were recorded as work-related by employers and either were not treated in hospitals/EDs or were not recognized by health care providers in hospitals/EDs as being work-related.

BLS reported 680 (390 in 2015 and 290 in 2016) non-fatal work-related farm injuries involving days away from work by selected worker and case characteristics for Michigan.[23,24] Farm injuries of upper extremities were the most common location both in the BLS data set (240; 35.5%) and in the Michigan surveillance system (595; 38.2%). BLS only collects information on the type of injury for the days away from work cases. Injuries in the BLS system that involve days away from work are likely to be the more severe injuries that are treated in hospitals/EDs, and this is likely to be the explanation why the predominate injury types in the BLS system were similar to the type of injuries reported in our surveillance system. Most farm injuries occurred in farm operators and workers in the 25–34 age group, both in BLS and Michigan surveillance, with 320 (47.1%) and 285 (18.7%), respectively.

A surveillance system based on workers' compensation data would markedly undercount farm injuries. Workers' compensation insurance was identified in the medical records as the payer for only 24.2% of the work-related farm injuries treated at Michigan hospital/ED or hospital-based outpatient clinic. The workers' compensation database identified only 78 (5.0%) of the 1,559 work-related farm injuries identified in our review of medical records. There are different reasons why relying on workers' compensation for farm-related injuries is not sufficient. First in Michigan, the workers' compensation database only included farm injuries that caused 7 or more consecutive days away from work, presumably the most severe cases. Second, WCA, similarly to the BLS, excluded the self-employed (Michigan's surveillance identified 523 owner/operators) and family members (Michigan's surveillance identified 138 family members). Furthermore, in Michigan, agricultural employers, if they employ fewer than 3 employees, do not have to carry workers' compensation coverage. Finally, it is possible that some companies handle farm injuries unofficially and do not report them to workers' compensation insurance companies or the WCA.[28]

Michigan surveillance greatly expands the scope of farm injuries identified as compared to previous state studies.[5,7–9,12–15] The use of Michigan's hospital, ED, and hospital-based outpatient clinic records have been very effective in providing a more accurate count of work-related farm injuries on all individuals irrespective of their age, occupation status, farm type, or severity of the injury. Michigan surveillance using medical records includes all individuals working on a farm, including categories of workers that are excluded by both BLS and WCA in their statistics, self-employed farm owners/operators, family workers, federal employees, and additionally excluded by BLS farm workers who work on farms with fewer than 11 employees. Similar, to the BLS and Workers' Compensation exclusion of certain categories of farm workers, most state studies do not provide injury information on all farm operators and workers or all farming types in specific states. Most studies do not include individuals other than farm operators[7,10] or who do not work or

live year-round on the farm, children, seasonal, and migrant workers.[9] Some state-based studies focused only on specific farming types, like dairy[8] or beef and dairy.[12] Some state-based studies focused only on more severe non-fatal agricultural injuries.[9,13,15] However, two international studies,[16,17] based on an analysis of all emergency department medical records, show more similarities to the design and scope of the Michigan's surveillance than the states' survey-based studies.

The Michigan surveillance system for farm injuries does have limitations. First, the information available from medical records varied. Therefore, information on race and ethnicity, injury source, category of worker, farm type, or source of payment was often missing or incomplete. Second, if individuals who sustained a work-related farm injury while working in Michigan were treated by their own personal doctor, in an urgent care, migrant health clinic, or in a medical facility out of state, that injury would have been missed. Some hospitals may have miscoded diagnoses as not being work- or farm-related, and those would have been missed. Costs of farm injuries were not available from medical records. The data available on the costs of occupational injuries in agriculture in the United States estimate the direct costs to be $1.66 billion and the indirect costs to be $2.93 billion.[29]

Conclusion

Surveillance of all farm-related fatalities in the BLS CFOI surveillance system that does not exclude important components of the farming community such as the self-employed farm owner/operator, family workers, and workers from farms with fewer than 11 employees has become important for targeting the causes of fatalities, such as tractor rollovers, and multiple intervention programs. Similarly, surveillance of work-related non-fatal farm injuries is crucial to the recognition and prevention of these conditions. An advantage of the Michigan surveillance system is that it not only provides a reliable count of the total number of non-fatal work-related farm injuries requiring hospitalization, an emergency department visit, or a hospital-based outpatient visit, but it also provides more detailed information about the farm-related injuries than provided in the BLS SOII. The Michigan system can be used to identify specific farms to perform follow-up investigations. The investigation completed at one farm identified a major correctible problem. The data derived are useful for educational material. For example, we have developed a hazard alert for the safe handling of animals in response to identifying animals, particularly dairy cows, as being the most common cause of injury.[30]

We plan to continue to collect data on non-fatal work-related farm injuries, because such surveillance is crucial to the targeting and evaluation of programs to prevent these conditions. This study is the first compilation of data on non-fatal work-related farm injuries in Michigan, and the number and distribution of non-fatal work-related farm injuries may differ in subsequent years.

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