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Agricultural injuries among central state region operators over a 5-year period: CS-CASH Farm and Ranch Health and Injury Survey 2011-2015

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Abstract

Background The high risk of occupational fatalities in agriculture is well documented, but information on non-fatal injuries is lacking due to challenges in injury surveillance. This surveillance study explored the frequency, characteristics, and risk factors for non-fatal injuries among farmers and ranchers in the central United States.

Methods The Central States Center for Agricultural Safety and Health (CS-CASH), in collaboration with the USDA National Agricultural Statistics Service (NASS), conducted annual surveys (n=34,777 sent) during 2011-2015 covering a seven-state region (Iowa, Kansas, Minnesota, Missouri, North Dakota, Nebraska, and South Dakota).

Results The average response rate was 32% in the five consecutive annual surveys. The average injury incidence rate was 7.0 injuries/100 operators per year. Most injuries (89%) occurred during agricultural work. The most frequent sources of injury were livestock (22%), machinery (13%), and hand tools (12%). Risk factors for injury included: male gender, younger age (vs. 65+ years), farming as the primary occupation, greater work time, greater land area, ranch (vs. farm), organic farming, internet access, and production of several types of crops and animals. Most injuries (56%) required a doctor visit, and 12% required hospitalization. The average medical costs were $1,936 out of pocket and $8,043 paid by insurance. The combined average costs for most serious injuries were $7,858. Most injuries (66%) resulted in some lost time from agricultural work, 13% were serious, resulting in more than 30 days of lost work time.

Conclusions The non-fatal injury rate for self-employed farmers and ranchers was higher than that of hired agricultural workers reported by the Bureau of Labor Statistics. This result reaffirms farming/ranching as a dangerous occupation and emphasizes the need for efforts to prevent agricultural injuries, especially those associated with identified injury sources and risk factors.

KEYWORDS: Agriculture, Injury, Industry, Occupation, Risk factor

Introduction

Agriculture ranks among the most hazardous industries worldwide, and high rates of occupational fatalities, injuries, and illnesses have been observed in many studies.[1–4] The United States Bureau of Labor Statistics (BLS) has reported the highest rates of both fatal and non-fatal injuries for agriculture in recent years compared to other major industry sectors. The incidence of fatal agricultural injuries was 23.4/100,000 full-time equivalent (FTE) workers, vs. 4.7 for all industries combined in 2018.[5] National BLS surveillance data show that agricultural total annual fatalities have declined over time. Still, the rate of fatalities has remained persistently high during the past two decades. The non-fatal injury rate was 5.3 injuries/100 FTE for hired farmworkers, vs. 2.8 injuries/100 FTE for all industries combined in 2018.[6] BLS surveillance of non-fatal injuries excludes self-employed farmers and ranchers, and there are currently no other national surveillance systems that cover this primary agricultural workforce in the United States (US). Under-reporting of agricultural injuries is also a challenge.[7]

Previous studies have identified numerous risk factors for agricultural injuries.[8,9] Some are personal characteristics, such as age, gender, existing health conditions, medication use, and history of prior injury. Injuries are also related to specific work tasks such as operating machinery, handling animals, and transporting goods.[10] Social-cultural factors also contribute to the risk of injury, including economic pressures and division of labor on farms.[11] Studies indicate that risk factors for serious injuries and all injuries are similar, but the severity of injuries varies by source: livestock incidents are most frequent, but machinery incidents are most often fatal.[12] Injuries suffered by farmers tend to be severe, but farmers often continue working even after injured or not fully healed from injury events.[10] Similarly, hired agricultural workers often continue working after injury due to fear of lost wages or losing the job. Injuries affect the farmer's ability to manage the operation, having to absorb costs resulting from the injury, and also having to work with limited ability while recovering from the injury. Injury costs per

person are roughly 30% higher for agricultural workers compared to the national average. [13] However, estimates of agricultural injury costs in the US have not been published recently.[7,13-15]

There is a great variation in agricultural injury characteristics and risk factors by region, type of production, and over time. Therefore, further research on the injury frequency, sources, risk factors, and preventive strategies is needed to reduce the burden of injury in agriculture. [16] This surveillance study aimed to describe the incidence, characteristics, costs, and risk factors of injuries among self-employed farm and ranch operators, using a five-year injury surveillance dataset (2011-2015) from the CS-CASH surveillance system.

Methods

Study Population and Design

This study was conducted as part of the Central States Center for Agricultural Safety and Health (CS-CASH) surveillance program in the Center's geographic region, which consists of seven states: Iowa, Kansas, Minnesota, Missouri, Nebraska, North Dakota, and South Dakota. Annual mail surveys were administered on contract by the USDA National Agricultural Statistics Service (NASS). The annual samples, stratified by state, were drawn randomly by NASS from their database of agricultural operations that responded to the most recent Census of Agriculture (2007 or 2012). [4] USDA defines agricultural operations (farms and ranches) as "any place from which $1,000 or more of agricultural products were produced or sold, or normally would have been sold, during the year". [17] There is no official USDA definition for a ranch, but ranches are commonly known as operations that raise grazing livestock on large land areas. Ranching is prevalent in the western part of the study region, and we asked respondents to self-identify their operation as a farm or a ranch.

In 2007, the Census of Agriculture reported 437,042 agricultural operations and 658,412 operators in the central states region, which represented (20%) of the total US agricultural operations (n = 2,204,792), and (20%) of operators (n = 3,281,534). Samples for the 2011 and 2012 surveys were drawn

from the 2007 Ag Census population, and 2012 Census data were used in the 2013, 2014, and 2015 surveys. NASS administered the stratified random sampling; 1000 operations per state were selected randomly for each annual survey.

The surveillance research plan was reviewed by the University of Nebraska Medical Center's (UNMC) biomedical institutional review board (IRB), which determined this surveillance research to be Exempt (not human subjects research) (#452-11-EX).

Data Collection

The Central States Center for Agriculture Safety and Health (CS-CASH) research team designed a four-page survey form, which included questions about demographics and injuries for up to three operators on the farm or ranch. The annual surveys were administered by NASS, including first mailing of the survey forms, second mailing to non-respondents, and data entry of the returned responses. The mailings occurred in the spring, requesting information for the previous calendar year (2011, 2012, 2013, 2014, and 2015). After the removal of duplicates, the final samples for mailing in the seven-state region were: n = 6953, 6912, 6912, 7000, and 7000 in the five consecutive years, 2011-2015; a total of 34,777 operations. NASS entered the data from returned surveys (n= 11,226 responses in five years) and merged selected farm production variables for each operation from the most recent Census of Agriculture data. NASS created a de-identified dataset and made it available for analyses by CS-CASH investigators authorized by UNMC IRB and USDA/NASS. Statistical analyses were conducted at the NASS office in Lincoln, Nebraska, using NASS computers and software. The investigators were required to comply with both UNMC IRB and NASS confidentiality procedures.

The primary outcome in this study was non-fatal injury, self-reported by the question: "How many farm-related injuries occurred to each operator during [calendar year]?". Response options were 0 (none), 1 (one), 2 (two), and 3 (three or more). "Injury" was defined as follows: "Injury" is the result of a sudden, unexpected, forceful event, which has an external cause, and which results in bodily damage or loss of

consciousness. “Farm-related” was defined as: work and leisure activities on this operation, plus commuting, transport, and business trips for this operation. Similar definitions have been used in Iowa’s Certified Safe Farm study[18] and worker’s compensation systems. [15,16] The survey form also included several questions on injury characteristics for the most serious injury.

Independent variables in this study included demographic variables from the injury survey and farm production variables from existing Ag Census data. Individual-level factors included: operator age (age groups 18-44, 45-64, 65+), sex (male, female), operator status (principal, 2nd, 3rd), primary occupation (farm/ranch, other), and percent of total work time spent on the farm/ranch work (0-24%, 25-49%, 50-74%, 75-99%, and 100%). Farm-level independent variables included operation type (farm, ranch), total acres, field crops, hay/forage, woodland crops, cattle, hogs, poultry, sheep/lambs, horses/ponies, other animals, number of tractors by horsepower, internet access, principal operator’s total household income, percent of the total household income that came from the agricultural operation, off-farm workdays, retirement status, and number of households sharing income from the operation.

Data analysis

Descriptive analyses included calculating injury rates for all operators during the five-year study period and specific rates for sub-groups and years. Each operator could report 0, 1, 2, or 3 or more injuries. All reported injuries for an individual were included in the injury rate calculations (vs. counting only injured people). Three or more injuries were counted as three. Person-years were used as the denominator of injury rates. Each person was considered as a full-time worker. The injury rate was calculated by dividing the total number of injuries by the total number of person-years multiplied by 100. Injury rates at the sub-population level were calculated similarly; that is, the incidence rate for each level of all categorical variables was calculated by dividing the number of injuries within the variable level by the total number of person-years reported for that level.

Analytical statistics included testing correlations of continuous variables and associations of categorical variables, followed by regression analyses of potential risk factors for injury. Unadjusted (crude) and adjusted models were tested to identify risk factors for injury. Models were fitted using Generalized Estimation Equations (GEE) with an exchangeable covariance structure, accounting for the clustering of operators within the same operation. We converted all continuous variables into categorical variables and conducted separate unadjusted analyses of all potential risk factors. Predictor variables that were statistically significant ($p<0.05$) were entered in multivariable models. Multivariable analyses were conducted adjusting for operator status, gender, and age group. The GEE results are expressed using odds ratios (OR) and their respective 95% confidence intervals (CI). All statistical analyses were conducted using SAS software (version 9.4; SAS Institute, Cary, NC). [19]

Results

Annual farm and ranch health and safety surveys were mailed to 34,777 operations during 2011-2015. A total of 11,226 responses were received containing information for up to three individual operators per operation. The average response rate (for all years and states combined) was 32.2%. The response rate was highest in 2013 (36.5%) and lowest in 2015 (29.5%). Among the seven states, Minnesota had the highest response rate (37.2%), and North Dakota had the lowest response rate (24.2%). The respondents reported 15,173 individual operators; 72.0% of them were principal operators, 23.3% second operators, and 4.7% third operators. Among the 11,226 responding farms and ranches, most were identified as farms (83%), and the remainder (17%) were ranches.

A total of 875 operators (5.8%) were injured, reporting one or more non-fatal injuries. Most injured operators were male (n=751) while (n=118) were female (Table I).

Out of 875 injured operators, 731 had one injury, 95 had two injuries, and 49 had three or more injuries. The number of injuries during 2011-2015 was 1,068 in total when three or more injuries were counted as three injuries. Most injuries (89%) occurred during agricultural work, while (11%) occurred during leisure time. The most frequent sources of injury were livestock (22%), machinery (13%), and hand tools (12%). More than half of the injuries (56%) required a doctor visit, and 12% required hospitalization. The average medical costs were $1,936 out of pocket and $8,043 paid by insurance. The average combined cost of both out of pocket medical costs (USD) and medical costs paid by insurance (USD) was $7,858. Two-thirds of the injuries (66%) resulted in some lost time from agricultural work, and 13% were serious, resulting in more than 30 days of lost work time. The overall injury rate (number of injuries/number of person-years * 100) for all five years combined was 7.04 injuries/100 person-years. The highest injury rate was observed in 2014 (8.3), followed by 2012 (7.5), 2011 (7.4), 2015 (6.3), and 2013 (6.1). Injury rates reported by state from highest to lowest were North Dakota (8.4), South Dakota (7.9), Iowa (7.5), Nebraska (7.3), Kansas (6.7), Minnesota (6.2), and Missouri (5.7). The frequencies are presented in more detail in Table II.

Several significant individual and farm-level risk factors were identified through univariable (crude) regression analyses (Table III). All predictors that were significant in univariable models were assessed and included in the multivariable (adjusted) models. The following were identified as significant predictors for injury: operator's primary occupation, worktime, land in use, retirement status, tractors on the operation (40-99 horsepower and 100+ horsepower), field and hay crops, poultry on the operation, other animals, total sales for operation and internet access (Table III).

Discussion

Reliable surveillance information is critical for the prevention of occupational injuries. This is a challenge in agriculture, however. After NIOSH discontinued surveillance in agriculture, no national surveillance

systems cover the primary agricultural workforce in the United States (US): self-employed farmers and ranchers.[20] The problem is universal; similar difficulties in agricultural injury surveillance exist in Canada[21] and much of Europe. [22] The Central States Center for Agricultural Safety and Health (CS-CASH) contributes to filling this gap by conducting surveillance of occupational injuries to self-employed farmers and ranchers in a seven-state region of the US.

Our analyses of the 2011-2015 surveillance data showed that the incidence rate, 7.0 injuries/100 person-years, was higher than the rate reported by the Bureau of Labor Statistics for hired workers in agriculture.[6] The NIOSH surveys of hired crop workers also found much lower injury rates, ranging from 2.9 to 4.3/100 workers in the 1999 - 2015 surveys.[23] Other studies of agricultural injuries have reported rates ranging from 4.1-16.6 injuries/100 workers per year. [24–28] Our study showed the average combined cost of both out of pocket medical costs and medical costs paid by insurance was $7,858 (USD).

Several risk factors for injury were identified in this study. Being a principal operator involved 1.5 times greater odds of injury compared to being the third operator. Similarly, McCurdy and Carroll found that the risk of injury to the primary operators was higher compared to all other operators. [29] Operating a ranch involved 1.4 times higher odds of injury compared to operating a farm. This is a unique finding in our surveillance study; we were unable to find other studies comparing injuries on farms vs. ranches. Earlier report[4] from three years of our surveillance data suggested the same, and with the current larger five-year dataset, this finding was statistically significant.

Younger age groups (18-44 and 45-64 years) had a significantly higher risk of injury than the oldest age group (65-years or more). Interestingly, age is included in most injury risk factor studies, but a systematic review and meta-analysis of 38 studies found inconclusive evidence on age as a risk factor. [9] However, there is a clear difference between non-fatal and fatal injuries in this regard as fatal injury counts and rates commonly increase by age, particularly in populations over 50 years of age. [28]

The odds of injury increased gradually with work exposure time, being highest for those who spent 75-99% of their work time on the farm or ranch (vs. off-farm employment). The risk for injury was slightly lower in the full-time (100% agricultural work) group. An increase in injury risk with worktime is expected in studies where the rates are calculated assuming that each person works full time. Other factors may also contribute. Brison et al. suggested that full-time workers have greater exposure to risky tasks such as operating machinery, handling animals, and transporting goods.[10] In contrast, some studies have also reported a higher risk of injury to part-time farmers.[26,27] Operators who reported being retired were at a lower risk of injury. Similarly, when serious injuries were examined, retired farmers were less likely to be at risk.[9] While many retired farmers still participate in agricultural work, their work time and exposures are likely reduced, resulting in a lower risk of injury.[4]

Operators with internet access were at increased risk of injury. Jadhav et al. reported similar results in a meta-analysis of two studies concerning internet use.[9] Opposite results should be expected, as internet use in itself could hardly cause injuries. On the contrary, Aakkula hypothesized that computer use is a predictor of knowledge-intensive management, which reduces uncertainties in farming, and should be related to better management, and lessening the number of disturbances and related injuries.[30,31] These unexpected results may be due to reporting bias or confounding factors, including longer working hours on modern farms.

The results of this study showed that having (vs. not having) larger tractors of 40-99 hp or 100+ hp increased the risk of injuries. The majority of cultivation, planting, and other fieldwork in this region is done with large tractors, the largest ones over 600 hp (~450kW). Operating largest tractors that are only used for pulling tillage, planting, and harvesting equipment should be less risky than using mid-size tractors used for a variety of tasks, including mowing, loading, haymaking, providing power for hydraulic and power take-off (PTO) driven implements, etc. A large number of non-fatal accidents happen in these types of tasks when connecting and disconnecting implements and stepping in and out of the operator

station/cab.[32] Tractor overturns, which are the most common sources of fatal injuries in agriculture, also tend to happen with small and mid-size tractors, particularly older ones that lack roll-over protective structures (ROPS). [29]

Many crops are grown in this region, including corn, soybeans, wheat, oats, sorghum, millet, and hay. Growing (any) field crops increased the risk of injury in this study, as did growing (any) hay crops. Among specific crops that increased the risk of injury were soybeans, wheat, and corn. Others have reported that crop-growing farmers are at an increased risk of injury when operating larger machinery, particularly when using combines for harvesting crops. [33]

Many types of livestock are raised in this region ranging from small-scale family farms and ranches to large scale confined animal feeding operations. Raising livestock, in general, increased the risk of injuries in the current study. The specific production of poultry and 'other animals' also increased the risk while raising hogs or dairy cattle had no association with injuries. Other studies have found similar results about increased injury risk in livestock production in general, as well as raising specific livestock species. [34–36]

Organic farming increased the risk of injury. Organic farming is often done on a smaller scale, with smaller and older equipment, and it may require more manual labor per unit produced. Performing a multitude of tasks contributes to physical stress among organic farmers. [37] Other studies have found a significant decline in workability among organic farmers. [38,39] Sources of injuries in organic farming may be similar to traditional farming practices, except for chemical exposures. Previous studies have shown that organic farming involves psychosocial, interpersonal, social, and contextual factors, with both adverse and protective effects. [37,40]

Our analyses showed that operating larger areas of land was associated with a higher risk of farm-related injury. Previous studies have shown similar results. [41–45] This may be partially due to the increase in exposure time on larger farms; however, larger operations typically also hire greater numbers of

employees to complete the physical work. [46] Also, low-intensity agriculture is more risk-averse, minimizing hazards from environmental factors such as terrain, livestock, and landscape modification. [35] Greater sales from the operation was a significant risk factor for farm-related injury in univariable (crude) and multivariable (adjusted) analyses. These findings are similar to the results in the meta-analysis conducted by Jadhav et al.[9]

Strengths and Limitations

The strengths of this surveillance include providing systematic population-based information on injury counts, rates, characteristics, medical costs, and lost time for farmers and ranchers, who are currently excluded from national surveillance efforts. The strengths also include covering a large, well-defined geographic area that contains about one-fifth of all US farms, ranches, and operators with diverse production of crops and animals. The ability to use existing Ag Census data rather than adding farm operation and production questions into the survey enabled condensing the surveys and focusing just on injury outcomes. Keeping the surveys short is important as the survey length is linked to response rates. [47] With the short 4-page survey, we were able to achieve a 32% average response rate, which can be considered relatively high. USDA NASS has extensive experience in surveys of farms and ranches, and having NASS administer the surveys ensured high data security, quality, and reliability in data management. Data analyses were conducted at NASS premises under their data security procedures, following the research plan approved by UNMC IRB. The injury surveys included questions on medical expenses and lost work time; both are essential aspects describing the burden of injury but are rarely included in surveillance efforts.

This study's limitations include the potential for errors in recall, as the survey (and Ag Census data) relies on self-reporting. The recall time, previous calendar year, is relatively long, although commonly used in injury surveys. The accuracy of some answers may also depend on who on the operation responded. People may remember their own injuries better than injuries to their family members. These errors in

recalling injury incidents could bias the injury counts and rates generally downward. We did not attempt to estimate the working hours for each operator in rate calculations but considered all operators to be full-time workers. This also contributes to under-estimating the injury rates as the denominator is larger than it would be if the actual working hour-based FTE person-year data were available and used as the denominator. The annual surveys utilized the most recent Ag Census data for drawing survey samples and merging farm characteristics data. As the Ag Census is conducted every five years, there was varying time lag (up to 5 years) between Census and survey responses. Misclassification may occur if farm characteristics change during the lag time. While the main farm characteristics are relatively stable, this is a limitation in our surveillance approach. Missing data reduced the power of some analyses, and unclassified 'other' categories left some of the detailed information on injury sources and risk factors unknown. In several cases, the 'other' category was identified as a risk factor, which is not useful for understanding what preventive action and targeting might be needed**.**

Conclusions

This study indicates that the non-fatal injury rate for self-employed farmers and ranchers is higher than rates reported by the Bureau of Labor Statistics for hired agricultural workers and workers in other major industry sectors. Male gender, younger age, farming/ranching as primary occupation, principal operator status, operating a ranch (vs. farm), organic production, and several specific crops and animals raised on the operation were identified as risk factors for injury. These results reaffirm farming/ranching as a dangerous occupation and emphasize the need for more substantial prevention efforts for injuries, especially those associated with identified injury sources and risk factors. The results could be used to evaluate injury trends and characteristics, target further analytical studies, design interventions, and target them to specific populations at risk.

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Application of Public Health Competencies

Throughout my project, I applied many public health competencies. The project allowed me to analyze data, communicate the data, apply systems thinking tools to a public health issue, and examine information sources and public health indicators in occupational and environmental health. One opportunity specifically that was impactful was when I was allowed to share my findings was the western agricultural and safety conference where I could give a poster presentation demonstrating project results.

MPHF22

One of the foundational public health competencies that were achieved was applying systems thinking tools to a public health issue. Using skills learned in correlated data analysis and epidemiology methods, I was able to conduct a literature review and use the proper analysis methods for the secondary source associated with the project.

The concentration-specific competencies that I was able to show during this project are as followed.

EOHMPH2

Analyze sources of exposure in the workplace and the environment that can cause health risks to humans or the degradation of ecosystems: For this study, I applied what I learned in the Injury Epidemiology course at the University of Nebraska Medical Center. I used statistical software to aid me in identifying risk factors for farm-related injuries among central state farmers and ranchers.

EOHMPH8

Examine information sources and public health indicators in occupational and environmental health. From this project, we were able to draft a manuscript; we strongly suggested that further research on injury sources, risk factors, and preventive strategies will be needed to reduce the burden of injury in agriculture now and in the future. This suggestion comes from our findings of available literature and results that have been less than convincing due to the number of intervention studies and lack of national agricultural injury surveillance systems.

Human Subjects

The surveillance research plan was reviewed by the University of Nebraska Medical Center's biomedical institutional review board and determined to be exempt (not human subjects research) (#452-11-EX). This study was exempted from the requirements of review and informed consent set by the biomedical institutional review board of the University of Nebraska Medical Center because we analyzed secondary data collected and de-identified by USDA NASS.

Table I. Operators by injuries and other characteristics (n=15,173)

Characteristics	Operators[a] With injuries[b] n (%)	Operators[a] Without injuries n (%)	Operators[a] Total n
Total	875 (5.8)	14,298 (94.2)	15,173
Gender			
Male	751 (6.2)	11,453 (93.8)	12,204
Female	118 (4.2)	2,694 (95.8)	2,812
Missing	6 (3.8)	151 (96.2)	157
Operator's age (years)			
18-44	176 (6.7)	2,441 (93.3)	2,671
45-64	486 (6.4)	7,097 (93.6)	7,583
65 or older	209 (4.4)	4,551 (95.6)	4,760
Missing	4 (1.9)	209 (98.1)	213
Primary occupation			
Farming/ranching	603 (7.2)	7,833 (92.8)	8,436
Other	264 (4.0)	6,293 (96.0)	6,557
Missing	8 (4.4)	172 (95.6)	180
Operation type			
Ranch	216 (7.7)	2,580 (92.3)	2,796
Farm	659 (5.3)	11,718 (94.7)	12,377
Worktime on operation (%)			
0-24	126 (3.1)	3,904 (96.9)	4,030
25-49	153 (5.4)	2,703 (94.6)	2,856
50-74	123 (6.5)	1,769 (93.5)	1,892
75-99	179 (8.1)	2,023 (91.9)	2,202
100	285 (7.3)	3,647 (92.7)	2,932
Missing	9 (3.5)	252 (96.5)	261
State[c]			
IA	150 (6.2)	2,278 (93.8)	2,428
KS	129 (5.9)	2,077 (94.1)	2,206
MN	126 (5.1)	2,349 (94.9)	2,475
MO	110 (4.9)	2,151 (95.1)	2,261
NE	124 (6.0)	1,955 (94.0)	2,079
SD	105 (6.4)	1,524 (93.6)	1,629
ND	130 (6.2)	1,962 (93.8)	2,092
Missing	1 (33.3)	2 (66.7)	3
Year			
2011	168 (6.2)	2,551 (93.8)	2,719
2012	195 (5.9)	3,086 (94.1)	3,281
2013	185 (5.3)	3,313 (94.7)	3,498
2014	187 (6.6)	2,661 (93.4)	2,848
2015	140 (5.0)	2,687 (95.0)	2,827

a. Farm-related injury: Sudden, unexpected, forceful event, that happens during work and leisure activities on this operation, plus commuting, transport, and business trips for this operation.

b. Each operator could report: None, One, Two, or Three or more injuries.

c. IA: Iowa, KS: Kansas, MN: Minnesota, MO: Missouri, NE: Nebraska, ND: North Dakota, SD: South Dakota

Table II. Distribution, rates, and cost of injuries by operator status, state, and year (n=15,173)

Variable	Number of Injuries reported by operators[a]					Injury count[c]	Injury rate[d]	Cost of most serious injury ($ USD)				
								Out-of pocket[e]		Insurance paid[f]		Combined[g]
	0	1	2	3	Any[b] (%)			Total[h] (n)[i]	Avg[j]	Total[h] (n)[i]	Avg[j]	Avg[j]
Total	14,298	731	95	49	15,173 (100)	1,068	7.0	1,338,369 (691)	1,936	3,678,330 (540)	8,043	7,858
Operator status												
Principal	10,249	561	80	39	10,929 (72.1)	838	7.7	1,102,517 (552)	1,997	3,597,294 (425)	8,464	8,231
Operator 2	3,374	140	14	10	3,538 (23.3)	198	5.6	191,144 (118)	1,620	666,500 (99)	6,732	6,753
Operator 3	675	30	1	0	706 (4.6)	32	4.5	44,708 (21)	2,129	79,870 (16)	4,992	4,983
State[k]												
IA	2,278	122	23	5	2,428 (15.9)	183	7.5	164,990 (109)	1,513	394,721 (89)	4,435	4,825
KS	2,077	118	4	7	2,206 (14.5)	147	6.7	141,872 (103)	1,377	860,582 (80)	10,757	9,547
MN	2,349	104	17	5	2,475 (16.2)	153	6.2	110,430 (103)	1,072	1,060,740 (77)	13,775	10,551
MO	2,151	96	10	4	2,261 (14.9)	128	5.7	199,221 (90)	2,213	344,934 (70)	4,927	5,914
NE	1,955	106	9	9	2,079 (13.7)	151	7.3	471,910 (92)	5,129	531,765 (76)	6,996	10,347
ND	1,524	83	12	10	1,629 (10.7)	137	8.4	164,257 (85)	1,932	649,987 (67)	9,701	9,148
SD	1,962	102	20	8	2,092 (13.8)	166	7.9	85,679 (108)	793	500,935 (80)	6,261	5,237
Year[k]												
2011	2,551	139	20	9	2,773 (18.4)	206	7.4	231,080 (136)	1,699	788,045 (103)	7,650	7,279
2012	3,086	160	24	11	3,233 (21.5)	241	7.5	521,627 (157)	3,322	770,069 (111)	6,937	7,924
2013	3,313	163	18	4	3,446 (22.8)	211	6.1	214,072 (140)	1,529	1,191,587 (115)	10,361	9,371
2014	2,661	152	24	11	2,801 (18.6)	233	8.3	225,250 (136)	1,656	1,014,901 (98)	10,356	8,612
2015	2,687	117	9	14	2,827 (18.7)	177	6.3	146,350 (122)	1,199	579,062 (113)	5,124	5,757

a. Count of operators by the number of injuries they reported. Options: 0, 1, 2, and 3 or more (counted as 3)
b. Any; Count and percentage of operators: total of columns 0, 1, 2, and 3
c. Count of injury cases: $\Sigma(1) + (\Sigma(2) * 2) + (\Sigma(3) * 3)$; Σ = sum; 1,2,3 = number of injuries in corresponding column
d. Rate: count of injuries / count of person-years * 100
e. Out of pocket: Total out of pocket medical costs (USD)
f. Insurance paid: Total medical costs paid by insurance (USD)
g. Combined cost: calculated as the sum of out of pocket and insurance costs / respondents reporting any (either or both) injury-associated medical costs
h. Total: Sum of all costs reported ($)
i. n: Number of people reporting any costs
j. Avg: Average costs
k. Numbers may not add up due to missing data.

Table III. Risk factors for farm-related injuries, 2011-2015 (n=15,173)

Risk factors	Operators (n)[a]					
	With injuries	Without injuries	Crude OR[b]	95% CI	Adjusted OR[b,c]	95% CI
Operator status						
Principal	680	10,249	1.76	(1.23-2.50)	-	-
Operator 2	164	3,374	1.28	(0.89-1.84)	-	-
Operator 3	31	675	Ref[d]	-	-	-
Operation type						
Ranch	216	2,580	1.48	(1.23-1.77)	-	-
Farm	659	11,718	Ref[d]	-	-	-
Operator's age (years)						
18-44	176	2,441	1.67	(1.36-2.05)	-	-
45-64	486	7,097	1.53	(1.29-1.81)	-	-
65 or older	209	4,551	Ref[d]	-	-	-
Missing	4	209	-	-	-	-
Gender						
Male	751	11,453	1.51	(1.25-1.81)	-	-
Female	118	2,694	Ref[d]	-	-	-
Missing	6	151	-	-	-	-
Primary occupation						
Farming/ranching	603	7,833	1.85	(1.58-2.16)	1.83	(1.56-2.15)
Other	264	6,293	Ref[d]	-	Ref[d]	-
Missing	8	172	-	-	-	-
Operator's retirement status						
Active	742	11,272	1.59	(1.28-1.99)	1.34	(1.07-1.69)
Retired	131	2,982	Ref[d]	-	Ref[d]	-
Missing	2	41	-	-	-	-
Worktime on operation (%)						
0-24	126	3,904	Ref[d]	-	Ref[d]	-
25-49	153	2,703	1.86	(1.44-2.40)	1.68	(1.30-2.17)
50-74	123	1,769	2.31	(1.76-3.03)	2.20	(1.68-2.89)
75-99	179	2,023	3.00	(2.34-3.85)	2.79	(2.17-3.59)
100	285	3,647	2.58	(2.05-3.26)	2.35	(1.86-2.98)
Missing	9	252	-	-	-	-
Land in use (acres)						
0-100	221	4,275	Ref[d]	-	Ref[d]	-
101-1,000	427	7,220	1.00	(0.99-1.01)	1.00	(0.99-1.01)
1,001-3,000	172	1,935	1.03	(1.01-1.04)	1.02	(1.01-1.04)
3,001-10,000	41	756	1.00	(0.98-1.01)	0.99	(0.97-1.01)
10,001 or higher	13	110	1.04	(0.97-1.11)	1.03	(0.96-1.10)
Missing	1	2	-	-	-	-
Tractor of 40-99 hp						
Yes	372	5,982	1.25	(1.03-1.52)	1.25	(1.03-1.52)
No	218	4,412	Ref[d]	-	Ref[d]	-
Missing	285	3,904	-	-	-	-
Tractor of 100 hp or higher						
Yes	254	3,779	1.51	(1.23-1.84)	1.47	(1.20-1.79)
No	260	5,800	Ref[d]	-	Ref[d]	-
Missing	361	4,719	-	-	-	-
Field crops						
Yes	460	6,626	1.42	(1.20-1.68)	1.51	(1.26-1.81)
No	309	5,953	Ref[d]	-	Ref[d]	-
Missing	106	1,719	-	-	-	-
Hay crops						
Yes	471	6,309	1.39	(1.19-1.63)	1.35	(1.15-1.58)
No	372	7,296	Ref[d]	-	Ref[d]	-

Missing	32	693	-	-	-	-
Poultry						
Yes	78	1,005	1.47	(1.11-1.95)	1.45	(1.09-1.93)
No	723	11,906	Ref[d]	-	Ref[d]	-
Missing	74	1,387	-	-	-	-
Other animals[e]						
Yes	120	1,489	1.38	(1.09-1.75)	1.23	(0.96-1.58)
No	559	9,583	Ref[d]	-	Ref[d]	-
Missing	196	3,226	-	-	-	-
Organic production						
Yes	14	89	2.10	(1.22-3.62)	2.24	(1.30-3.87)
No	830	13,552	Ref[d]	-	Ref[d]	-
Missing	31	657	-	-	-	-
Total sales (USD)						
0-9,999	153	2,838	Ref[d]	-	Ref[d]	-
10,000-69,999	208	3,405	1.10	(0.87-1.39)	1.09	(0.86-1.37)
70,000-249,999	185	2,591	1.31	(1.02-1.67)	1.25	(0.97-1.60)
250,000 or higher	248	3,165	1.55	(1.23-1.94)	1.57	(1.24-1.98)
Missing	58	1,771	-	-	-	-
Internet access						
Yes	673	10,377	1.30	(1.08-1.56)	1.24	(1.03-1.49)
No	201	3,919	Ref[d]	-	Ref[d]	-
Missing	1	2	-	-	-	-

a. Farm-related injury: Sudden, unexpected, forceful event, that happens during work and leisure activities on this operation, plus commuting, transport, and business trips for this operation. Totals may vary due to missing data.
b. Models were fitted using Generalized Estimation Equations (GEE) to account for correlated data.
c. Each variable was adjusted for operator status, age, gender, and operation type.
d. Ref: Reference category
e. Other animals: Other than dairy, beef, swine, sheep, goats, or poultry.