Injuries in the Iowa Certified Safe Farm Study

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ABSTRACT. *The aims of this article are to assess injury characteristics and risk factors in the Iowa Certified Safe Farm (CSF) program and to evaluate the effectiveness of CSF for reducing injuries. This intervention program includes a health screening, on-farm safety review, education, and monetary incentives. Cohorts of farmers in an intervention group (n = 152) and control group (n = 164) in northwestern Iowa were followed for a three-year period. During the follow-up, there were 318 injuries (42/100 person-years), of which 112 (15/100 person-years) required professional medical care. The monetary cost of injuries was $51,764 ($68 per farm per year). There were no differences in the self-reported injury rates and costs between the intervention and control groups. Raising livestock, poor general health, and exposures to dust and gas, noise, chemicals and pesticides, and lifting were among risk factors for injury. Most injuries in this study were related to animals, falls from elevation, slips/trips/falls, being struck by or struck against objects, lifting, and overexertion. Machinery was less prominent than generally reported in the literature. Hurry, fatigue, or stress were mentioned as the primary contributing factor in most injuries. These findings illustrate the need for new interventions to address a multitude of hazards in the farm work environment as well as management and organization of farm work.*

Keywords. *Accident, Agriculture, Injury, Injury cost, Injury risk factor, Safety.*

In 2000, agriculture had the highest fatality rate (22.5/100,000 workers) in the U.S. (NSC, 2001). The non-fatal injury rates vary from 0.5 to 29 per 100 person-years, depending on the source (McCurdy and Carroll, 2000; Hard et al., 2002; Osorio et al., 1998). Worker's compensation premiums are 1.3% to 4.1% of the payroll for most industries, but are 2.8% to 16.9% of the payroll for agricultural workers, reflecting the hazardous nature of this industry (Oregon, 2001). Agricultural injury costs in the U.S. have been estimated at $4.573 billion per year, which is $2400 per farm, or 2.8% of the value of farm sales and 15.0% of the net cash returns in the U.S. in 1992 (Leigh et al., 2001; USDA-NASS, 1992). Work-related illnesses are also common in agriculture, including respiratory disease, musculoskeletal problems, noise-induced hearing loss, certain cancers, skin conditions, and zoonoses (Rautiainen and Reynolds, 2002).

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Many preventive programs have been developed to reduce injuries and illnesses in agriculture. However, a recent systematic review of farm safety interventions concluded that there is little evidence that these programs are effective (DeRoo and Rautiainen, 2000). Multifaceted programs combining several preventive approaches appeared most successful.

Certified Safe Farm (CSF) is a multifaceted intervention program designed to: (1) detect work-related health problems at an early stage and refer farmers to appropriate care, (2) identify and remove hazards on the farm, (3) educate farmers about safe working methods and personal protective equipment use, and (4) share the cost savings from reduced injuries and illnesses among farmers and their business partners. Features of this program have been discussed earlier by Von Essen et al. (1997), Thu et al. (1998), Hodne et al. (1999), Jaspersen et al. (1999), and Schneiders (2003). The University of Iowa investigators developed the current program concept in 1996 and initiated a feasibility study, which was funded by NIOSH (Grant No. U06/CCU712913). This study was conducted in collaboration with the Spencer Agrisafe clinic in a nine-county area in northwestern Iowa. The aim of this study was to demonstrate whether the program reduces farm-related injuries, illnesses, and associated costs. This article presents the results of a three-year follow-up of injuries based on quarterly phone interviews from September 1999 to August 2002.

Methods

Cohort

The targeted nine-county area had 7,617 farms (USDA-NASS, 1997). An introductory mailing was sent to 5,287 active farms identified from the U.S. Postal Service mailing list and other sources. Those who returned the postage-paid card were interviewed by telephone in the following months until a total of 300 farmers were recruited. A small number of respondents were excluded due to minimal agricultural production or not meeting the USDA farm criteria (at least $1,000 in sales of agricultural products per year). The 300 farms were pair matched on: (1) crop, corn, and soybean acres; (2) number of cattle and hogs; and (3) previous injury experience. The pairs were randomly assigned into the intervention and control groups. The intervention and control cohorts had similar demographic and farm production characteristics but differed from Iowa farms in terms of the mean farm size (intervention = 643 acres, control = 612 acres, Iowa = 339 acres), the proportion raising hogs (intervention and control = 41%, Iowa = 33%), mean hog herd size (intervention = 2309, control = 3287, Iowa = 445 hogs), and the proportion raising cattle (intervention = 33%, control = 35%, Iowa = 45%). Additional recruiting in year 2000 added 19 intervention farms and 39 control farms to replace dropouts and maintain at least 125 farms in each cohort.

Intervention

The CSF intervention is designed to reduce injuries, illnesses, and related costs. It includes a health screening, an on-farm safety review, education, and incentives. The agricultural occupational health screening was designed to address specific risks from agricultural exposures. The screenings were conducted annually by a trained nurse at the Spencer Agrisafe clinic. The on-farm safety review was designed to detect injury and illness hazards in the farm work environment using a specific CSF checklist. The CSF program requires a minimum level of safety, and farms must achieve a safety score of at least 85% to become certified. On-farm safety reviews were conducted annually

by three trained farm safety consultants who also farm in the Spencer area. The education component included one-on-one discussions during the clinic visits regarding specific health concerns as well as proper use and fit-testing of personal protective equipment. Hazard identification and safe working methods were discussed during the on-farm safety reviews. Informational meetings and focus groups were held to discuss aspects of the CSF program. The monetary incentive was a payment of $200 each year. In the future, this incentive is intended to be replaced by private sector discounts and benefits. Control farms did not receive CSF interventions, but participated in data collection, and received $75 annually as compensation.

Data Collection

Both intervention and control farms completed annual occupational history forms and quarterly phone calls, and used specific CSF calendars for recording health problems. Additionally, annual health screening and farm review results were recorded for the intervention group. The CSF intervention and data collection focused on the principal farm operators. Computer-aided telephone interviews (CATI) were conducted quarterly from September 1999 to August 2002 by trained students at The University of Iowa's Social Sciences Institute. Each call took about 10 to 15 minutes to complete. The call script involved questions on work exposures, injuries, and illnesses. The script was essentially the same during each of the 10 rounds of data collection.

Injury was defined in this study as an event that is sudden, unexpected, unintentional, has an external cause, occurs during farm work, and results in bodily harm and some loss of work time, loss of consciousness, or considerable pain or discomfort. This definition was included in the CSF calendars. The injury question was: "Did you experience any farm work-related injuries between [*first month*] and [*last month*]?" Injury costs were addressed by four questions: "How was the cost (if any) for this injury paid for?"; "How much were your out of pocket expenses for medical care, drugs, and transportation?"; "What dollar amount was paid by insurance?"; and "How much were your costs other than medical care, like pay for hired help, damage to crops or animals, or cost to others helping with the injury situation?". Several questions addressed injury characteristics, and most of them had predetermined classifications. The injury mechanism and preventability variables were constructed afterwards from the narrative injury descriptions.

The quarterly calls included questions about farm and off-farm work hours and exposures to dust, gas, noise, lifting, chemicals, and other hazards. The questions also addressed stress, depression, back, muscle and joint, hearing, and skin problems. The stress question was: "How would you rate your level of stress between [*first month*] and [*last month*] - Would you rate it as very low, low, average, high, or very high?" The categories very low and low, as well as high and very high, were combined for some analyses. The general health question was: "How would you rate your health in general between [*first month*] and [*last month*] - Would you rate it as very good, good, fair, poor, or very poor?" Demographic and farm production variables were included in the annual occupational history forms, and selected data from these forms were included in the analyses.

Data Analysis

The power calculations for this study were based on power 0.8, alpha 0.05, sample sizes $n = 125 + 125$, and an injury rate of 16 injuries per 100 farms per year. This rate

was derived from the preliminary phone call data. With these assumptions, the smallest reduction that could be detected was from 16 to 12 injuries per 100 farms (23% reduction). The primary dataset consisted of up to ten repeated quarterly observations of injuries and potential risk factors for each person in the study. Injury rates were calculated by dividing the number of reported injuries by the number of person-years of observation. The chi-squared test compared crude injury rates between the intervention and control cohorts. The mean injury costs were compared using the t-test. The generalized estimating equations (GEE) method (SAS, 2003) was used for assessing the risk factors. Unadjusted rate ratios and 95% confidence intervals were calculated for each factor. Adjusted rate ratios were also estimated using GEE in order to control for potential confounding effects of injury risk factors for which there was no matching between the intervention and control cohorts. The GEE analyses were performed using Poisson as the link factor, the number of months of observation as the offset factor, and the farm identification number as the clustering factor (SAS, 2002; Flynn, 2003).

Results

Cohorts

A total of 316 principal farm operators (intervention group n = 152, control group n = 164) responded to at least one quarterly call during the three-year observation period. The mean number of respondents was 130 in the intervention group (SD = 6.6) and 123 in the control group (SD = 8.5). The overall response rate was 92%. The total observation time was 390 person-years in the intervention group and 368 person-years in the control group. Only three principal operators in each group were female. The mean age was 49 years in the intervention group and 47 years in the control group at the beginning of the study. Both groups had about 14 years of education, 30 years of farm work experience, 38 farm work hours per week, and three household members on the average. About 39% of the intervention farmers and 43% of the control farmers had off-farm jobs. The mean weekly off-farm work hours were 12 hours for the intervention group and 13 hours for the control group. Most participants (intervention 93%, control 82%) were married, and slightly over half of the participants (intervention 52%, control 56%) raised livestock.

Injury Rate

During the three-year follow-up, 47% of the participants had no injuries, 28% had one injury, 14% had two injuries, 5% had three injuries, 3% had four injuries, and 3% had five or more (up to ten) injuries. A total of 318 injuries were reported, and the overall injury rate was 42 injuries/100 person-years. The rates for severe injuries resulting in professional care, hospitalization, or considerable cost were much lower, as shown in table 1. None of the crude rate differences between the intervention and control groups were statistically significant. The quarterly injury rate varied from 17 to 66/100 person-years.

Injury Characteristics

Most injuries were not severe; 57% resulted in less than one lost workday, 23% resulted in 1 to 3 lost days, 9% resulted in 4 to 7 lost days, and 11% resulted in more than 7 lost days. Most injuries (59%) did not require professional care, but 16% were

Table 1. Injury rates (injuries per 100 person-years).

	Control	Intervention	Total	Chi-squared p-value
Number of participants	164	152	316	
Person-years of follow-up	368	390	758	
Injury rate:				
All reported cases	41	43	42	0.68
At least 1 day disability	13	17	15	0.27
At least 1 visit for professional care	13	16	15	0.34
Required hospital care	9	6	8	0.34
At least $100 cost	8	10	9	0.42
Some costs covered by insurance	6	5	6	0.54

treated at a doctor's office, 13% at a chiropractor's office, 8% at a hospital, and 4% at an emergency room. October (16%), August (11%), and May (10%) had the highest proportions of injuries, which expectedly coincided with the harvesting and planting seasons. Most injuries happened before noon (47%), followed by afternoon (41%), evening (10%), and night (1%). Leg/knee/hip (22%), fingers (22%), back (14%), hand/wrist (11%), and head/neck (10%) were the most commonly injured parts of body. Sprain and strain (24%), bruise (22%), and cut (22%) were the most common types of injury outcomes.

The most common reported injury source/cause was human error, followed by other source/cause, machinery excluding the tractor, livestock, hand tool, working surface, and tractor (table 2). Hurry was mentioned most often as a contributing factor to injury, followed by other factor, fatigue, stress, previous injury, weather, and lack of machinery guarding (table 3).

Although the injury situations varied, some common injury mechanisms were identified (table 4). Many injuries involved animals (46 cases), consisting of cows, calves, or beef cattle (19), horses (3), sheep (8), and swine (16). Many of these injuries were from being run over, pushed against a structure, stepped on, or kicked by an animal.

Falls from elevation caused 39 injuries. Falls from machinery occurred in 22 of these cases, including falls from a tractor (9), wagon (5), combine (2), and loader (2). Falls from ladders occurred in 12 cases including five falls from grain bin ladders.

Table 2. Sources/causes of injury.

Source/Cause	Number of Cases	Percent of Cases
Human error	79	24.8
Other	61	19.2
Other machinery	50	15.7
Livestock	41	12.9
Hand tool	24	7.5
Working surface	21	6.6
Tractor	16	5.0
Unknown	14	4.4
Plant/tree	7	2.2
Truck/auto	4	1.3
Other vehicle	1	0.3
Total	318	100

Table 3. Contributing factors.

Contributing Factor	Number of Cases	Percent of Cases
Hurry	50	37.6
Other	20	15.0
Fatigue	18	13.5
Stress	16	12.0
Previous injury	13	9.8
Weather	9	6.8
Poor machine guarding	6	4.5
Illness	1	0.8
Total[a]	133	100

[a] This question was used during quarters 1-4 only. Therefore, the total number of injuries is less than 318.

Table 4. Injury mechanisms.

Mechanism	Total	Percent
Contact with animal	46	14.5
Fall from elevation	39	12.3
Struck by object	36	11.3
Slip, trip, fall	28	8.8
Lifting an object	24	7.5
Cut from/by object	23	7.2
Struck against object	23	7.2
Contact with tool	21	6.6
Contact with machine	20	6.3
Overexertion	20	6.3
Other mechanism	10	3.1
Burn from cutting torch	9	2.8
Burn from hot surface	9	2.8
Cumulative trauma	6	1.9
Chemical burn/irritation	4	1.3
Total	318	100

Furthermore, one fatality occurred when falling from a grain bin ladder. Slips/trips/falls on the same level occurred in 28 cases, and 14 of them were slips on ice.

Lifting various objects was involved in 24 cases, and overexertion was involved in 20 cases. These cases resulted in back problems, pulling a muscle, or other injuries to the musculoskeletal system. The varied working situations in these cases included lifting bags, tires, logs, rocks, and animals, or scooping corn, moving heavy machine parts, and pulling tarps.

Farmers were struck against objects in 23 cases involving cultivators, tractors, mowers, buildings, augers, and tree branches. In 36 cases, farmers were struck by objects such as logs, machine parts, winch handles, doors, and windows. Twenty of these cases were injuries to the fingers from hooking and unhooking implements, removing truck rear gates, loading cinder blocks, using metal post drivers, and moving rocks, concrete pieces, wheels, and machine parts.

Tools were involved in 21 cases. Hitting fingers with a hammer occurred in six of these cases, and a slipping wrench was involved in 12 cases. A cutting torch caused burns in nine cases. Contact with machinery was involved in 20 cases, and an implement tongue falling on a foot caused seven of these injuries. Five cases were related to construction work on the farm, and involved nail punctures and falls from

roofs and scaffoldings. Six cases were caused by cumulative trauma from repetitive motion. Four cases were related to chemicals, including oils and detergents, but none were related to pesticides.

A panel of four CSF experts reviewed the short narrative injury descriptions and assessed whether the injury could have been prevented by the current CSF procedures. The result was that only 10% of the injuries could be directly linked to an item in the CSF farm review checklist, clinical screening, or education. Most animal-related injuries, slips and falls, lifting, overexertion, struck by, and struck against injuries were among those not considered directly preventable by current CSF procedures. Among those that were considered preventable were stepped on by an animal, falls off tractor steps, injuries from augers, and falls from work platforms.

Injury Costs

More than a third of the injuries (35%) involved no costs. In other cases, the costs were covered partially by insurance (29%), all out-of-pocket (22%), or totally by insurance (14%). The total cost of injuries during the three-year period was $51,764, and the mean injury cost was $163. There was no significant difference in the mean injury costs of the intervention and control groups (t-test, $p = 0.95$). The injury cost burden for all study participants was $68 per person per year. One fatality case occurred in the control group during this study period. The cost of this case was not determined, and it was excluded from the data. Table 5 shows the out-of-pocket costs, insurance costs, and other losses.

Among the most costly injuries were cases described by the injured persons as follows: “I was sorting hogs and I tore some cartilage in my knee”, “I lifted too much and went in tractor without seat cushion which caused tension”, “Picking up round corn stalk bales jumped out of the cab and twisted my ankle on some stubble”, “Got a cut on my finger and it got hydraulic oil in it and it got infected”, “I was replacing the clutch in a grain truck and did something to my back. It turned out being a herniated disc”, “I was working in the hog house and stuck my hand with a needle and had to have intravenous antibiotics because I got an infection in it”, and “I was sanding some quarter-round, and there was a piece of wood hanging out, and I got a deep 2” sliver.“

Risk Factors for Injury

The GEE analyses showed that the injury rate was associated with year of birth, raising livestock, general health, stress, alcohol consumption, and exposures to dust and gas, noise, chemicals and pesticides, and unusual heavy lifting (table 6). Sex, marital status, education, farm work hours, intervention/control status, acres, and off-farm job were among factors that were not significant.

Table 5. Injury costs.

	Total Cost ($ U.S.)			Cost per Person per Year ($ U.S.)		
	Control	Intervention	Total	Control	Intervention	Total
Paid out of pocket	12,400	13,486	25,886	34	35	34
Paid by insurance	13,716	10,344	24,060	37	27	32
Other losses	368	1,450	1,818	1	4	2
Total	26,484	25,280	51,764	72	65	68

Table 6. Selected risk factors for injuries (continued).[a]

Parameters and Levels	*N*[b]	Unadjusted Rate Ratio	Confidence Limits Lower 95%	Confidence Limits Upper 95%	Adjusted Rate Ratio[c]	Confidence Limits Lower 95%	Confidence Limits Upper 95%t
Cohort							
Intervention	1316	1.03	0.82	1.30	1.08	0.86	1.37
Control	1255	Referent	--	--	--	--	--
Year of birth							
1919-1939	589	1.03	0.71	1.48	1.29	0.86	1.93
1940-1949	606	0.89	0.61	1.31	1.16	0.78	1.71
1950-1959	908	1.24	0.89	1.73	**1.53**	**1.08**	**2.17**
1960-1973	456	Referent	--	--	--	--	--
Acres farmed							
0-160	380	0.94	0.66	1.35	1.08	0.70	1.64
161-640	1101	1.10	0.86	1.41	1.04	0.79	1.37
641+	1030	Referent	--	--	--	--	--
Off-farm job							
Yes	1047	0.92	0.73	1.16	1.01	0.77	1.32
No	1464	Referent	--	--	--	--	--
Livestock							
Yes	1426	**1.41**	**1.11**	**1.78**	1.27	0.99	1.65
No	1085	Referent	--	--	--	--	--
General health							
Very good	560	**0.46**	**0.28**	**0.76**	**0.43**	**0.25**	**0.73**
Good	1116	**0.41**	**0.26**	**0.66**	**0.38**	**0.23**	**0.63**
Fair	733	**0.51**	**0.31**	**0.83**	**0.52**	**0.31**	**0.87**
Poor	101	Referent	--	--	--	--	--
Alcohol consumption							
3+ per week	585	**0.65**	**0.47**	**0.89**	**0.70**	**0.50**	**0.98**
1-2 per week	1005	0.85	0.67	1.10	0.81	0.62	1.05
None	919	Referent	--	--	--	--	--
Stress							
High, very high	584	1.05	0.78	1.42	0.87	0.63	1.18
Average	1213	0.79	0.60	1.03	**0.70**	**0.53**	**0.93**
Low, very low	722	Referent	--	--	--	--	--
Dust and gas							
Yes	855	**1.41**	**1.12**	**1.77**	1.22	0.95	1.57
No	1668	Referent	--	--	--	--	--
Noise							
Yes	1318	**1.53**	**1.19**	**1.96**	1.25	0.95	1.64
No	1205	Referent	--	--	--	--	--
Chemicals and pesticides							
Yes	922	**1.81**	**1.44**	**2.28**	**1.76**	**1.39**	**2.22**
No	1601	Referent	--	--	--	--	--
Heavy lifting							
Yes	1634	**1.90**	**1.43**	**2.52**	**1.63**	**1.20**	**2.21**
No	889	Referent	--	--	--	--	--

[a] Statistically significant factors are shown in **bold** type.
[b] *N* = number of responses to quarterly calls.
[c] Estimates are adjusted for all factors listed in this table using the full model.

The injury rate was elevated in the age group born in 1950-1959. Those who had livestock had a higher injury rate than those who had no livestock. Those who reported very good, good, and fair general health had lower injury rates than those who reported poor health. Those who consumed three or more drinks per week had a lower injury rate than those who consumed no alcohol. Those whose stress level was average had a lower injury rate than those whose stress level was low. Those exposed to dust and gas, noise, chemicals and pesticides, and unusual heavy lifting had higher injury rates than those who were not exposed.

Discussion

The injury rate (42/100) in this study was higher than those usually reported in the literature, including 6.8/100 (BLS, 2001), 4.5/100 (NSC, 2001), 6.8/100 (Myers, 2001), 0.5 to 17/100 (McCurdy and Carroll, 2000), 29/100 (Osorio et al., 1998), and 32/100 (Rasmussen et al., 2000). We used a broad injury definition, routine record keeping, and quarterly calls for data collection. With this method, 53% of the participants reported one or more injuries during three years. However, only 36% of the same population reported injuries during the past five years in the occupational history forms. Similar differences were found in a Danish study when using different data collection systems (Rasmussen et al., 2000). These findings suggest that the injury rate is greatly influenced by the data collection method, recall time, and injury definition.

The CSF intervention is designed to reduce injury and illness hazards, and a great number of improvements were documented on intervention farms. However, no differences were found in the injury rates of the intervention and control groups. Many factors may contribute to this result. The recruitment rate was low, and the study participants were largely self-selected. They knew that they needed to pass a farm safety review, if assigned to the intervention group. Thus, only those who thought their farm is already "safe" may have opted to participate in this study, which could reduce the relative effect of the intervention. The high initial passing rate (86%) suggests that the safety level of the intervention farms was high. Control farms were not inspected, but pair matching and randomization should result in similar groups in the beginning of the study. Over time, intervention farms made safety improvements, but it is not known if the controls also made improvements.

Several sources of bias may contribute to the result as well. First, participants in the intervention group who passed their farm review were paid $200 annually, simulating the financial incentives that are part of the CSF program concept, but control farmers received only $75 annually. Greater compensation may result in better willingness to record and report injuries. Second, the intervention farmers received annual health screenings, farm reviews, and education, which may have sensitized them to be more observant and aware of injuries and health problems. Third, the intervention could not be blinded. Both intervention and control farmers knew in which group they belonged, including the different compensation levels. This may have influenced their motivation to report. No objective third-party data, such as insurance claims, were available to augment our self-reported data.

Contact with animals, slips/trips/falls, falls from elevation, lifting, overexertion, and being struck by and struck against objects were among the most common injury mechanisms in this study. Other studies have made similar findings, but machinery often has a greater emphasis (McCurdy and Carroll, 2000; Harlan, 2000). These injuries are challenging to prevent. Some machinery-related injuries in this study, such as an implement tongue falling on a leg, can be prevented by better machine design and using

proper jacks/stands. Welding burns and flying objects from grinders can be prevented with proper personal protective equipment. Falls from machinery can be reduced by proper steps and handrails. Auger injuries can be prevented by guarding. Construction-related injuries can be reduced by appropriate scaffolding, ladders, guardrails, and tools. Falling on ice could sometimes be prevented by covering building entrances with a roof and routing water and ice away from the entrance. Sand could be kept available near the house and barn entrances for those days when pathways outside are icy. Permanent steps could be built in places where ladders are used frequently. Ladders could sometimes be attached at the top to prevent them from sliding and falling down. Lifting injuries may be reduced by alternative handling methods and proper lifting techniques.

The CSF farm review, health screening, and education provide a comprehensive preventive approach. However, based on the brief injury descriptions, the majority of injury situations were not directly addressed by current measures, and the CSF tools need to be re-evaluated to better respond to the real-life injury situations. Most farm safety checklists, including CSF, emphasize machinery and guarding of moving parts. A relatively small percentage of the CSF injuries were related to machinery, while most injuries were related to animals, falls from elevation, slips and falls, lifting, and being struck by or struck against objects. Current preventive strategies may not address these injuries adequately. Specific behavioral and engineering interventions are needed to address each of these common injury types.

We included human error in a list of injury causes. Interestingly, this was the most frequently chosen option. The early industrial accident causation theories emphasized human error and education to modify behaviors and avoid errors (Heinrich, 1941). Currently, this factor is generally ignored, as it takes away attention from more controllable factors, places blame on the worker, and reduces the worker's options for legal compensation. Unlike hired workers, farmers generally do not have worker's compensation, and their avenues to seek other compensation are limited. They can therefore discuss the "human factor" issues without financial consequences. The high percentage (25%) reporting human error as the main cause is noteworthy, and it indicates that efforts to influence behavior should not be neglected.

Hurry (38%), fatigue (15%), and stress (14%) were commonly reported as contributing factors. This finding is no surprise in today's fast-paced working life. On the other hand, it is important to recognize that 2/3 of injuries are influenced by management and organization of work. Interventions aimed at reducing hurry, fatigue, and stress should be emphasized in injury prevention.

Most of the 318 reported injuries had little or no related cost, and only 22% had costs over $100. The average injury cost was $163. The total cost burden from injuries was $68 per person per year, which is very low in comparison to typical health care costs. The average farm family health insurance premiums were $3,570 in 1998 on CSF farms (Schneiders et al., 2002). Worker's compensation premiums are typically 3% to 17% of the payroll for agricultural workers (Oregon, 2001), which is equivalent to $726 to $4,114 based on the 1997 net farm income ($24,199) (USDA-NASS, 1997). One estimate of the annual injury costs in U.S. agriculture is $2,400 per farm (Leigh et al., 2001; USDA-NASS, 1997). Finnish farmers' compensation insurance cost burden was 215 Euros per farmer in 1999 (Rautiainen, 2002).

Injury cost data typically have a log-normal distribution in which a few outliers greatly influence the total costs. This sample was relatively small, and other than one fatality, we did not find extreme outliers. Only nine cases had costs over $1,000, and the most costly case was $7,200. Very few farmers reported losses other than medical care. This may indicate that in this type of study, farmers may not readily think of the

"indirect" injury costs, such as loss of work time, loss of productivity, damage to crops or animals, or contributions from friends and family members helping with the situation. Injuries may have far-reaching effects on the injured person and the person's family, business, and society as a whole. Such effects have been discussed in the literature. Dembe (2001) provides one summary of broader societal effects from injuries.

Stress has been associated with injuries (Thu et al., 1997). However, we found that the high stress level did not differ from the low stress level, and the average stress level was protective of injuries. Poor general health was associated with injuries as well. These results must be interpreted with caution, as stress and general health were measured at the same time as injuries, and it is not clear whether these conditions existed before the injury occurred. Alcohol consumption was also associated, and surprisingly, greater alcohol consumption appears to be protective. Our scale was none, 1-2 servings per week, and 3+ servings per week. We were not able to assess higher consumption levels due to the small number of heavy drinkers in this population.

One fatality occurred during this study. The farmer fell from a ladder when coming down from a grain bin. Approximately 1,500 person-years of observation accrued over the entire study period, which gives a rate of 1 fatality per 1,500 person-years. This is higher than the national fatality rate in U.S. agriculture of 22.5/100,000, which equals 1 fatality per 4,545 person-years (NSC, 2001). A NIOSH Fatality Assessment and Control Evaluation was conducted in this fatality case. The cost was not determined, but using any common method for estimating the value of a human life would result in a much higher cost than the total costs from all other injuries in this study.

Strengths and Weaknesses

A major strength of this study is the consistent follow-up of a clearly defined, adequately sized population over three years, yielding relatively stable data. The study design was a community trial in which the subjects were randomly assigned into the intervention and control groups. The groups were similar in terms of basic demographic and farm production characteristics, and fairly representative of full-time farming operations with an emphasis on corn, soybean, and hog production in this area.

Our data were self-reported, and such data are influenced by features of the research instruments (Schwartz, 1999). Generally, participants in a case/intervention group have a tendency to over-report compared to controls (Raphael, 1987). Recall and reporting biases could be introduced by the different payment levels and the different awareness levels due to intervention.

The recruitment rate was low (6%). The farmers were aware that they might need to pass a safety review to become certified, if assigned to the intervention group. It is possible that the recruiting process attracted farms that were safer than average. About 86% of the intervention farms passed the initial farm review. Another 100 farms were recruited in four locations in Iowa in 2001. Only 33% of these farms passed the farm review, indicating that our study group may be "safer" than Iowa farms in general.

Conclusions

The injury rate in this study was high, but most injuries were minor cases that resulted in no lost time, no professional medical care, and little or no costs. The injury cost burden, $68 per person per year, was low compared to other estimates in the literature. Raising livestock, poor general health status, and exposures to dust and gas,

noise, chemicals and pesticides, and heavy lifting were among risk factors for injury. Higher alcohol consumption and average stress level were protective for injuries. Overall, this study showed that the current CSF intervention did not reduce self-reported injury rates and costs. The results could be influenced by self-selection into the study, recall and reporting biases due to different compensation and awareness levels, and the non-blinded study design. Further studies would benefit from independent data from a third party, such as an insurance company, to verify actual injury rates and costs.

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