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Work-Related Injuries Among Iowa Farm Operators: An Analysis of the Iowa Farm Family Health and Hazard Surveillance Project

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In 1994, the Iowa Farm Family Health and Hazard Surveillance Project carried out a two-stage, stratified, cluster survey of Iowa farms using a mail survey. With data from this representative sample of Iowa farmers, we examined the associations between farm-work–related injuries and possible risk factors for 390 principal farm operators. Forty (10.3%) of these operators reported being injured while doing farm work. We developed a logistic regression to assess associations between potential risk factors and injury. We found three factors significantly associated with injury: younger age (odds ratio [OR] = 3.1, confidence interval [CI] = 1.1–9.3), having an impairment or health problem that limits work (OR = 2.4, CI = 1.5–3.8), and hand or arm exposure to acids or alkalis (OR = 2.6, CI = 1.1–5.9). In the univariate analysis, safety training did not seem to protect farmers from injuries. Am. J. Ind. Med. 33:510–517, 1998. *© 1998 Wiley-Liss, Inc.*

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Agriculture is a most hazardous occupation. The National Safety Council reported that 800 people lost their lives due to agricultural work-related injuries in the United States in 1995 [National Safety Council, 1996]. The fatal injury rate (24 of 100,000) reported for agriculture was second only to the rate of 30 of 100,000 in mining and quarrying. In comparison, the fatal injury rate for all industries was just four deaths per 100,000 workers. Nonfatal farm injuries are often serious. In 1995, there were 140,000 disabling injuries associated with agricultural work [National Safety Council, 1996]. In a study of hospitalization rates in Iowa, farmers were hospitalized for work-related injuries three times more often than nonfarmers, indicative of the seriousness of farm-work–related injuries [Fuortes et al., 1990]. There have been few studies of the risk factors associated with farm-work–related injuries that have been based on samples of farming populations representative of entire states or regions. Previous such studies from Alabama [Zhou and Roseman, 1994], eastern Ontario [Brison and Pickett, 1992], and New York [Pratt et al., 1992] have reported associations between farm-work–related injury and younger age, increased amount of work being done, and ownership of the farm. The Farm Family Health and Hazard Surveillance (FFHHS) Project in Iowa is one of the few population-based studies designed to assess risk factors associated with farm-work-related injury, an important initial step in developing strategies for prevention.

One group of potential risk factors, which included alcohol use [Zhou and Roseman, 1994; Dawson, 1994] and hearing impairment [Karlovich et al., 1988], was chosen because of previously reported associations with injury in farmers and other occupations. The other potential risk factors were included because of conflicting associations in the literature or lack of previously available data. In Brison

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and Pickett's study of nonfatal farm injuries in Ontario, the data showed that farm operators younger than 30 years old and those over 70 years old were more likely to be injured [Brison and Pickett, 1991]. In their study of nonfatal farm injuries, Purschwitz and Field [1990] reviewed National Safety Council data for 31 states and found that a higher percentage of younger persons were being injured.

This study aimed to (1) describe the number and circumstances of farm-work–related injuries, and (2) examine associations between these injuries and potential risk factors that were included in the study among Iowa farm operators.

METHODS

Sample Design

The FFHHS in Iowa was a stratified, two-stage, cluster sample of Iowa farms. Using the definition from the Bureau of Agricultural Census (U.S. Census of Agriculture, 1987]), we defined a farm as a ''business where $1,000 or more in agricultural or livestock produce is sold each year.'' Iowa is divided into nine soil conservation districts (also called crop-reporting districts) that are approximately equal to intersections when the state is divided into three tiers, both vertically and horizontally. These districts are relatively uniform in soil types and farming practices. Using simple random sampling, two counties were selected from within each of the nine crop and livestock reporting districts.

In collaboration with the Iowa Agricultural Statistics Service (IASS), a division of the U.S. Department of Agriculture, principal operators were selected from the 18 counties. IASS maintains an up-to-date sampling frame consisting of 95,000 of Iowa's principal operators. The IASS defined a principal operator as ''the senior partner or the farmer who is in charge of the day-to-day farming decisions.'' By using this database, IASS personnel randomly selected 100 principal operators from within each of the 18 counties.

In December of 1991, the IASS office mailed 1,800 introductory letters and surveys. Three hundred and thirty (18%) of these farm operators agreed to participate by returning the recruitment survey, which collected data regarding farm characteristics. To increase the number of participants, IASS conducted a telephone follow-up in May of 1992 that resulted in an additional 385 principal operators who completed the recruitment survey. This follow-up brought the number of prospective participants to 715 (40%).

There was a 2-year lag between initial contact with potential subjects and the start of the study, because of unforeseen administrative requirements. During this hiatus, 150 operators dropped out of the study, leaving 565 participants. Principal operators dropped out because of retirement, death, sale of the farm, lack of spare time, and decrease in interest. Just before the start of the data collection portion of the study, we recruited additional participants to replace those who had dropped out during the 2-year period. In February of 1994, the IASS randomly selected approximately 1,200 principal operators from within the already randomly selected counties and contacted them by telephone to request their participation. An additional 424 principal operators agreed to participate, for a total of 989. The FFHHS questionnaire was mailed to these operators; information from their families and full-time employees was also sought. Three hundred ninety principal operators completed the questionnaire for an overall participation rate of 39.4%. Follow-up contact using reminder letters was made to nonresponders about 1 mo after the initial mail-out, and researchers conducted another follow-up by telephone 1 mo after that. Reasons for nonparticipation were the following: 499 were not interested in participating in the study; 100 nonresponders could not be reached by mail or telephone follow-up and were dropped from the study. Data collection was completed by April of 1995.

The IASS provided us with summary statistics for respondents and nonrespondents. Because no important differences in participants selected in 1992 and 1994 were evident, we pooled the data from the groups. The information provided to us included farm characteristics such as total acres operated, crop type and number of acres grown, and type and number of livestock raised. No further demographic data on the nonresponders were available.

Variables

Most of the questions in our survey instrument had been previously used in other surveys. (For a copy of the questionnaire used to collect data on risk factors, please contact Dr. Zwerling.) Our questionnaire was reviewed by several collaborators at The University of Iowa, at NIOSH, and by outside peer reviewers. The final questionnaire was pilot tested among a small group of Iowa farmers.

We defined a farm-work–related injury as meeting both of the following criteria: (1) positive response to the question ''During the past 12 months, have you had an injury for which you: (a) received either medical attention or treatment other than first aid for minor injuries or from a doctor or medical assistant, or (b) had to cut down on your usual activities for more than half a day, or (c)lost consciousness?'' (2) The injury occurred during farm work or chores. For each injury as defined above, determination of farm-work relatedness was made jointly by the principal investigator and project coordinator after review of the free-text responses to questions on activity at the time of injury and circumstances of injury. An injury was not classified as farm-work-related if there was a positive response to the

following: ''Were you working at a nonagricultural job at the time of your injury?''

Noncases were those who answered no to the question in criterion 1 above or those who answered yes to the question in 1 above, but it was found to be a nonfarm injury.

We grouped the potential risk factors into five categories: demographic, medical, personal, economic, and work practices. We dichotomized variables into categories of high or low and presence or absence. Except for weight and income, we chose the median as the cut-points to dichotomize the continuous variables. For weight, we calculated body mass index (BMI) and chose the top 10% of the scores in this cohort (a BMI of 30 or higher) as our cut-point [Zwerling et al., 1995]. We divided gross farm income into three categories as follows: low = less than $40,000 per year, medium = $40,000 to $100,000 per year, and high = over $100,000 per year.

Data were double-keyed for quality control. Cases with missing values were not included in the analysis.

Statistical Analysis

Our analysis was completed in three stages. First, we described the demographics of the sample with regard to age, gender, and race. We also compared FFHHS participants with Iowa principal operators for demographic factors [U.S. Agriculture Census, 1992], livestock production, and crop acres planted [Iowa Agricultural Statistics Service, 1994]. We described the injuries reported by principal operators according to type of injury, severity, activity being performed at the time of the injury, and the season when the injury occurred.

Second, we calculated odds ratios for injured principal operators and those without injuries for the five groups of potential risk factors. We calculated Mantel-Haenszel [Mantel and Haenszel, 1959] χ^2 to determine the strength of the associations between these risk factors and injury. We constructed 90% confidence intervals using the Taylor linearization series, which takes into account correlated data.

Third, we constructed a logistic regression model using the approach of Higgins and Koch for variable selection [Higgins and Koch, 1977]. During the first step in the Higgins and Koch procedure, we calculated Mantel Haenszel χ^2 divided by the degrees of freedom for all of the variables. At the second step, we stratified by the variable with the largest χ^2 value at the first step and reanalyzed the remaining variables to determine their relative importance to injury. At the third step, we stratified by the variable with the next highest χ^2 along with previously identified risk factors, while we analyzed the remaining variables. We repeated this process until no further variables were significant at $P \leq 0.10$. We entered the selected variables into a logistic regression model [Hosmer and Lemeshow, 1989].

For convenience, all preliminary analyses were carried out using SAS software [SAS Institute, Inc., 1985]. To account for the complex sample design, we then repeated the final analysis using SUDAAN software [Shah et al., 1992]. We weighted each sample farm to reflect the total number of farms in the county and in the crop-reporting district.

To increase the likelihood for screening potentially important risk factors in this exploratory study, we chose a 90% confidence interval and a P value of ≤ 0.10. However, because of this choice of significance level and because of the large number of independent variables chosen, results should be interpreted with caution. Our entire protocol was reviewed and approved by our institutional human subjects review board.

RESULTS

Table I describes demographics for the 390 FFHHS principal operators. The average age was 54 years, all were white, and all but five (98.7%) were male. Forty (10.2%) principal operators reported 48 farm-work–related injuries. The average age of the injured principal operators was 47.7 years, ranging from 28 to 69 years. Thirty-six (90%) of the injured operators received medical treatment for their injuries, and nearly half were injured seriously enough to have missed more than half a day of work at the time of the injury.

Table II shows the types of injury. The predominant type was classified as overexertion/strenuous movement. Half of all the injuries involved the back (data not shown). Table III shows the activity at the time of the injuries. Most of the injuries occurred during work with livestock, equipment, or in performing routine chores. The injuries were distributed nearly evenly throughout the seasons (Table IV).

The univariate analysis (Table V) revealed that the following independent variables may be risk factors for injury: younger age (born after 1940), more education, trouble hearing, having an impairment or health problem that limits work, being bothered by loss of balance, having work-related respiratory symptoms, working on other farms, and having gotten acids/alkalis or glues on the hands or arms while doing farm work. Working a high number of hours per season doing fieldwork was protective against injury as was working a high number of hours per season doing fieldwork with a vehicle (tractor, combine, etc.).

The Higgins and Koch variable selection process led us to focus on four variables as possible risk factors for injury: younger age, hearing trouble, being limited in the kind or amount of work done because of a health problem or physical impairment, and having gotten acids or alkalis on the hands or arms. These four variables were used in the

TABLE I. Demographic Characteristics of 390 Principal Operators in the Iowa Farm Family Health and Hazard Surveillance Project

Variable	Mean (s.d.) or % (range)
Age (yr)	53.9 (±12.3) (28–84)
Gender (male)	98.7%
Race (white)	100%
Years of farming	32 (±15.3) (1–70)
Acres owned	241.3 (±212.0) (0–1700)

TABLE II. Types of Injuries Seen Among 390 Principal Operators in the Iowa Farm Family Health and Hazard Surveillance Project, 1994

Type of injury	Number
1. Overexertion/strenuous movement	23
2. Cut/laceration	8
3. Broken bone/fracture/crushed	6
4. Contusion	3
5. Sprain	2
6. Miscellaneous:	
Torn cartilage	1
Burn	1
Whiplash/concussion	1
Overcome by CO	1
7. Unknown	2
Total	48

TABLE III. Activity at Time of Injury Among Farmers in the Iowa Farm Family Health and Hazard Surveillance Project, 1994

Activity	Number injured
1. Livestock work	16
2. Work with equipment	14
3. Routine chores	10
4. Field work	4
5. Operating motor vehicle	2
6. Activity unknown	2
Total	48

logistic regression model: (1) age ($\chi^2 = 9.3$, $P = 0.002$, 1 df), (2) exposure to acids/alkalis ($\chi^2 = 7.9$, $P = 0.005$, 1 df), (3) limitations affecting work ($\chi^2 = 4.5$, $P = 0.035$, 1 df), (4) hearing problem ($\chi^2 = 4.4$, $P = 0.036$, 1 df).

Greater than 10% of the responses were missing for the hearing variable, so we dropped it from the model. In the first step of the final model, principal operators who reported being limited in the amount or kind of work they could perform due to a health impairment had nearly three times the risk of injury ($P = 0.02$) than operators who did not report limitations. The same was true for principal operators who had gotten acids or alkalis on their hands or arms ($P = 0.05$) compared with those who did not get these substances on their skin. Table VI shows the final logistic regression model. Three variables continued to be significant predictors of injury. Principal operators in the younger age category had more than three times the risk of injury ($P = 0.09$) as their older counterparts. Operators who reported being limited in their work due to a health impairment had nearly two and a half times more risk for injury ($P = 0.008$) than those who had no limitations. Principal operators who had gotten acids or alkalis on their hands or arms had more than two and a half times the risk of being injured ($P = 0.06$).

TABLE IV. Seasonality of Injuries to 390 Principal Operators in the Iowa Farm Family Health and Hazard Surveillance Project, 1994

Season	Frequency
Winter (Dec. through Feb.)	11
Spring (Mar. through May)	10
Summer (June through Aug.)	15
Fall (Sept. through Nov.)	10
Date missing	2
Total	48

We compared FFHHS principal operators with principal operators in the state of Iowa using the 1990 U.S. Census of Agriculture. FFHHS principal operators had an average age of 54 compared with the state's principal operators' average age of 50. Gender (98.7% male for FFHHS and 96.1% male for state of Iowa) and race (100% white for FFHHS and 99.9% white for state of Iowa) were very similar among the two groups. Table VII shows that the distribution of crops and livestock among the principal operators from the FFHHS and the state of Iowa was similar. The IASS reported that in 1994, principal operators in the state of Iowa cultivated fewer acres, on average, than the FFHHS principal operators (329 vs. 476 acres).

Results of the comparison of farm characteristics between respondents and nonrespondents are shown in Table VIII. Farm characteristics were similar but the respondents had 15% more acres of soybeans than did the nonrespondents.

DISCUSSION

The main findings of the Iowa Farm Family Health and Hazard Surveillance Project were that 10.4% (CI = ±3.9) of the principal operators had a farm-work–related injury in the past 12 months and that major risk factors were younger age,

TABLE V. Results of Univariate Analysis Using 2 × 2 Tables to Determine Whether Associations Exist Between Risk Factors and Farm-Work-Related Injuries Among Principal Operators in the Iowa Farm Family Health and Hazard Surveillance Project, 1994

	Number with risk factor	Number injured	Odds ratio	90% Confidence interval
Demographic risk factors				
Age (born after 1940)	210	31	3.13	1.10–8.94
Education	167	24	2.13	1.24–3.62
Body mass index (>30)	47	8	1.79	0.75–4.25
≥3 people in household	122	18	1.85	0.99–3.46
Medical risk factors				
Hearing problem	109	18	2.04	1.02–4.07
Vision problem	24	2	0.63	0.13–3.03
Health status	133	17	1.52	0.72–3.21
Limitations due to impairment or health problem	49	7	1.57	1.18–2.09
Ever had seizures	6	1	1.61	0.18–14.33
Bothered by loss of balance	37	7	2.20	1.05–4.62
Had difficulty grasping things	67	9	1.46	0.53–3.98
Have work-related respiratory symptoms	101	16	2.03	1.05–3.92
Personal risk factors				
Current smoker	50	1	0.19	0.03–1.42
Alcohol screen	21	1	0.59	0.07–5.14
No home smoke detector	58	6	0.98	0.31–3.11
Economic risk factors				
Acres owned (≥200)	168	12	0.48	0.20–1.15
Acres worked (≥270)	233	24	0.82	0.43–1.56
Work on other farms	147	22	2.14	1.17–3.92
Have nonagricultural job	86	10	1.38	0.61–3.14
Income <$40,000/yr	118	10	0.74	0.31–1.74
Income $40,000–$100,000/yr	109	10	0.81	0.50–1.31
Income >$100,000/yr	128	19	1.56	0.79–3.09
Work practice risk factors				
Had safety training	192	19	0.96	0.69–1.33
Hours work with animals (>62 per season)	148	20	1.09	0.76–1.56
Maintenance hours (>31 per season)	160	14	0.59	0.30–1.17
Total field hours (>95 per season)	165	12	0.43	0.25–0.74
Field hours with vehicle (>84 per season)	166	10	0.31	0.16–0.61
Hours operating vehicles on roadway (>26 per season)	156	15	0.67	0.43–1.06
Get cutting oils on skin	204	27	1.87	0.93–3.75
Get paints, varnish on skin	272	34	2.48	0.91–6.72
Get glues on skin	228	31	2.91	1.11–7.59
Get acids/alkalis on skin	90	16	2.86	1.19–6.87
Get pesticides on skin	223	26	1.25	0.65–2.42

being limited in the amount or type of work that can be done because of an impairment or health problem, and having gotten acids/alkalis on the skin.

Work with livestock (33% of injuries), work with equipment (29% of injuries), and routine chores (21% of injuries) were the three most common activities being done at the time of the injury. These findings agree with those of Brison and Pickett [1992], who found that agricultural equipment (34% of injuries) and livestock (24% of injuries) were commonly involved in injury in their study of nonfatal

TABLE VI. Results of Logistic Regression Analysis of Risk Factors for Injury Among Principal Operators in the Iowa Farm Family Health and Hazard Surveillance Project, 1994

Variable	Odds ratio	Lower 90% confidence interval	Upper 90% confidence interval
Age			
Young (born after 1940)	3.12	1.05	9.27
Work limited by impairment			
Yes	2.38	1.48	3.82
Exposure to acids or alkalis			
Yes	2.60	1.15	5.91

TABLE VII. Comparison of Target Population with Iowa Farm Family Health and Hazard Surveillance Project Cohort, 1994

		State of Iowa	
	Cohort (%)	1992 (%)	1994 (%)
Livestock Produced[a]			
Grain-fed cattle	26.0	16	15
Beef cows	32.5	28	29
Hogs and pigs	37.6	34	29
Sheep and lambs	9.5	7	6
Dairy cows	6.7	6	5
Crop Type[a]	Sample (%)		
Corn	39.0	39.0	39.0
Soybeans	27.0	24.0	30.0
Oats	1.5	2.6	1.8
Wheat	0.09	0.21	0.17
Total	67.6[b]	65.8[b]	71.0[b]

[a]From 1992 and 1994 Iowa Agricultural Statistics Service. The livestock categories are not mutually exclusive.
[b]Remainder of acres was planted in other crops or was included in the Conservation Reserve Program.

TABLE VIII. Comparison of Farm Family Health and Hazard Surveillance Project Respondents (RS) and Nonrespondents (NRS) in Iowa, 1994

	RS		NRS		
Type	Mean	SD	Mean	SD	*P*
Corn acres	161	183	152	189	0.21
Soybean acres	114	148	99	149	0.01
Hay acres	21	43	19	53	0.15
Total acres	353	349	348	518	0.75
Grain storage on farm (in bushels)	20618	32579	18486	29862	0.08
Hogs	154	367	141	368	0.37
Beef cattle	53	131	55	191	0.73
Milk cattle	2	12	3	14	0.11

injuries to farmers in eastern Ontario. In the Iowa FFHHS, the most common external cause of injury was overexertion or strenuous movements (48%), followed by being struck by an object (19%), and falls (10%). Zhou and Roseman [1994] also listed these three factors as major external causes of injury in their study of farm operators in Alabama. In a 1991 study of farm operators in Alabama, 23.2% of the farm operators were injured by falls, 10.7% by overexertion, and 5.4% by being struck by an object.

Younger operators (those born after 1940) were more likely to be injured in this study. A similar finding was reported by Myers in his surveillance study of agricultural injuries [1990]. For non-fatal injuries, he found that injury incidence declined with age. Brison and Pickett [1991] also found in their study of nonfatal farm injuries that those owner-operators younger than 30 years old were more likely to be injured. However, the opposite was true when they looked at all persons living on the farm. The age variable could be related to injury because the younger operators are doing the majority of work. Within the logistic regression analysis, hours worked was not a significant risk factor for injury. In the FFHHS study, we found that younger farmers worked an average of 10 more hours per week than the older farm operators did. Pratt et al., in a study of dairy farming, found that a higher number of weekly hours on the job resulted in an increase in injury [1992].

The FFHHS data indicate that farmers who reported some trouble hearing had twice the risk of injury. Hearing loss can have an adverse effect on communication and awareness, which could increase risk for injury if warnings for hazards go unheard. In their study of older agricultural workers, however, Zwerling et al. [1995] found that trouble hearing was protective for injury. They speculated that the years of experience working around noisy equipment both caused the hearing problem and enabled them to work safely due to their years of experience.

An interesting result from the univariate analysis was that safety training made almost no difference in injury outcome. Farm operators who reported having some training had slightly less risk of injury (OR = 0.96, CI = 0.69-1.33), but this difference was not statistically significant. This finding is noteworthy because we place a great deal of emphasis on safety training for agricultural workers. The finding also supports those of Murphy [1981], who showed that the development of farmers' attitudes toward safety has no effect on injury occurrence. He recommends that other methods such as improving equipment and workplace

design may be more effective in reducing work-related injuries.

The significance of the exposure to acids or alkalis is unclear. This variable, which remains in the final logistic regression model as an important contributor to farm-work–related injury, may be a surrogate for risk-taking behavior. One study suggested that risk attitude and risky behavior was an important association with farm work injury. In a study by Harrell, injured farmers ranked higher on a measure of personal risk-taking [1995]. Alternatively, this variable may be a marker for the amount or intensity of the work done on a farm. However, it is also possible that this variable was retained in the model by chance.

Strengths and Weaknesses of the Study

Weaknesses of the study are the low response rate (39.4%), missing data, and the possibility of recall bias. However, the IASS predicted, based on their own experience, that we would do no better than a 20% response rate with a mail-out questionnaire. There are several reasons for the low response rate: the questionnaire was long (during pilot testing, it took respondents an average of 1 hr to complete); the previous year was the year of the floods and farmers were anxious and unwilling to participate; farmers were inundated with surveys; and, incentives were not offered to participants. Despite a suboptimal response rate, nonrespondents and respondents had similar farm characteristics. Because we were not able to obtain information about other potential injury risk factors from nonrespondents, we cannot fully address self-selection bias and questions of external validity raised by the low response rate.

The recall period for injuries sustained by the principal operator was 12 months. Farmers can forget some injuries over that time, resulting in an underestimation of injury incidence in this study. We will be able to minimize or estimate recall bias using data from a follow-up study that asked the same questions about injury occurrence 1 year after the initial study. The follow-up allows us to collect information on outcome (injury), whereas we already have information about possible risk factors from the previous questionnaire.

Because this investigation was a cross-sectional study, all information regarding the injuries and possible risk factors was collected at the same time. Therefore, it is not possible to say which risk factors, such as impairment, preceded or were a result of the injury. A longitudinal study could better determine cause and effect.

A major strength of this research study is that this was a population-based research study; consequently, the findings are truly representative (using the state's agricultural census information; see Table VII) of farmers in the state of Iowa. Another strength is the large amount of information that was collected, allowing us to consider many possible explanations for work-related injury. Principal operators who were younger were more likely to have a farm-work–related injury, as was true in a study by Zhou and Roseman [1994]. Other studies have found the opposite to be true—that older farmers are more likely to be injured while working. This contradiction could be addressed by conducting additional studies looking at amount of time working as we did in this study. We found that the younger farmers were doing the majority of the work, thereby increasing their exposures to potential hazards. Further exposure studies might be useful in illuminating the relationship between injury and having gotten acids or alkalis on the skin. If this is a surrogate for risk-taking behavior, a study of other such behaviors (such as seatbelt use) might be useful. We found that farm operators whose work was limited due to a health problem or impairment were more likely to be injured. Studies that focus on the effects of assistive devices or re-engineered equipment for farmers with disabilities or health problems may be useful in preventing injuries from occurring.

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