

Fall-Related Injuries Among Agricultural Household Members: Regional Rural Injury Study II (RRIS-II)

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Objective: *The objective of this study was to identify the magnitude and consequences of and potential risk factors for fall-related injuries among agricultural operation households. Methods:* Demographic, injury, and exposure data were collected through 1999 from 3765 households in a five-state region. A causal model facilitated survey design, data analyses, and interpretation of results; directed acyclic graphs guided multivariate modeling. **Results:** *The 16,538 participants experienced 766 fall-related injury events (48.3 per 1000 persons). Consequences included lost agricultural and other work time. Increased risks involved residence in states other than Minnesota, male gender, and injury history. Decreased risks were among those less than 35 years of age and those who worked 40 hours or less per week. Conclusions:* *Fall-related injury is a major problem for the agricultural population. This effort serves as a basis for further in-depth research. (J Occup Environ Med. 2006;48:959–968)*

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Agriculture has consistently been identified as one of the most hazardous occupations in the United States. In 2003, this industry experienced 20.9 fatalities per 100,000 workers, a rate 6.5 times greater than the national average (3.2 per 100,000). The estimated rate of nonfatal injuries per 100,000 workers was 1.3 times greater (4,000 versus 3,000).¹ However, these data are considered conservative due to underreporting.

Falls are one of the most common occupational injuries. In 2001, falls accounted for 12% of all fatal occupational injuries; of these, 8% occurred in the agriculture, forestry, and fishing industry.²

Knowledge of the etiology of occupational falls is not well understood. A major limitation in agricultural injury research has been the lack of specific fall-related questions.³ The purpose of the current study was to identify the magnitude and consequences of all types of fall-related injuries among agricultural household members in a five-state region and to identify potential risk factors.

Materials and Methods

Before initiation of this effort, approval was obtained from the Institutional Review Board pertinent to human subjects in accordance with federal regulations. To examine the problem of fall-related agricultural injuries, the 1999 Regional Rural Injury Study II (RRIS-II) cohort database was used. RRIS-II was designed to examine the magnitude and consequences of the injury problem

among all ages and the etiology of agricultural injury among children less than 20 years of age in Minnesota (MN), Wisconsin (WI), North Dakota (ND), South Dakota (SD), and Nebraska (NE) for 1999.

Study Population and Cohort

The study population involved all farming/ranching operations in the five-state region. A random sample of 16,000 farming/ranching operations (3200 from each state) was generated from the U.S. Department of Agriculture's (USDA) National Agricultural Statistics Service (NASS) Master List Frame of Farming Operations.

Data Collection/ Contact Procedures

First, an introductory letter that provided informed consent information and elaborated on the nature of the study, including information about the 5-minute participation interview and the two subsequent full interviews, was sent to the 16,000 operations. Subsequently, a participation interview was initiated by telephone. This interview served to establish eligibility for the study based on the following criteria: 1) the operator's household was associated with the operation and included one or more children who were less than 20 years of age as of January 1, 1999; 2) the operation received at least \$1000 in revenue from agricultural products during the past year; and 3) the farming/ranching operation was active as of January 1, 1999. With the establishment of eligibility, participation in the comprehensive study was requested; this included two subsequent full interviews covering the two 6-month periods of 1999. Before initiation of the full interviews, designed to collect data retrospectively from January 1 through June 30, 1999, and July 1, 1999, through December 31, 1999, the participating eligible households received follow-up letters and information cards to facilitate the interviews that were started in July 1999 and January 2000 for the respective periods.

Data Collection Instruments

This study was conducted using computer-assisted telephone interview (CATI) instruments especially designed and pretested by the investigators. For purposes of the current study, data resulting from administration of the household log and the injury log instruments were used. The household log enabled collection of basic demographic information for all members of each household and the agricultural operation. The injury log was used to facilitate identification of any injuries that may have occurred in each 6-month period; these included injuries incurred in activities associated with their own operation, another operation, or as a result of all other nonfarming/ranching-related activities. The interviews were administered by USDA NASS interviewers in key interviewing offices located in North and South Dakota; these interviewers were trained by study investigators, who also monitored interviewing activity, in concert with NASS supervisors, for the study duration.

Injury Definition and Inclusions

For inclusion in RRIS-II, an injury was defined as any acute traumatic event that met one or more of the following criteria: restricted normal activities for at least 4 hours; resulted in loss of consciousness, loss of awareness, or amnesia for any length of time; or required professional health care. For the purpose of this study, falls were classified by a modification of the International Classification of Diseases, 9th Revision, Clinical Modification, external cause codes (ICD-E codes). A fall could be classified in any of the following eight categories: 1) fall on or from stairs or steps (880); 2) fall on or from ladders or scaffolding more than 20 feet (881) or 3) fall on or from ladders or scaffolding less than or equal to 20 feet (881); 4) fall from or out of building or other structure (882); 5) fall into hole or other opening in surface (883); 6) fall on same level from slipping, tripping, or stum-

bling (885); 7) fall from one level to another (884); and 8) slips and trips not resulting in a fall (no single E code available; description of event coded separately).

Analyses

Descriptive analyses, using standard statistical software,^{4,5} addressed occurrences of 1) agriculture-related injuries on their own operation, or 2) on another operation, and 3) injuries related to all other types of activities. Rates of injury events per 1000 persons at risk, per year, were generated with events and person time from both reporting periods and were adjusted for within-household correlation using generalized estimating equations⁶ excluding levels for missing values and nonresponse. Confidence intervals for event rate estimates were generated using Poisson regression (proc genmod in SAS).⁴ Potential selection bias was controlled by inversely weighting observed responses with probabilities of nonresponse⁷ estimated as a function of characteristics available from the NASS Master List Frame, including state in which the operation was located, type of operation, and operation revenue by quintile. To account for unknown eligibility among nonrespondents, the probability of eligibility was estimated for these same characteristics.⁸

The following variables were examined for specific injury occurrences and associated consequences: types of falls, additional sources/vehicles of injury, types of injuries (diagnoses), anatomic parts injured, associated activities, locations, severity of injuries (hospitalization, additional health care, duration of normal activity restriction, lost time from farming/ranching work, and lost time from other work activities, persistent problems, current restriction and degree of restriction).

Multivariate analyses of agriculture-related fall injuries associated with their own operation, considering relevant exposures, used logistic regression to assess potential risk factors for fall-related agricultural injury. Exposures of interest included state of residence (MN, WI, ND, SD,

NE), age group, gender, race, level of education, marital status, prior agricultural injuries, and hours worked/involved in chores on one's own operation (hours/week). A causal model (Fig. 1), based on previous research and expert knowledge, identified complex hypothesized interactions among potential confounders. Selection of confounders for each exposure of interest was based on directed acyclic graphs (DAGs) established from the causal model.⁹ This enabled identification of parsimonious models and excluded covariates that should not be entered into the regression because they could introduce bias.

Results

Among the 16,000 operations sampled, a total of 4402 (27.5%) households were found to be eligible and, of these, 3765 households (85.5% of those eligible and 23.5% of the total sample), including 16,538 people, participated in the study; of these, 97.8% of the households provided information on the second 6 months. Through the screening process, 8288 operations (51.8%) were found to be ineligible based on the study participation screening criteria. Overall, there was a known refusal rate of 24.5% of the original sample; this included 618 of

the known eligible operations and 3302 operations that refused participation during the screening process.

A total of 2586 injury events were reported among this population (own operation: 1215; another operation: 69; not agriculture-related: 1299; unknown: 3); of these, 766 events (29.6%) were identified as fall-related injuries, accounting for an overall injury rate of 48.3 events per 1000 persons at risk per year (Table 1). Fall-related injury rates for events associated with their own operation, or another operation, and with nonagriculture-related activities were 17.7, 1.1, and 29.4 per 1000 persons per year, respectively. Ana-

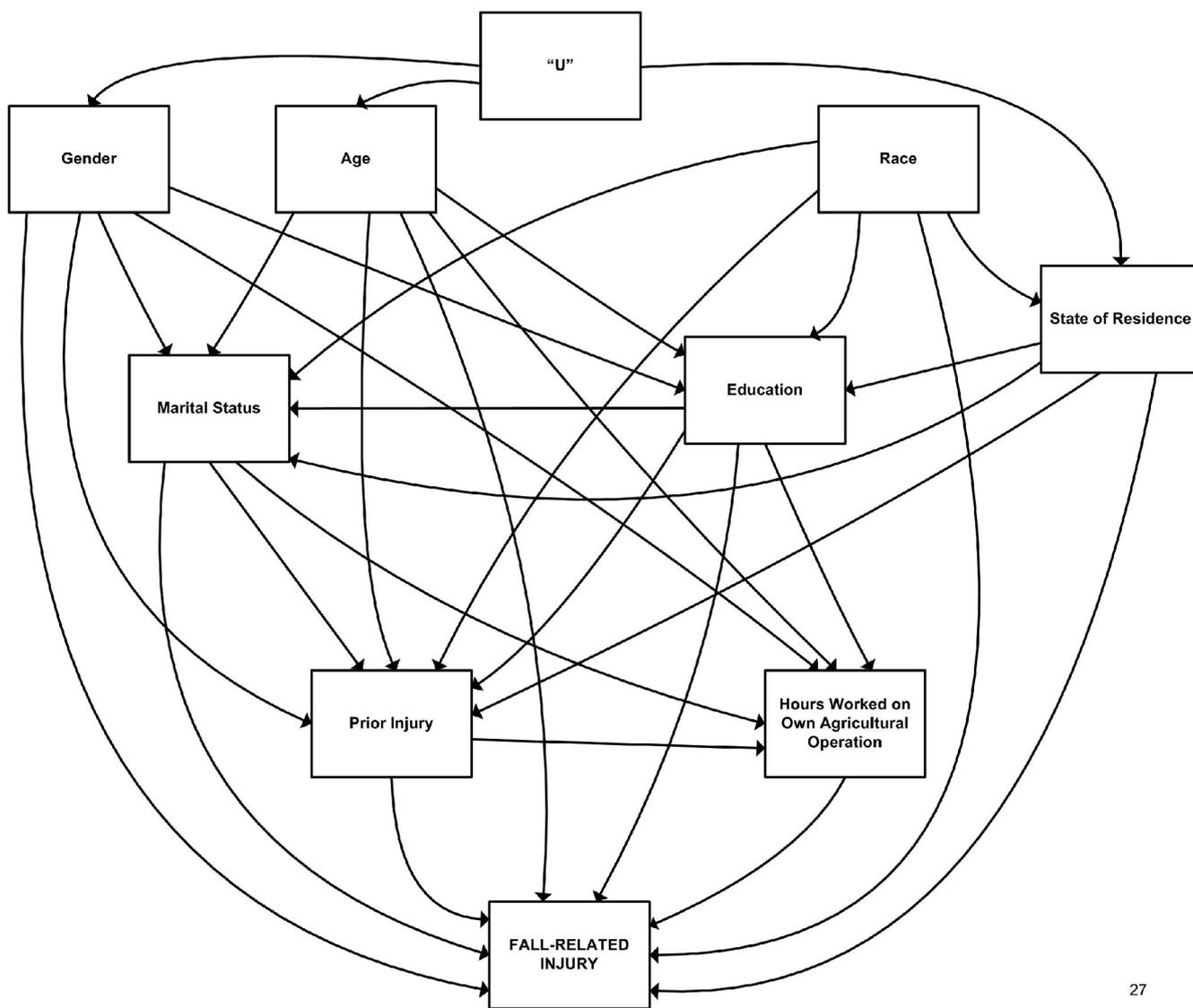


Fig. 1. Causal model used for multivariate modeling of fall-related injuries occurring on one's own agricultural operation, Regional Rural Injury Study-II. *U, unidentified association between variables.

TABLE 1

Fall-Related Injury Event Rates Per 1000 Persons/Year Among Agricultural Household Members, Regional Rural Injury Study-II

Exposure	Number Exposed*	Own Operation Number; Rate (95% CI)	Another Operation Number; Rate (95% CI)	Not Farm/Ranch-Related Number; Rate (95% CI)†	Total Number; Rate (95% CI)
Total population	16,538	287; 17.7 (15.5–20.2)	17; 1.1 (0.7–1.9)	462; 29.4 (26.5–32.7)	766; 48.3 (44.4–52.5)
State of residence					
Minnesota	3178	32; 9.9 (6.7–14.5)	2; 0.6 (0.1–2.4)	72; 26.9 (19.6–36.8)	106; 37.3 (29.1–48.0)
Nebraska	3381	57; 17.4 (12.7–23.9)	5; 1.7 (0.7–4.5)	115; 34.4 (28.2–42.0)	177; 53.6 (44.6–64.4)
North Dakota	3498	67; 19.8 (14.8–26.4)	3; 0.9 (0.3–2.8)	102; 30.3 (24.4–37.7)	172; 51.0 (43.0–60.5)
South Dakota	3528	83; 24.5 (19.3–31.0)	6; 1.9 (0.8–4.1)	102; 29.0 (23.7–35.6)	191; 55.3 (47.4–64.4)
Wisconsin	2953	48; 16.5 (12.3–22.1)	1; 0.4 (0.1–2.6)	71; 25.3 (19.7–32.6)	120; 42.2 (34.8–51.1)
Males					
Total	8540	191; 23.2 (19.7–27.3)	11; 1.5 (0.8–2.7)	276; 33.5 (29.5–38.1)	478; 58.1 (52.4–64.5)
Ages 0–19	4411	41; 10.8 (7.1–16.5)	2; 0.4 (0.1–1.8)	237; 55.8 (48.8–63.8)	280; 67.2 (58.7–77.0)
Ages 20+	4124	150; 36.0 (30.6–42.5)	9; 2.5 (1.3–5.1)	39; 10.1 (7.1–14.3)	198; 48.7 (42.0–56.4)
Females					
Total	7998	96; 11.0 (9.6–14.8)	6; 0.8 (0.3–1.7)	186; 25.1 (21.1–30.1)	288; 37.8 (33.0–43.3)
Ages 0–19	4077	28; 6.8 (4.6–10.2)	4; 1.0 (0.4–2.8)	126; 32.9 (27.4–39.5)	158; 40.9 (34.7–48.1)
Ages 20+	3917	68; 17.2 (13.4–22.1)	2; 0.5 (0.1–2.1)	60; 17.0 (12.4–23.4)	130; 34.7 (28.3–42.7)
Age group (yr)					
0–4	1108	6; 5.2 (2.2–12.2)	0; 0	41; 38.4	47; 43.8 (32.0–58.2)
5–9	1917	10; 6.0 (3.1–11.5)	3; 1.7	56; 29.2	69; 36.8 (29.1–46.6)
10–14	2644	32; 13.7 (9.0–20.9)	1; 0.4	140; 58.2	173; 72.5 (61.3–85.8)
15–19	2819	21; 7.9 (5.1–12.1)	2; 0.7	126; 45.5	149; 54.0 (45.8–63.7)
20–24	553	6; 12.7 (5.2–31.1)	0; 0	10; 19.7	16; 32.3 (19.2–54.3)
25–34	1059	21; 19.0 (12.1–29.8)	3; 2.9	16; 14.0	40; 36.0 (25.6–50.4)
35–44	3721	113; 30.0 (24.8–36.2)	6; 1.6	44; 13.2	163; 44.9 (38.0–53.0)
45–54	2277	63; 27.1 (20.8–35.4)	2; 1.5	25; 13.3	90; 41.9 (32.4–54.2)
55–64	353	10; 26.8 (14.6–49.1)	0; 0	4; 9.8	14; 36.0 (21.4–60.6)
65+	78	5; 69.7 (25.81–88.3)	0; 0	0; 0	5; 69.2 (25.51–88.3)
Race					
White	16,347	283; 17.7 (15.5–20.2)	17; 1.1	450; 29.0 (26.4–32.2)	752; 48.0 (44.1–52.2)
Nonwhite	172	4; 23.6 (8.1–68.5)	0; 0	6; 36.5 (16.7–80.1)	10; 60.4 (32.7–111.5)
Educational status					
Incomplete (age <20)	8488	69; 8.9 (6.6–11.9)	6; 0.7 (0.3–1.6)	363; 44.8 (40.2–49.9)	438; 54.5 (49.1–60.5)
Less than high school graduate	266	6; 24.1 (10.7–54.5)	1; 4.1 (0.6–28.7)	2; 7.1 (1.6–30.3)	9; 35.1 (16.7–73.7)
High school graduate or equivalency	3222	102; 31.4 (25.6–38.6)	5; 1.5 (0.6–3.7)	36; 12.0 (8.5–17.0)	143; 45.1 (37.8–53.8)
Technical school or some college	2897	69; 23.9 (18.8–30.4)	2; 0.7 (0.2–2.8)	42; 14.2 (10.2–19.8)	113; 38.5 (31.7–46.7)
College graduate/postgraduate	1652	41; 23.7 (16.9–33.2)	3; 2.7 (0.8–9.4)	19; 16.0 (8.4–30.8)	63; 42.7 (30.8–59.2)
Marital status					
Premarital age (<16)	6309	51; 9.0 (6.3–12.9)	5; 0.8	268; 45.0	324; 54.8 (48.5–62.0)
Married/living as married	7255	205; 27.7 (24.0–32.1)	11; 1.7	88; 13.3	304; 42.8 (37.6–48.8)
Never married	2770	25; 9.4 (6.2–14.2)	1; 0.4	104; 38.3	130; 48.2 (40.3–57.5)
Separated/divorced	144	3; 20.0 (6.3–64.2)	0; 0	1; 7.7	4; 28.2 (10.7–74.3)
Widowed	43	2; 47.7 (10.9–208.9)	0; 0	0; 0	2; 48.9 (11.6–206.0)
Hours worked on one's own operation/week					
0	2765	6; 2.3 (1.1–5.0)	0; 0	85; 32.0 (25.8–39.7)	91; 34.5 (28.1–42.4)
0–20	7715	92; 12.3 (9.8–15.8)	10; 1.3	266; 36.4 (31.8–41.6)	368; 50.0 (44.3–56.4)
>20–40	2287	47; 20.3 (15.1–27.2)	2; 1.5	66; 29.9 (23.2–38.4)	115; 51.7 (42.7–62.4)
>40–60	1446	48; 33.6 (25.4–44.5)	1; 0.7	23; 15.1 (9.7–23.6)	72; 49.2 (38.6–62.6)
>60–80	1290	56; 41.8 (31.8–54.9)	3; 2.2	10; 7.9 (4.0–15.6)	69; 52.1 (40.6–66.8)
>80	481	26; 54.4 (37.0–79.9)	0; 0	1; 2.0 (0.2–15.5)	27; 55.6 (37.9–81.6)

*Number exposed may vary due to nonresponse.

†Confidence intervals could not be calculated in some cases due to inadequate numbers.

CI indicates confidence interval.

lyzed by state, the highest rate per 1000 persons was found in South Dakota (55.3) and the lowest in Minnesota (37.3); the highest rates were found for nonagricultural-related injuries, whereas the lowest were associated with those sustained on another operation.

By gender, males had a higher overall injury rate than females (58.1 per 1,000 persons and 37.8 per 1,000 persons, respectively). Males less than 20, compared with those 20+ years of age, had higher overall injury rates (67.2 per 1,000 persons and 48.7 per 1,000 persons, respectively), whereas the respective ratios for injuries associated with nonagricultural versus agriculture-related injuries were 5:1 and 0.26:1. Females less than 20, compared with those 20+ years of age, had higher overall injury rates (40.9 per 1,000 persons and 34.7 per 1,000 persons, respectively), with respective ratios for nonagriculture versus agriculture-related injuries of 4.2:1 and 0.96:1.

Similar observations were noted when more refined age groups were used, especially for younger age groups; however, for age groups beginning with those 25 to 34 and continuing to 65+, the ratios reverse with much higher rates for agricultural compared with nonagricultural injuries. Of note is the elevated rate for those 65+ years of age for injuries associated with their own operation (69.7 per 1,000 persons).

Analyzed by race, the respective overall injury rates for nonwhite

and whites were 60.4 per 1,000 persons and 48.0 per 1,000 persons; this difference occurred in both the nonagriculture- (36.5 per 1,000 persons; 29.0 per 1,000 persons) and agriculture-related (23.6 per 1,000 persons; 17.7 per 1,000 persons) injuries. Findings for educational status were similar to those reported earlier for age groups.

Analysis by marital status identified the highest overall rate among those of premarital age (<16 years) (54.8 per 1,000 persons) and the lowest for those who were separated/divorced (28.2 per 1,000 persons). For those married/living as married, separated/divorced, and widowed, injuries incurred on their operation accounted for the greatest proportion of overall injuries. Nonagricultural injuries accounted for the greatest proportion for those who were of premarital age or never married.

Overall injury rates varied by the number of hours worked on their operation per week and, in general, increased with increasing hours of work, ranging from 2.3 per 1,000 persons for zero hours to 54.4 per 1,000 persons for more than 80 hours.

Characteristics and Consequences of the Injury Events

Fall-related injury events were classified into eight fall categories (with modified ICD E codes) and are presented in Table 2. Fall injuries associated with their operation were most frequently from one level to another (43.2%) or on the same level

from slipping, tripping, or stumbling (28.2%). Fall injuries associated with another operation were most frequently those from one level to another (29.4%) and on/from stairs or steps (23.5%). Nonagricultural injuries occurred most frequently on the same level (58.6%) or from one level to another (21.5%). Overall, the least common type of fall was on or from a ladder or scaffolding greater than 20 feet. Only six subjects (0.8%) experienced this type of fall and, of these, two were less than 20 years of age. It was also possible to classify an injury as having more than one source. Overall, falls were most commonly associated with sports/recreational activities (37%), animals (17%), motor vehicles (9%), and tractors and other large machinery (10%). For events associated with their operation, another operation, and those related to nonagricultural activities, respectively, falls were most frequently associated with animals (38%) or tractors (14%), animals (41%), and sports/recreational activities (60%) or motor vehicles (14%).

Fall-related events most frequently resulted in sprains or strains (35%), fractures or dislocations (34%), or bruises/contusions (24%). Other diagnoses included cuts/lacerations (11%), concussions (7%), and torn ligaments (3%). Among these events, the most common body parts injured were arms/elbows/wrists (19%), ankles (16%), knees (12%), backs (12%), legs (10%), faces (7%), and heads/skulls (5%) were also injured. Injuries asso-

TABLE 2
Types of Falls Among Agricultural Household Members, Regional Rural Injury Study-II

Type of Fall (ICD E code)	Own Operation Number (percent)	Another Operation Number (percent)	Not Farm/Ranch-Related Number (percent)	Total Number (percent)
On/from stairs/steps (880.00)	23 (8.0)	4 (23.5)	35 (7.6)	62 (8.1)
On/from ladder/scaffolding >20 ft. (881.00)	3 (1.0)	0 (0)	3 (0.7)	6 (0.8)
On/from ladder/scaffolding ≤20 ft. (881.00)	4 (1.4)	1 (5.9)	7 (1.5)	12 (1.6)
From/out of building/structure (882.00)	7 (2.4)	2 (11.8)	15 (3.3)	24 (3.1)
Into hole or surface opening (883.00)	20 (7.0)	1 (5.9)	3 (0.7)	24 (3.1)
Same level—slip/trip/stumble (885.00)	81 (28.2)	3 (17.6)	270 (58.6)	354 (46.3)
From one level to another (884.00)	124 (43.2)	5 (29.4)	99 (21.5)	228 (29.8)
Slip/trip without fall (separate code created)	25 (8.7)	1 (5.9)	29 (6.3)	55 (7.2)

ICD E code indicates International Classification of Diseases external cause code.

ciated with one's own operation were most frequently strains/sprains of the back or ankle, concussions, and bruises/contusions of the back or leg. Injuries associated with another operation were primarily strains/sprains of the ankle, whereas those related to nonagricultural activities were most often fractures/dislocations of the upper extremities, sprains/strains of the upper extremities, knee, ankle, or back, concussions, bruises/contusions of the knee, and cuts/lacerations/scratches of the face.

Fall-related injuries associated with one's own operation most often occurred while riding animals (19%), mounting/dismounting (17%), walking (5%), three-wheeling/four-wheeling (5%), handling/transferring feed/grains (4%), climbing/climbing ladder (4%), or feeding (4%). Injuries associated with another operation most frequently occurred while climbing/climbing a ladder (24%), mounting/dismounting (18%), or riding animals (18%). Those that were nonagriculture-related were most often associated with football (14%), basketball (13%), walking (7%), going up/down stairs (7%), playground activities (5%), running/jogging (3%), skiing/snowboarding downhill (3%), volleyball (3%), or riding animals (3%).

Of the 287 falls that were associated with one's own operation, 95% occurred around the farm or ranch. This was also the most common location of all fall injuries associated with another operation (71%). Most nonagriculture-related injuries occurred at school (28%), in a sports/recreation area (21%), around the farm or ranch (17%), or in or around the house (17%).

Several variables were used as proxies for measuring the severity of the fall-related injuries: hospitalization, additional medical treatment, duration of normal activity restriction, lost time from farm operation work, lost time from other work activities, persistent problems, and current restriction/level of restriction (Table 3). Hospitalization was required for approximately 5% of the fall-related injuries (own operation:

5%; another operation: 0%; nonagricultural: 5%). Although the percentage of fall-related injuries resulting in hospitalization was low, the vast majority required some form of health care (87%), including treatment in a doctor's office, hospital emergency department, dentist's office, chiropractor's office, at the scene of the injury, or at another healthcare facility (own operation: 78%; another operation: 82%; nonagricultural: 92%).

Although 10% of those with injuries related to their own operation were not restricted from regular activities, 39% were restricted for 1 week or more, and 17% were restricted 1 to 3 months (Table 3). For events related to another operation, 18% had no restriction, whereas 29% were restricted for a week or more and 6% were restricted 1 to 3 months. Much higher proportions of nonagriculture-related injuries caused restriction for 1 week or more (47%) and 1 to 3 months (24%); 10% had no restriction. Overall, 43% of fall-related injuries resulted in restricted activity for 1 week or more, 21% 1 to 3 months, and 10% involved no restriction.

Of the fall injuries related to one's own operation, 23% resulted in more than 1 week of lost agricultural work time, 11% 1 to 3 months, and 4% more than 3 months (Table 3). For events associated with another operation, respective percentages were 24%, 6%, and 0%; for nonagriculture-related injuries, the percentages were 21%, 10%, and 2%. The respective overall burden of these injuries pertinent to lost agricultural work time was 22%, 10%, and 3%. Lost time from other work occurred in 11% of the total cases (own operation: 8%; another operation: 0%; nonagricultural: 13%).

Persistent problems as a result of the injuries were reported by 19% of the cases (own operation: 23%; another operation: 12%; nonagricultural: 16%). Overall, only 8% reported being restricted from regular activity at the time of the interview. "A small amount" of current restriction was reported by 5% of those who sustained

injuries related to their own operation, "a moderate amount" by 4%, and "a large amount" by 1%. The respective percentages for those with persistent problems resulting from nonagricultural injuries were 4%, 3%, and 1%.

When examining the severity of different types of falls, consistent trends were evident. Regardless of the severity measures examined, falls on the same level (slip, trip, or stumble) and falls from one level to another were the most severe. Of all hospitalized fall injuries, 31% were associated with a fall on the same level and 44% from one level to another. Of those resulting in lost farm work time, the respective percentages were 42% and 32%; of the fall injuries resulting in continued activity restriction, the percentages were 31% and 27%.

Multivariate Analyses

Multivariate analyses were conducted using data relevant to agriculture-related injuries associated with one's own operation and pertinent exposure information for all persons at risk. Application of DAGs,⁹ based on the causal model (Fig. 1), enabled selection of confounders. Analyses were conducted to determine odds ratios for personal risk (Table 4).

When compared with Minnesota, all other states of residence showed increased odds of fall-related injury. Estimates indicated that age groups less than 35 years of age had decreased risks compared with those in the ≥ 35 to < 45 age group. An increased risk was identified for males compared with females (1.94). Prior agricultural injury history was also associated with an increased risk of agricultural fall-related injury (3.11). A strong dose-response relation between hours worked and risk of fall injury was identified; compared with working more than 80 hours per week, decreased risks were identified for working zero hours, > 0 to ≤ 20 hours, and > 20 to ≤ 40 hours per week. No notable effects were identified for race, education level, or marital status (Table 4).

TABLE 3
Severity Measures Associated With Fall-Related Injury Events, Regional Rural Injury Study-II

Severity Measure	Own Operation Number (percent)	Another Operation Number (percent)	Not Farm/ Ranch-Related Number (percent)	Total Number (percent)
Hospitalized				
No	273 (95.1)	17 (100)	440 (95.2)	730 (95.3)
Yes	14 (4.9)	0 (0)	22 (4.8)	36 (4.7)
Where treatment was first sought				
None	62 (21.6)	3 (17.6)	35 (7.6)	100 (13.1)
Doctor's office	105 (36.6)	7 (41.2)	193 (41.8)	305 (39.8)
Hospital emergency department (ED)	65 (22.6)	5 (29.4)	179 (38.7)	249 (32.5)
Hospital in-patient	14 (4.9)	0 (0)	22 (4.8)	36 (4.7)
Hospital in-patient or ED	71 (24.7)	5 (29.4)	191 (41.3)	267 (34.9)
Dentist's office	5 (1.7)	0 (0)	9 (1.9)	14 (1.8)
Chiropractor's office	59 (20.6)	1 (5.9)	41 (8.9)	101 (13.2)
At scene of incident	7 (2.4)	1 (5.9)	23 (5.0)	31 (4.0)
Other healthcare facility	7 (2.4)	0 (0)	20 (4.3)	27 (3.5)
Duration of normal activity restriction				
None	28 (9.8)	3 (17.6)	47 (10.2)	78 (10.2)
>0 hrs to <4 hrs	15 (5.2)	1 (5.9)	25 (5.4)	41 (5.4)
4 hrs to <1 d	34 (11.8)	1 (5.9)	47 (10.2)	82 (10.7)
1 d to <7 d	97 (33.8)	7 (41.2)	126 (27.3)	230 (30.1)
7 d to <14 d	34 (11.8)	1 (5.9)	54 (11.7)	89 (11.6)
14 d to <1 mo	28 (9.8)	3 (17.6)	50 (10.8)	81 (10.6)
1 mo to <3 mo	34 (11.8)	1 (5.9)	86 (18.7)	121 (15.8)
3 mo +	16 (5.6)	0 (0)	25 (5.4)	41 (5.4)
Not applicable, dead	1 (0.3)	0 (0)	1 (0.2)	2 (0.3)
Lost agricultural work time				
None	131 (45.8)	7 (41.2)	283 (61.5)	421 (55.2)
>0 hrs to <4 hrs	11 (3.8)	0 (0)	6 (1.3)	17 (2.2)
4 hrs to <1 d	24 (8.4)	0 (0)	13 (2.8)	37 (4.8)
1 d to <7 d	53 (18.5)	6 (35.3)	62 (13.5)	121 (15.9)
7 d to <14 d	18 (6.3)	2 (11.8)	25 (5.4)	45 (5.9)
14 d to <1 mo	16 (5.6)	1 (5.9)	24 (5.2)	41 (5.4)
1 mo to <3 mo	21 (7.3)	1 (5.9)	37 (8.0)	59 (7.7)
3 mo+	11 (3.8)	0 (0)	9 (2.0)	20 (2.6)
Not applicable, dead	1 (0.3)	0 (0)	1 (0.2)	2 (0.3)
Lost other work time				
No	263 (92.0)	17 (100)	399 (86.7)	679 (89.0)
Yes	23 (8.0)	0 (0)	61 (13.3)	86 (11.0)
Persistent problems				
No	219 (76.6)	15 (88.2)	387 (84.1)	621 (81.4)
Yes	67 (23.4)	2 (11.8)	73 (15.9)	142 (18.6)
Still restricted				
No	259 (90.6)	17 (100)	423 (91.9)	699 (91.6)
Yes	27 (9.4)	0 (0)	37 (8.1)	64 (8.4)
Degree of current restriction				
None	259 (90.6)	17 (100)	423 (92.0)	699 (91.6)
A small amount	13 (4.5)	0 (0.0)	18 (3.9)	31 (4.1)
A moderate amount	11 (3.8)	0 (0.0)	14 (3.0)	25 (3.3)
A large amount	3 (1.0)	0 (0.0)	5 (1.1)	8 (1.0)

Discussion

Fall-related injuries are a major burden to the agricultural population. Almost 30% of the injuries experienced by this population, during the 1-year study period, were attributed to falls, accounting for respective rates per 1000 persons per year, for

total falls and those associated with their own operation, of 48.2 and 17.8; falls accounted for 24% of all agriculture-related injuries. Although there is a possibility for changes over time within a study population, there is evidence of no difference in rates between the current study and recent

data for 2001 that were collected in a comparable manner. This includes rates for the total population, males, females, children and adults.¹⁰ Previous studies indicated estimates for fall-related injuries that accounted for 10% of agricultural injuries¹¹ and 17% and 18%, respectively, for agriculture-related

TABLE 4

Risk of Fall-Related Injury: Multivariate Results Based on Causal Model, Regional Rural Injury Study-II

Variable	Number at Risk	Events	Odds Ratio for Personal Risk	95% Confidence Interval
State of residence†				
Minnesota	3110	31	1	—
Nebraska	3327	56	1.79*	1.11–2.89*
North Dakota	3371	61	1.93*	1.21–3.07*
South Dakota	3482	80	2.49*	1.59–3.90*
Wisconsin	2849	47	1.70*	1.06–2.75*
Age group (yr)‡				
0–4	1092	6	0.18*	0.08–0.41*
5–9	1891	10	0.20*	0.10–0.40*
10–14	2575	31	0.42*	0.27–0.64*
15–19	2740	20	0.24*	0.15–0.38*
20–24	543	5	0.33*	0.13–0.83*
25–34	1037	20	0.65	0.40–1.04
35–44	3627	109	1	—
45–54	2217	60	0.82	0.59–1.14
55–65	345	10	0.80	0.41–1.55
65+	72	4	1.86	0.68–5.08
Gender§				
Male	8335	184	1.94*	1.50–2.50*
Female	7804	91	1	—
Race				
White	15,973	271	1	—
Nonwhite	159	4	1.43	0.47–4.39
Educational status^				
Incomplete (age <20)	8293	67	0.80	0.40–1.60
Less than high school graduate	253	6	0.98	0.38–2.50
High school graduate or equivalent	3147	98	1.34	0.90–2.00
Technical school or some college	2832	67	1.11	0.73–1.70
College graduate/postgraduate	1605	37	1	—
Marital status¶				
Premarital age (<16)	6174	50	0.91	0.24–3.52
Married/living as married	7076	196	1	—
Never married	2700	23	0.57	0.21–1.52
Separated/divorced	141	3	0.61	0.19–1.96
Widowed	37	2	2.77	0.59–12.92
Injury history**				
No	13,039	135	1	—
Yes	3082	139	3.11*	2.31–4.20*
Hours worked on one's own operation/week††				
0	2759	6	0.09*	0.03–0.25*
0–20	7698	87	0.41*	0.23–0.73*
>20–40	2282	46	0.54*	0.32–0.92*
>40–60	1441	47	0.70	0.42–1.16
>60–80	1284	54	0.77	0.47–1.27
>80	475	25	1	—

All analyses adjusted for within-household correlation using GEEs and weighted for nonresponse.

*95% confidence interval = excludes 1.

†Adjusted for age and gender.

‡Adjusted for gender and state.

§Adjusted for age and state.

^Adjusted for age, gender and state.

¶Adjusted for age, gender, state, and education.

**Adjusted for age, gender, marital status, education, and state.

††Adjusted for education, marital status, prior injury, age, and state.

injuries experienced by farm and non-farm residents.¹² Only Xiang et al, who reported that falls accounted for 26% of agricultural injuries, reported results of

a magnitude similar to the current study¹³; however, injury definitions and inclusion criteria varied from those of RRIS-II.

Although a majority of the injured persons received some form of health care, a very small percentage of the fall-related injuries in this study re-

quired hospitalization. However, it is crucial to not underestimate the potential severity of agricultural injuries by these figures alone. Despite not being hospitalized, the vast majority of the injured persons in this study required some form of professional health care. Both the RRIS-I¹⁴ and OATS¹⁵ research efforts reported similar trends in injury severity and healthcare need, although those findings addressed agricultural injury in general. The current findings suggest that hospital records and hospital-based surveillance systems are seriously limited in identifying the magnitude and consequences of the problem.

By examining measures of activity restriction, the impact that fall-related injuries can have on an agricultural household was highlighted. Among the injuries associated with people's own operations, 36% reported activity restriction that lasted for more than 1 week, 23% for more than 2 weeks, and 13% more than 1 month. Over half of this same group lost farm work time and 8% lost other work time as a result of their injury. Also, one in five study participants reported persistent problems as a result of the fall injury. Similar findings regarding both activity restriction and persistent problems, although not focused specifically on fall-related injuries, have been reported previously in similar populations.¹⁴⁻¹⁷ Restrictions of this magnitude can affect the output and productivity of the operation and may have heavy financial impacts, especially on small family farms that have few people to manage the required tasks.

A regulation exists¹⁸ that prohibits certain hazardous agricultural tasks from being performed by children under the age of 16 on an operation other than that of their own family. Included in this list of tasks is working on ladders or scaffolding that are greater than 20 feet in height. In the current effort, only six subjects experienced events in this category, the youngest of whom were 17 and 19 years of age. Although the regulation was not violated in this participating population, the potential legal impli-

cations of hazardous exposures on agricultural operations remain an important consideration.

Although no differences in risk of all types of agricultural injury, based on state of residence, were found in RRIS-I,¹⁴ the present effort found all states, compared with Minnesota, to be at increased risk for fall-related injuries. Whether this was due to differences in the specific types of agricultural activities among the states, safety cultures, or demographic variables and other factors not examined in the present study remains unknown.

In the current study, younger age groups were shown to have decreased risks of fall-related injury compared with those aged ≥ 35 to < 45 years. It is possible that people in these groups were not engaged in work on the operation to the same degree as those in the older age groups and, therefore, had less exposure to potentially dangerous situations. Other studies that examined agricultural injury, in general, have reported higher fall injury rates among the age groups of 40 to 49¹² and 70 and older¹⁹ but have not reported differences in fall injury risk.

Men, compared with women, were shown to be at a greater risk of fall-related injury in the current study. According to McCurdy and Carroll,²⁰ other research, although not focused specifically on falls, has shown that men have a greater risk of general agricultural injury. Again, this may reflect greater exposures to more hazardous situations.

A high risk associated with prior agricultural injury was identified in this research effort. Potential explanations may be that physical limitations persisting from prior injuries may cause vulnerability to subsequent injury or that individuals sustaining fall-related injuries may be involved in more dangerous tasks and continue to be involved in these same tasks despite having been injured in a similar manner in the past.

The present study found that people who spent less time doing farm work, compared with those who

worked more than 80 hours per week, had a decreased risk of fall-related injury. From other studies,^{3,16} increased risks of agricultural injury have also been identified for those who worked more compared with fewer hours.

The potential for recall bias, which is inherent in any study that uses interviews to obtain retrospective data, could have resulted in the misclassification of subjects on exposure and/or outcome. This possibility was decreased in RRIS-II by using two 6-month recall periods rather than a 12-month period. This approach was based on the OATS validation data, which resulted in the recommendation for using two 6-month reporting periods and designating the female head of household as the preferred respondent for injury and demographic information to enhance quality of reporting.^{15,21} In addition, a study that assessed a 3-year recall of self-reported injury found that self-reporting was adequate to enumerate injuries occurring in a 6-month period.²² A final method of reducing potential recall bias in this effort was the inclusion of follow-up letters and booklets that were sent to participants before each full interview; each household was provided with information about the injury definition and types of injuries that were of interest and forms on which they could record injury information throughout the study period.

Another limitation to the present study is potential misclassification of the type of injury that occurred. For example, a large percentage of tractor-related injuries are due to slipping and falling off the tractor while mounting or dismounting¹⁶; in this case, the injury may be classified as a tractor-related injury rather than as a fall-related injury. This bias was minimized in RRIS-II by allowing an injury to be coded with more than one source. The example given here would have been coded as both a tractor-related injury and a fall-related injury within the data set.

Selection bias due to nonresponse is also a concern. It is possible that

more than 766 falls occurred, and it is unknown if they may have been similar in nature to those that were included. However, RRIS-II obtained an 85.5% response rate among those eligible, so the present study had the advantage of using data surrounding the vast majority of falls that may have occurred in the population under investigation. Most importantly, potential selection bias was controlled by inversely weighting observed responses with probabilities of response estimated as a function of characteristics available from the NASS Master List Frame.⁷ To account for unknown eligibility among nonrespondents, probability of eligibility was estimated from these same characteristics.⁸

A final potential limitation was the amount of detail obtained regarding the conditions surrounding the events. Information that would be useful to investigate in future studies includes variables such as weather conditions (rain, snow), housekeeping habits (surface debris, tripping hazards), type of footwear worn, history of falls, balance and gait, and the use of fall protection devices.^{3,23-25} Within the current design, this level of detail was not possible for every source/vehicle of injury.

Despite the limitations of this research effort discussed here, RRIS-II enabled an important contribution to the understanding of the total burden of fall-related injuries among agricultural household members in a major agricultural region of the United States. Most importantly, it serves as a basis for further fall-related injury research.

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