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Animal-related injuries: A population-based study of a five-state region in the upper midwest: Regional rural injury study II ☆

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Abstract

Problem: While agricultural injury has been identified among the major causes of occupational injury mortality and morbidity, data have been limited pertinent to the magnitude, consequences, and potential risk factors for animal-related injuries – a major source of morbidity among agricultural operations. *Methods:* Demographics, exposure, and injury data were collected for 1999 and 2001 among agricultural households in a five-state region. Causal models facilitated survey design, data analyses, and interpretation of results; directed acyclic graphs guided multivariate modeling. *Results:* From 7,420 households (84% response of eligible), a total of 5,045 injury events were reported; 1,016 (20.1%) were animal-related. Multivariate analyses revealed increased risks for those <20 years; residents of all states compared to Minnesota; all age groups compared to 0–4 years; >0 hours worked; and prior agricultural injury history. For those 20+ years, increased risks were identified for: South Dakota residents; males; >0 hours worked; and prior agricultural injury history. For those cases <20 and 20+ years of age, 58% and 46%, respectively, resulted in lost work time on their agricultural operations (31% and 50%, one week or more). *Conclusions:* Animal-related injury has a major impact on the agricultural industry. Results serve as a basis for interventions and further research. *Impact on Industry:* The impact of animal-related injuries on the agricultural industry appears significant; among age groups <20 and 20+, 85% and 82%, respectively, had some resulting restriction. For all events combined, 29% and 30%, respectively, involved restriction from one week to 3+ months; 12% and 15% involved restriction for one month or more. Among those <20 and 20+ years of age, 58% and 46%, respectively, lost work time on their own agricultural operation as a result of injuries associated with their own operation; 22% and 15% lost one week or more. Moreover, of the non-agriculture-related injuries, 31% and 50% resulted in lost work time on their own operation; 15% and 28%, respectively, lost one week or more. Restrictions such as these can affect the productivity of the operation, resulting in financial impacts, especially on small operations that have few people to manage the required tasks.

Keywords: Injury; Animal-related injury; Agricultural operation; Agricultural injuries; Epidemiology of injuries

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1. Introduction

Agriculture is among the most hazardous industries in the United States, with rates of fatal occupational injuries approximately nine times greater (31.6 per 100,000 workers) than for all industries combined (3.5 per 100,000 workers; National Safety Council [NSC], 2006). Although the agricultural environment poses a number of dangers to people in all age groups, there are also notable hazards for children that are important sources of childhood mortality and morbidity (Marlenga, Pickett, & Berg, 2001).

Because of the increasing mechanization of agricultural operations over the past half-century, and the high fatality rate associated with injuries due to machinery and tractors, much of the literature has focused on injuries due to these sources. However, animal-related injuries are also an important source of operation-related injuries (Layde et al., 1996) and have frequently been reported as a major source of nonfatal agricultural injury (Boyle et al., 1997; Gerberich et al., 2001, 2003, 2004; Cogbill, Busch, & Stiers, 1985). Several studies have identified animals as a leading source of injury to children on agricultural operations (Gerberich et al., 2001, 2003; Cogbill et al., 1985; Pickett et al., 2001). Jones and Field (2002) found that 33% of all fatalities to Amish adults and children were directly or indirectly related to animals. A major barrier to progress in the prevention of agricultural injuries has been a lack of knowledge about the magnitude of the problem and of specific risk factors associated with these injuries (Gerberich et al., 2001). Despite the large number of documented animal/livestock injuries, little is known about the consequences of this problem or factors that increase or decrease the risk of injury (Boyle et al., 1997).

The objectives of this study were to determine the rates of occurrence, as well as the consequences of and the potential risk factors for animal-related injuries among a population of agricultural operation households in a five-state region of the Midwestern United States.

2. Methods

2.1. Study Design and Population

This study utilized data from the Regional Rural Injury Study-II (RRIS-II), phase 1 and phase 2 efforts (Gerberich et al., 2003, 2004). Phase 1 involved data collection for 1999 and was designed to identify the incidence and consequences of all types of injuries, and potential risk factors for agricultural injuries among all age groups in the five-state region of Minnesota (MN), Wisconsin (WI), North Dakota (ND), South Dakota (SD), and Nebraska (NE) (Gerberich et al., 2003); a nested case-control study focused on specific risk factors for agricultural injuries among children (not addressed in this paper). Phase 2 involved comparable data collection for 2001 and was designed as a model for surveillance of agricultural injuries, enabling the monitoring for changes in incidence, consequences, and risk factors compared to phase 1 (Gerberich et al., 2004). The current study involves analyses of one of many problems identified in this population that have been addressed through this major database since completion of the total surveillance effort in 2004. Approval to conduct the study was obtained from the Institutional Review Board, Human Subjects Committee, of the University of Minnesota. Interview instruments and all materials sent to the agricultural operations are available for review on a website (RIPRC, 2004).

For each study phase (1999 and 2001), the U.S. Department of Agriculture (USDA) National Agricultural Statistics Service (NASS) provided a roster of farming and ranching operations from the Master ListFrame of Farming Operations. Random samples of 3,200 agricultural operations were selected from each state (MN, WI, ND, SD, and NE), providing a total of 16,000 selected operations for each phase.

Study investigators developed the data collection instruments and trained USDA NASS interviewers to conduct the study interviews. Initial screening interviews were conducted to determine eligibility of the 16,000 operations and request participation of those that were eligible in each year of study. To be eligible for participation, the agricultural operations had to have: (a) a household associated with the operation that included children younger than 20 years of age (<20), as of January 1st (1999 or 2001); (b) been actively farming/ranching as of January 1st (1999 or 2001) or actively involved in a Conservation Reserve Program (CRP); and (c) produced or had sales of at least $1,000 of agricultural goods in the prior year or were actively involved in a Conservation Reserve Program (CRP). Participation in the study also involved willingness to complete two subsequent telephone interviews for six-month intervals in each of the study phases. Non-respondents for whom eligibility status was not established were sent a cover letter, one-page survey, and postage-paid, return envelope to ascertain the eligibility of the households. All 16,000 sampled operations were eligible to be entered into a drawing, in each study phase, which provided at least a 1 in 32 opportunity of receiving a $100 United States saving bond; justification for use of this type of incentive was based on past research efforts (Woodward, Douglas, & Miles, 1985; Elkington, 1990; Boyle, 1995).

Prior to the full interviews, participating households received a comprehensive packet containing a letter describing each upcoming interview, along with informational cards to be used to facilitate data collection. The two study interviews were conducted by USDA NASS interviewers, utilizing specially designed Computer-Assisted Telephone Interview (CATI) instruments to collect information on demographics, some exposures, and injury occurrences for each member of the household. The female head of household was the preferred respondent for this information; the male head of household served as the respondent, as appropriate.

An injury was defined as any event resulting in one or more of the following: restriction from normal activities for four or more hours; loss of consciousness, loss of awareness, or amnesia for any length of time; use of professional health care. An event was classified as an animal-related injury if the participant identified an animal as a source of injury, associated with either agricultural or non-agricultural activities. Agriculture-related injuries were those that occurred as a result of any activity associated with an agricultural operation, as well as standing or

playing in areas where agricultural work occurred, or that resulted from direct contact with agricultural property (animals, equipment, etc.).

Responses in phase 2 were very similar to those in phase 1. In phases 1 and 2, respectively, 8,288 (51.8%) and 8,652 (54.1%) of the 16,000 farms/ranches sampled were identified as not eligible, based on the study participation screening criteria. A total of 4,402 (27.5%) of the farms/ranches were found to be eligible in phase 1 and, of those, 3,765 (85.5%) participated in the full study, while in phase 2, 4,408 (27.5%) operations were found to be eligible and 3,655 (82.9%) participated in the full study. Overall, the known refusal rate decreased from 24.5% in phase 1 to 19.3% in phase 2. Because of the comparability of response rates, as well as numerous population characteristics (Gerberich et al., 2004), the two phases of data collection were combined for this analysis.

2.2. Analyses

Descriptive analyses, using standard statistical software (SAS, 1999; SPSS, 1999), addressed occurrences of animal related injuries: (a) associated with their own operation, or (b) associated with another operation, and (c) injuries related to all other types of activities, according to age group (<20 years; 20+ years). Rates of injury events per 1,000 persons at risk, per year, were generated from both reporting periods, and were adjusted for within-household correlation using generalized estimating equations (Liang & Zeger, 1986), excluding levels for missing values and non-response. Confidence intervals for event rate estimates were generated using Poisson regression (*proc genmod,* SAS, 1999). Potential selection bias was controlled by inversely weighting observed responses with probabilities of response (Horvitz & Thompson, 1952), estimated as a function of characteristics available from the NASS Master ListFrame, including: state in which the operation was located; type of operation; and operation revenue, by quintile. To account for unknown eligibility among non-respondents, the probability of eligibility was estimated for these same characteristics (Mongin, 2001).

The following variables were examined for specific injury occurrences and associated consequences: type of animal involved; associated activity; location; severity of injury (hospitalization, additional health care, duration of normal activity restriction, lost time from farming/ranching work, lost time from other work activities, persistent problems, current restriction and degree of restriction).

Multivariate analyses of agriculture-related animal injuries associated with their own operation, considering relevant exposures, used logistic regression to assess potential risk factors. 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). Causal models (Figs. 1 and 2),

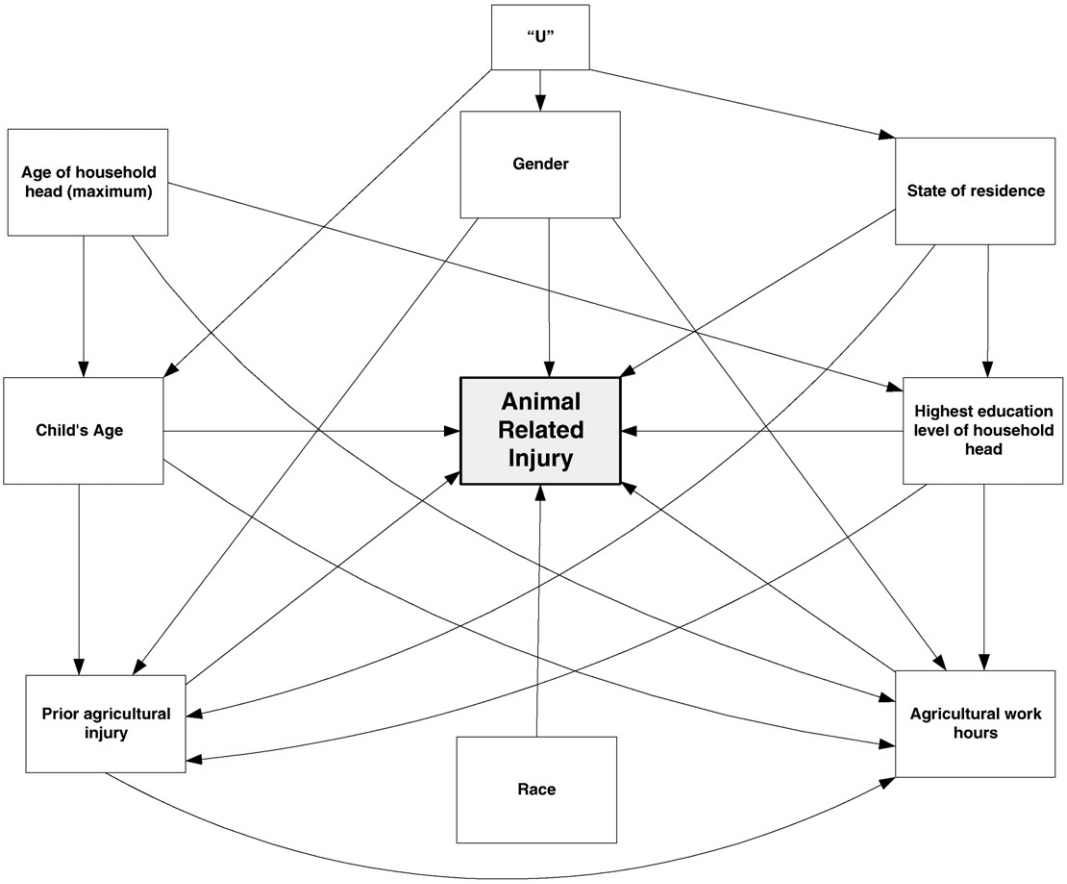

Fig. 1. Multivariate Model: Animal-Related Injuries to Children - Regional Rural Injury Study-II.

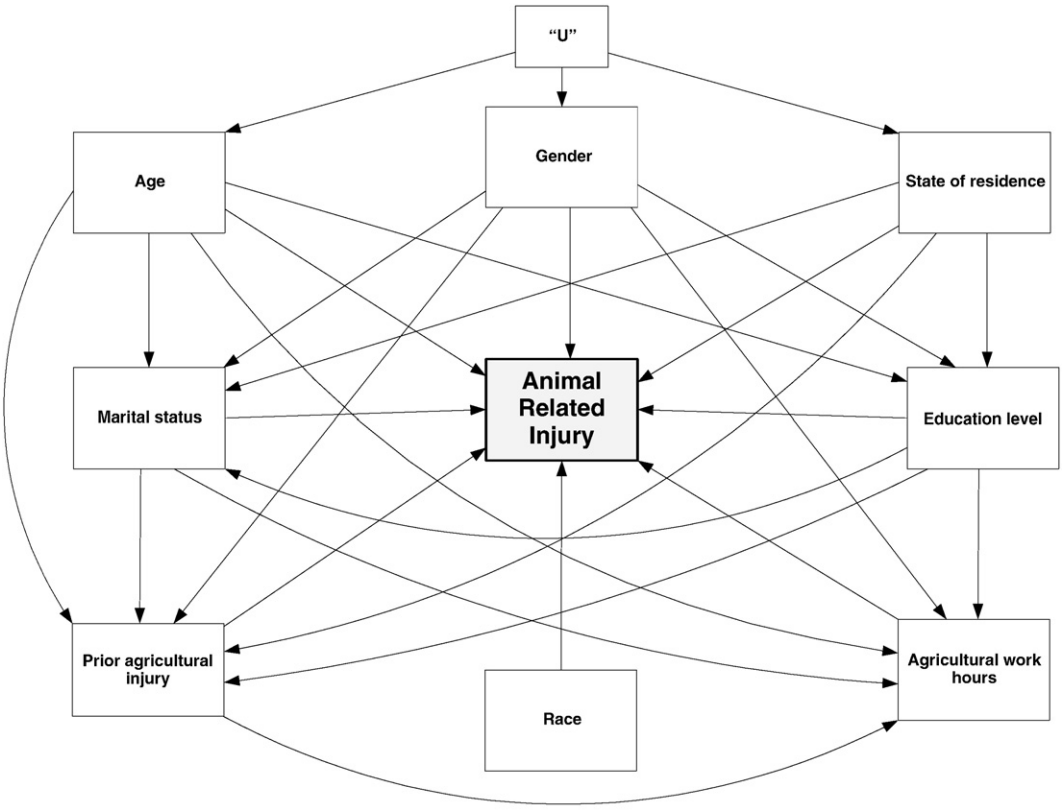

Fig. 2. Multivariate Model: Animal-Related Injuries to Adults - Regional Rural Injury Study-II.

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 (Greenland, Pearl, & Robins, 1999). Separate models were used for analyses of children's and adults' injuries. This enabled identification of parsimonious models and excluded covariates that should not be entered into the regression because they could introduce bias.

3. Results

From 7,420 households (84% response of eligible), a total of 5,045 injury events, from all sources, were reported among this population. Of these, 1,016 events (39.3%) were identified as animal-related injuries, accounting for an overall injury rate of 31.8 events per 1,000 persons at risk per year (Table 1). Animal-related injury rates for events associated with their own operation, another operation, and other non-agriculture-related activities were 25.9, 1.9, and 4.0 per 1,000 persons per year, respectively. Among all variables analyzed, the relative differences by category were similar (Table 1). Analyzed by state, the highest and lowest total rates per 1,000 persons were found for South Dakota (39.6) and Minnesota (22.8), respectively. By gender, males had a higher overall injury rate than females (38.4 and 24.7, respectively). Males less than 20, compared with those 20+ years of age, had lower overall injury rates (17.3 and 60.3, respectively). This pattern was similar for females (18.1 and 31.5, respectively). In general, rates increased with increasing age, to the 35–44 year age group (50.5), then decreased with subsequent age groups. The respective overall injury rates for non-Caucasians and Caucasians were 41.5 and 31.7, respectively, with overlapping 95% confidence intervals. Those who had not completed their education (age <20; rate 17.7/1000 persons per year) had a lower rate than those with all other levels of educational status. By marital status, the lowest rates were observed among those of pre-marital age (<16; 16.0) or never married (23.9), while the highest rates (with overlapping 95% confidence intervals) were shown for those who were married/living as married (47.4), or separated/divorced/widowed (58.7). Overall injury rates, based on injuries associated with their own operation, varied by the number of hours worked on their operation per week and increased in a dose-response pattern with increasing hours of work, ranging from 1.2 for zero hours to 94.5 for more than 80 hours. This effect was not seen for other categories of injuries. Prior, versus no prior agricultural injury history, was associated with an overall rate that was 4.2 times higher and one that was five times greater for injuries associated with their own operation (Table 1).

3.1. Severity Associated with Animal-Related Injury Events

As identified in the Methods section, several variables were used as proxy measures of severity and to identify the consequences of the animal-related injuries. Relevant results are identified in Table 2 with key findings identified below.

Approximately 80% of all agricultural injuries required some type of health care; for non-agricultural injuries, 92% required

Table 1
Animal-Related Injury Event Rates Per 1,000 Persons Per Year Among Agricultural Household Members: Regional Rural Injury Study II

Exposure	Number Exposed	Agricultural: Own Operation Number (Rate); (95% C.I)	Agricultural: Other Operation Number (Rate); (95% C.I)	Not Agricultural Operation-Related Number (Rate); (95% C.I)	Total Number (Rate); (95% C.I)
Total population	32602	827 (25.9) (23.8, 28.1)	63 (1.9) (1.5, 2.5)	127 (4.0) (3.3, 4.9)	1016 (31.8) (29.5,34.2)
State of residence					
MN	6539	118 (18.1) (14.7, 22.3)	9 (1.3) (0.6, 2.7)	20 (3.4) (2.0, 5.7)	147 (22.8) (19.0, 27.5)
NE	6751	167 (24.7) (20.9, 29.3)	23 (3.3) (2.1, 5.2)	34 (4.8) (3.3, 7.1)	224 (32.8) (28.2, 38.3)
ND	6258	157 (25.8) (21.1, 31.6)	9 (1.5) (0.7, 3.1)	31 (5.0) (3.5, 7.3)	197 (32.3) (27.2, 38.5)
SD	7366	242 (33.7) (29.0, 39.2)	17 (2.4) (1.4, 4.0)	27 (3.7) (2.5, 5.5)	285 (39.6) (34.4, 45.6)
WI	5687	143 (26.5) (21.8, 32.4)	5 (0.9) (0.4, 2.2)	15 (2.8) (1.5, 5.3)	163 (30.3) (25.0, 36.7)
Males					
Total	16835	525 (31.7) (28.7, 34.9)	43 (2.5) (1.8, 3.4)	72 (4.3) (3.3, 5.5)	639 (38.4) (35.1, 42.0)
Age 0–19	8615	88 (10.6) (8.5, 13.2)	9 (1.0) (0.5, 2.0)	49 (5.6) (4.1, 7.7)	146 (17.3) (14.4, 20.8)
Ages 20+	8197	437 (53.5) (48.2, 59.5)	34 (4.1) (2.9, 5.8)	23 (2.8) (1.9, 4.2)	493 (60.3) (54.6, 66.6)
Females					
Total	15762	302 (19.7) (17.3, 22.3)	20 (1.3) (0.8, 2.2)	55 (3.7) (2.8, 4.9)	377 (24.7) (22.0, 27.7)
Age 0–19	7927	84 (11.1) (8.8, 14.1)	9 (1.2) (0.6, 2.3)	42 (5.7) (4.1, 8.0)	135 (18.1) (15.0, 21.7)
Ages 20+	7810	218 (28.3) (24.5, 32.8)	11 (1.4) (0.7, 2.9)	13 (1.7) (1.0, 2.9)	242 (31.5) (27.4, 36.1)
Age Group (years)					
0–4	2301	4 (2.2) (0.8, 6.0)	0 (0.0)	13 (5.5) (3.0, 9.8)	17 (7.7) (4.7, 12.8)
5–9	3634	23 (6.3) (4.2, 9.4)	2 (0.6) (0.1, 2.4)	20 (6.1) (3.8, 10.0)	45 (13.1) (9.6, 17.8)
10–14	5056	81 (16.9) (13.3, 21.3)	5 (1.0) (0.4, 2.5)	24 (4.8) (3.1, 7.5)	110 (22.8) (18.6, 27.9)
15–19	5551	64 (12.0) (9.2, 15.6)	11 (2.0) (1.1, 3.5)	34 (6.3) (4.3, 9.2)	109 (20.3) (16.2, 25.3)
20–24	1232	20 (17.1) (10.5, 27.9)	4 (3.7) (1.4, 9.7)	4 (3.5) (1.3, 9.2)	28 (24.0) (16.0, 35.8)
25–34	2153	90 (41.9) (33.5, 52.3)	5 (2.4) (1.0, 5.9)	5 (2.4) (1.0, 5.8)	100 (46.2) (37.5, 57.0)
35–44	7160	317 (44.5) (39.4, 50.4)	25 (3.4) (2.2, 5.3)	17 (2.4) (1.5, 3.9)	358 (50.5) (45.0, 56.7)
45–54	4629	201 (43.0) (36.5, 50.8)	10 (2.0) (1.1, 3.8)	9 (2.0) (1.0, 3.8)	220 (6.9) (40.0, 55.0)
55+	833	27 (32.5) (21.7, 48.8)	1 (1.2) (0.2, 8.0)	1 (0.9) (0.1, 6.2)	29 (34.8) (23.4, 51.9)
Race					
Caucasian	32185	813 (25.8) (23.7, 28.0)	63 (2.0) (1.5, 2.6)	126 (4.0) (3.3, 4.9)	1001 (31.7) (29.4, 34.2)
Non-Caucasian	360	14 (38.4) (22.4, 66.0)	0 (0.0)	1 (3.3) (0.5, 22.5)	15 (41.5) (24.6, 69.8)
Educational Status					
Incomplete (Age<20)	16542	172 (10.9) (9.2, 12.8)	18 (1.1) (0.7, 1.8)	91 (5.7) (4.5, 7.2)	281 (17.7) (15.4, 20.3)
Less than high school graduate	494	20 (41.9) (25.3, 69.4)	2 (4.6) (1.2, 17.6)	1 (2.3) (0.3, 15.7)	23 (49.2) (31.3, 77.4)
High school graduate or equivalency	5962	278 (47.3) (41.5, 54.0)	17 (2.7) (1.6, 4.5)	13 (2.2) (1.3, 3.8)	308 (52.4) (46.3, 59.3)
Technical school or some college	5832	227 (38.9) (33.6, 45.1)	19 (3.2) (1.9, 5.3)	14 (2.4) (1.4, 4.0)	259 (44.3) (38.6, 50.8)
College graduate/post graduate	3692	130 (35.0) (28.8, 42.7)	7 (2.0) (0.9, 4.1)	8 (2.2) (1.1, 4.5)	145 (39.2) (32.5, 47.2)
Marital status					
Pre-marital age (<16)	12187	116 (10.1) (8.2, 12.3)	9 (0.7) (0.4, 1.4)	61 (5.2) (3.9, 6.9)	186 (16.0) (13.6, 18.8)
Married/living as married	14351	608 (42.4) (38.7, 46.5)	41 (2.8) (2.0, 3.9)	31 (2.2) (1.5, 3.1)	679 (47.4) (43.5, 51.7)
Never married	5632	84 (15.3) (12.0, 19.3)	13 (2.4) (1.4, 4.1)	34 (6.2) (4.2, 9.2)	131 (23.9) (19.5, 29.3)
Separated/divorced/widowed	348	19 (56.7) (30.4, 105.8)	0 (0.0)	1 (2.3) (0.3, 16.6)	20 (58.7) (32.0, 107.7)
Hours worked on one's own operation/week					
0	5918	6 (1.2) (0.5, 2.8)	0 (0.0)	15 (2.5) (1.5, 4.1)	21 (3.9) (2.5, 5.9)
>0–20	15060	238 (15.6) (13.5, 17.9)	24 (1.6) (1.0, 2.4)	73 (5.1) (3.9, 6.6)	334 (22.1) (19.6, 25.0)
>20–40	4479	179 (40.0) (34.0, 47.1)	19 (4.2) (2.6, 6.8)	23 (4.9) (3.2, 7.5)	221 (49.1) (42.2, 57.0)
>40–60	2693	135 (50.6) (42.2, 60.8)	10 (3.5) (1.9, 6.5)	6 (2.1) (1.0, 4.8)	151 (55.9) (47.0, 66.6)
>60–80	2322	175 (73.9) (62.6, 87.2)	6 (2.6) (1.2, 5.8)	5 (2.1) (0.9, 5.0)	186 (78.5) (66.9, 92.1)
>80	861	79 (94.5) (72.7, 122.7)	2 (2.4) (0.3, 16.8)	3 (3.7) (1.2, 11.3)	84 (100.9) (78.4, 130.0)
Prior Injury					
No	26025	358 (14.3) (12.7, 16.0)	26 (1.0) (0.7, 1.5)	97 (3.9) (3.1, 4.8)	481 (19.2) (17.4, 21.2)
Yes	6560	469 (70.9) (63.7, 78.9)	37 (5.6) (3.9, 8.0)	30 (4.5) (2.9, 6.9)	535 (80.7) (72.9, 89.4)

Table 2
Severity Measures Associated with Animal-Related Injury Events: Regional Rural Injury Study-II

Severity Measure	Agricultural: Own Operation				Agricultural: Other Operation				Not Agricultural Operation-Related				Total			
	<20 (N=172)		20+ (N=655)		<20 (N=18)		20+ (N=45)		<20 (N=91)		20+ (N=36)		<20 (N=281)		20+ (N=736)	
Where treatment was first sought																
None	36	20.9	131	20.0	5	27.8	8	17.8	7	7.7	3	8.3	48	17.1	142	19.3
Hospital ER	50	29.1	112	17.1	5	27.8	15	33.3	46	50.5	16	44.4	101	35.9	143	19.4
Doctor's office	59	34.3	218	33.3	4	22.2	13	28.9	34	37.4	9	25.0	97	34.5	240	32.6
Chiropractor's office	16	9.3	175	26.7	4	22.2	5	11.1	2	2.2	4	11.1	22	7.8	184	25.0
Hospital in-patient	5	2.9	28	4.3	0	0.0	4	8.9	9	9.9	2	5.5	14	5.0	34	4.6
Other health care facility	6	3.5	19	2.9	0	0.0	2	4.4	2	2.2	1	2.8	8	2.8	22	3.0
At scene of accident	6	3.5	17	2.6	1	5.6	1	2.2	9	9.9	1	2.8	16	5.7	19	2.6
Dentist's office	1	0.6	11	1.7	0	0.0	0	0.0	0	0.0	1	2.8	1	0.4	12	1.6
Missing/unknown/refused	0	0.0	2	0.3	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	2	0.3
Hospitalized																
Yes	5	2.9	28	4.3	0	0.0	4	8.9	9	9.9	2	5.5	14	5.0	34	4.6
Time activities restricted																
No restriction	23	13.4	119	18.2	2	11.1	8	17.8	16	17.6	3	8.3	41	14.6	130	17.7
>0–<4 hours	11	6.4	56	8.6	1	5.6	6	13.3	10	11.0	1	2.8	22	7.8	63	8.6
4 hours–<1 day	29	16.9	94	14.4	4	22.2	5	11.1	10	11.0	4	11.1	43	15.3	103	14.0
1 day–<7 days	61	35.5	196	29.9	4	22.2	9	20.0	28	30.8	10	27.8	93	33.1	215	29.2
7 days–<14 days	18	10.5	50	7.6	3	16.7	2	4.4	8	8.8	2	5.6	29	10.3	54	7.3
14 days–<1 month	10	5.8	51	7.8	2	11.1	6	13.3	6	6.6	4	11.1	18	6.4	61	8.3
1 month–<3 months	14	8.1	63	9.6	1	5.6	9	20.0	7	7.7	9	25.0	22	7.8	81	11.0
3 months+	6	3.5	24	3.7	1	5.6	0	0.0	6	6.6	3	8.3	13	4.6	27	3.7
Unknown	0	0.0	2	0.3	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	2	0.3
Work time lost on their agricultural operation																
No restriction	72	41.9	349	53.3	12	66.7	25	55.6	63	69.2	18	50.0	147	52.3	392	53.3
>0–<4 hours	4	2.3	35	5.3	0	0.0	2	4.4	1	1.1	0	0.0	5	1.8	37	5.0
4 hours–<1 day	15	8.7	52	7.9	0	0.0	1	2.2	1	1.1	3	8.3	16	5.7	56	7.6
1 day–<7 days	44	25.6	113	17.3	2	11.1	8	17.8	12	13.2	5	13.9	58	20.6	126	17.1
7 days–<14 days	16	9.3	25	3.8	2	11.1	2	4.4	6	6.6	1	2.8	24	8.5	28	3.8
14 days–<1 month	6	3.5	26	4.0	1	5.6	1	2.2	2	2.2	4	11.1	9	3.2	31	4.2
1 month–<3 months	11	6.4	35	5.3	1	5.6	6	13.3	5	5.5	4	11.1	17	6.1	45	6.1
3 months+	4	2.3	13	2.0	0	0.0	0	0.0	1	1.1	1	2.8	5	1.8	14	1.9
Unknown	0	0.0	7	1.1	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	7	0.9
Other work time lost																
No restriction	162	94.2	591	90.2	13	72.2	34	75.6	80	87.9	25	69.4	255	90.8	650	88.3
>0–<4 hours	1	0.6	3	0.5	0	0.0	2	4.4	1	1.1	0	0.0	2	0.7	5	0.7
4 hours–<1 day	1	0.6	7	1.1	0	0.0	2	4.4	1	1.1	2	5.6	2	0.7	11	1.5
1 day–<7 days	5	2.9	31	4.7	1	5.6	2	4.4	4	4.4	2	5.6	10	3.6	35	4.8
7 days–<14 days	1	0.6	6	0.9	2	11.1	1	2.2	2	2.2	2	5.6	5	1.8	9	1.2
14 days–<1 month	2	1.2	6	0.9	1	5.6	1	2.2	0	0.0	1	2.8	3	1.1	8	1.1
1 month–<3 months	0	0.0	5	0.8	1	5.6	3	6.7	1	1.1	4	11.1	2	0.7	12	1.6
3 months+	0	0.0	5	0.8	0	0.0	0	0.0	1	1.1	0	0.0	1	0.4	5	0.7
Missing/Unknown/Refused	0	0.0	1	0.1	0	0.0	0	0.0	1	1.1	0	0.0	1	0.4	1	0.1
Persistent problems																
No	159	92.4	509	77.7	16	88.9	33	73.3	82	90.1	23	63.9	257	91.5	565	76.8
Yes	13	7.6	144	22.0	2	11.1	12	26.7	9	9.9	13	36.1	24	8.5	169	23.0
Unknown	0	0.0	2	0.3	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	2	0.3
Degree of current restriction																
None	168	97.7	613	93.6	17	94.4	39	86.7	89	97.8	28	77.8	274	97.5	680	92.4
A small amount	0	0.0	18	2.8	0	0.0	4	8.9	1	1.1	2	5.6	1	0.4	24	3.3
A moderate amount	2	1.2	16	2.4	0	0.0	1	2.2	1	1.1	4	11.1	3	1.1	21	2.9
A large amount	2	1.2	7	1.1	1	5.6	1	2.2	0	0.0	2	5.6	3	1.1	10	1.4
Missing/Unknown/Refused	0	0.0	1	0.2	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	1	0.1

care. For those <20 years and 20+ years of age, respective health care provision differences were: hospital emergency departments (36%; 19%); doctors' offices (35%; 33%); and chiropractors' offices (8%; 25%). Differences, according to the category of injury (i.e., own operation-related, another operation-related, and non-agriculture-related) are further delineated in Table 2.

For all injury events combined, only 5% of either age group was hospitalized. For events that were associated with their own operation, 3% and 4%, respectively, were hospitalized; in contrast, for non-agriculture-related events, 10% and 6% of the respective age groups were hospitalized.

The length of restriction from regular activities as a consequence of animal-related injury events is also identified in Table 2 for age groups <20 and 20+; 85% and 82%, respectively, had some restriction. For all events combined, 29% and 30%, respectively, involved restriction from one week to 3+ months; 12% and 15% involved restriction for one month or more. Of the own operation-related events, 28% and 29%, respectively, of the two age groups were restricted for one week or more; 12% and 13% involved one month or more of restriction. For those events associated with non-agricultural activities, 30% and 50%, respectively, involved restriction of one week or more, while 14% and 33% involved one month or more.

Among those <20 and 20+ years of age, 58% and 46%, respectively, lost work time on their own agricultural operation, as a result of injuries associated with their own operation; 22% and 15% lost one week or more. Moreover, of the non-agriculture-related injuries, 31% and 50% resulted in lost work time on their own operation; 15% and 28%, respectively, lost one week or more (Table 2).

Lost work time from other types of work associated with the total injury events was 9% and 12%, respectively, among those <20 and 20+ years of age. Differences among the categories for the two age groups are noted in Table 2: own operation-related (6% and 10%); another operation-related (28% and 24%); and non-agriculture-related (12% and 31%).

At the time of interview, those who had incurred an injury were asked if there were persistent problems associated with their animal-related injuries (Table 2). Among the total events, 9% and 23% of those <20 and 20+ years of age responded affirmatively. Some differences were also noted among the injury categories by age: own operation (8% and 22%); another operation (11% and 27%); and non-agriculture-related (10% and 36%).

Current activity restriction (at the time of the interview), ranging from a small amount to a large amount, was reported by those <20 and 20+ years of age for all events combined (2% and 8%). This also varied among the categories: own operation-related (2% and 6%); another operation-related (6% and 13%); and non-agriculture-related (2% and 22%).

3.2. Types of Animals and Activities Associated With Injury Events

As shown in Table 3, the types of animals associated with the injury events varied by category of injury and age group. The greatest proportions of total injuries, identified for those <20 and

Table 3
Types of Animals and Activities Associated With Injury Events: Regional Rural Injury Study-II

	Agricultural: Own Operation				Agricultural: Other Operation				Not Agricultural Operation-Related				Total			
	<20 (N=172)		20+ (N=655)		<20 (N=18)		20+ (N=45)		<20 (N=91)		20+ (N=36)		<20 (N=281)		20+ (N=736)	
Type of animal associated with animal-related injuries																
Dairy cow/heifer/calf	32	18.6	148	22.6	5	27.8	1	2.2	0	0.0	0	0.0	37	13.2	149	20.2
Beef	55	32.0	280	42.7	4	22.2	23	51.1	9	9.9	7	19.4	68	24.2	310	42.1
Sow/piglets/boar	8	4.6	38	5.8	0	0.0	6	13.3	0	0.0	3	8.3	8	2.9	47	6.4
Sheep	7	4.1	18	2.8	0	0.0	0	0.0	0	0.0	0	0.0	7	2.5	18	2.5
Horse	54	31.4	115	17.6	7	38.9	14	31.1	29	31.9	4	11.1	90	32.0	133	18.1
Other animals [a]	12	7.0	45	6.9	2	11.1	1	2.2	53	58.2	20	55.6	67	23.8	66	9.0
Unknown	4	2.3	11	1.7	0	0.0	0	0.0	0	0.0	2	5.6	4	1.4	13	1.8
Activities associated with injury events																
Feeding	28	16.3	70	10.7	1	5.6	1	2.2	1	1.1	3	8.3	30	10.7	74	10.1
Milking	8	4.7	59	9.0	2	11.1	0	0.0	0	0.0	0	0.0	10	3.6	59	8.0
Herding/Moving	34	19.8	167	25.5	4	22.2	16	35.6	0	0.0	7	19.4	38	13.5	190	25.8
Branding/Tagging/Tattooing	7	4.1	12	1.8	1	5.6	2	4.4	0	0.0	0	0.0	8	2.9	14	1.9
Treatment	3	1.7	43	6.6	1	5.6	3	6.7	0	0.0	1	2.8	4	1.4	47	6.4
Helping w/birthing	0	0.0	23	3.5	0	0.0	1	2.2	0	0.0	0	0.0	0	0.0	24	3.3
Riding animals	34	19.8	65	9.9	5	27.8	4	8.9	20	22.0	3	8.3	59	21.0	72	9.8
Chasing animals	6	3.5	22	3.4	0	0.0	2	4.4	1	1.1	1	2.8	7	2.5	25	3.4
Working with animals NEC	27	15.7	75	11.5	1	5.6	7	15.6	7	7.7	4	11.1	35	12.5	86	11.7
Rodeo/Rodeo activities	0	0.0	0	0.0	0	0.0	0	0.0	13	14.3	2	5.6	13	4.6	2	0.3
Checking on/looking for animals	1	0.6	7	1.1	0	0.0	0	0.0	1	1.1	0	0.0	2	0.7	7	0.9
Other specify [b]	21	12.2	89	13.6	3	16.7	6	13.3	44	48.4	14	38.9	68	24.2	109	14.8
Unknown	3	1.7	23	3.5	0	0.0	3	6.7	4	4.4	1	2.8	7	2.5	27	3.7

[a] poultry, cow (unspecified), cattle (unspecified), Bull (unspecified), calf (unspecified) dog, cat, insect, deer.

[b] bystander, mounting/dismounting, standing, handling/transferring feed/grain, play, bicycling, opening/closing door/gate, hunting, yard work /gardening, driver of tractor/vehicle, play (general), horseplay/horsing around, A3 –wheeling/ A4 –wheeling.

Table 4A
Multivariate Analyses - Personal Risk of Animal-Related Injury Among Child and Adult Agricultural Household Members: Regional Rural Injury Study–II

CHILD

Variable	Number at Risk	Events	Odds Ratio For Personal Risk	95% CI
State of residence[*]				
MN	3179	13	1.0	- -
NE	3414	34	2.6	(1.3, 5.0)
ND	3036	43	3.8	(2.0, 7.2)
SD	3691	43	3.1	(1.6, 5.8)
WI	2774	31	2.8	(1.5, 5.4)
Age group (years)[‡]				
0–4	2261	4	1.0	- -
5–9	3554	23	3.4	(1.0, 10.9)
10–14	4895	78	9.6	(3.0, 31.4)
15–19	5384	59	6.9	(2.0, 23.7)
Gender[§]				
Male	8394	85	1.0	(0.7, 1.3)
Female	7700	79	1.0	- -
Race				
Caucasian	15859	159	1.0	- -
Non-Caucasian	214	5	2.3	(0.8, 6.2)
Hours worked on one's own operation/week[¶]				
0	4445	3	1.0	- -
>0–20	9559	105	12.4	(4.0, 38.1)
>20–40	1603	44	34.7	(10.7, 112.7)
>40–60	232	7	48.3	(11.9, 196.0)
>60–80	61	1	24.0	(2.5, 228.4)
Prior Injury[†]				
No	14506	115	1.0	- -
Yes	1574	49	3.6	(2.5, 5.3)
Head of Household Age Group				
25–34	1463	7	0.3	(0.1, 0.9)
35–44	8393	90	0.8	(0.4, 1.5)
45–54	5371	55	0.7	(0.4, 1.4)
55+	845	12	1.0	- -
Educational Status[**]				
Less than high school graduate	130	5	1.3	(0.3, 5.1)
High school graduate or equivalency	3882	33	0.8	(0.5, 1.2)
Technical school or some college	6381	64	1.0	(0.7, 1.4)
College graduate/post-graduate	5689	65	1.0	- -

*Adjusted for child's age and gender.
‡Adjusted for head of household age, gender and state.
§Adjusted for child's age and state.
**Adjusted for head of household age, state.
¶Adjusted for child's age, head of household age, gender, head of household education, prior agricultural injury.
†Adjusted for child's age, state, gender, head of household education.

Table 4B

ADULT

Variable	Number at Risk	Events	Odds Ratio For Personal Risk	95% CI
State of residence[*]				
MN	3072	94	1.0	- -
NE	3257	124	1.2	(0.9, 1.7)
ND	2987	98	1.1	(0.8, 1.5)
SD	3582	176	1.7	(1.3, 2.2)
WI	2663	95	1.2	(0.9, 1.7)

Table 4B (*continued*)

ADULT				
Variable	Number at Risk	Events	Odds Ratio For Personal Risk	95% CI
Age group (years)[f]				
20–24	1204	18	0.3	(0.2, 0.5)
25–34	2091	82	1.0	(0.8, 1.3)
35–44	6952	286	1.0	- -
45–54	4506	175	0.9	(0.7, 1.1)
55–64	658	21	0.7	(0.4, 1.1)
65+	150	5	0.7	(0.3, 1.7)
Gender[§]				
Male	7955	389	1.9	(1.6, 2.2)
Female	7606	198	1.0	- -
Race				
Caucasian	15405	578	1.0	- -
Non-Caucasian	131	9	1.9	(0.9, 3.8)
*Educational Status***				
Less than high school graduate	467	18	1.2	(0.7, 2.0)
High school graduate or equivalency	5786	248	1.2	(1.0, 1.6)
Technical school or some college	5690	250	1.2	(0.9, 1.5)
College graduate/post graduate	3592	116	1.0	- -
Marital status[†]				
Married/living as married	13943	547	1.0	- -
Never married	1263	26	0.7	(0.3, 1.3)
Separated/divorced	244	11	1.0	(0.5, 1.8)
Widowed	80	3	1.5	(0.4, 5.8)
Hours worked on one's own operation/week[¶]				
0	1441	2	0.02	(0.01, 0.09)
>0–20	5452	123	0.3	(0.2, 0.4)
>20–40	2864	116	0.5	(0.3, 0.7)
>40–60	2450	114	0.6	(0.4, 0.8)
>60–80	2254	154	0.8	(0.6, 1.0)
>80	834	68	1.0	- -
Prior Injury[¥]				
No	10685	227	1.0	- -
Yes	4832	360	3.2	(2.6, 3.9)

*Adjusted for age and gender.
*f*Adjusted for gender and state.
§Adjusted for age and state.
**Adjusted for age, gender and state.
†Adjusted for age, gender, state, education.
¶Adjusted for age, gender, marital status, education, prior injury.
¥Adjusted for age, gender, marital status, education.

20+ years of age, were associated with dairy (13%; 20%), beef (24%; 42%), and horses (32%; 18%). The beef- and dairy-related events were largely associated with their own operation and, within this category, proportions by age group were: dairy (19%; 23%); and beef (32%; 43%). For injuries associated with horses, those associated with their own operation (31%; 18%), another operation (39%; 31%), and non-agriculture-related (32%; 11%) were identified. The "other" animal category included various types with respective numbers too small to delineate.

Associated activities, identified at the time of the injury events, are also presented in Table 3. Primary activities for the total injuries, by age group, were: feeding (11%; 10%); herding/moving animals (14%; 26%); riding animals (21%; 10%); working with animals - not elsewhere classifiable (NEC) (13%; 12%); and "others" (24%, 15%), each of which involved small numbers. While feeding, herding, and working with animals NEC resulted in injuries primarily associated with their own operation, riding animals involved important proportions of injury events associated with both their own operation (20%; 10%) and non-agricultural activities (22%; 8%). "Other" activities were primarily associated with their own operation (12%; 14%) and events that were non-agriculture-related (48%; 39%).

Among the dairy cow/heifer-related injuries (not shown), which accounted for 81% of all dairy-related injury events, the primary associated activities were milking (43%), herding/moving (21%), working with animals NEC (9%), and feeding

(4%). Among the beef cow/steer/heifer-related injury events, accounting for 52% of all beef-related injuries, primary associated activities were herding/moving (36%), working with animals NEC (18%), and feeding (8%). For horse-related events, herding/moving (11%), working with animals NEC (10%), and rodeo activities (5%) were primarily involved.

3.3. Multivariate Analyses

Multivariate analyses were conducted separately for children (<20 years of age) and adults (20+ years of age); models included confounders identified with the respective DAGS that were derived from the original causal models (Greenland et al., 1999; Table 4; Figs. 1 and 2). According to state of residence, children were at increased risk of animal-related injury in all states, compared with Minnesota; for adults, risk was less pronounced, with the exception of South Dakota. Compared with those aged 0–4 years, children of all other age groups were at increased risk with the age group 10–14 years being at greatest risk. For adults, compared with those 35–45 years, all other age groups were at reduced risk. By gender, no difference in risk was identified among children, while adult males, compared with females, were at increased risk.

Analyses were also conducted, pertinent to hours worked. Compared with the reference of 0 hours worked per week on one's own operation, risk increased greatly with increasing ranges of hours worked by children; however, beyond 40 hours per week, the estimates became less stable due to smaller numbers. For adults, with a reference of 80 or more hours worked per week on one's own operation, risk was decreased overall; however, it was evident that, with each group of increasing hours, there was increased risk. A history of prior agricultural injury was also found to be important both for children and adults. For children who had a prior history the risk was 3.6 times greater, compared with those who did not. Among adults, this risk was 3.2 times greater.

For adults, neither educational status nor marital status were found to be important factors. Race, included only in the adult model, was also found not to be important.

The multivariate analysis for children (Table 4A) also included two variables associated with the head of household: their age group and educational status. Compared with the age group 55+ years, reduced risk was shown only for the age group including persons 25–35 years of age. Educational status was not found to be an important factor.

4. Discussion

This study provides important information on the magnitude and consequences of, and potential risk factors for, animal-related injuries among agricultural households in a five-state Midwest Region. Almost 40% of the total injuries were attributed to animals, accounting for injury rates of 31.8, and 25.9 events per 1,000 persons per year, for total animal-related injuries and those associated with their own operation, respectively. The high proportion of animal-related injuries among agricultural operation households indicates that animals are a major hazard to this population. Previous research in the same states indicated similar estimates for animal-related injuries (Gerberich et al., 1993, 2001). Although not comparable, due to differences in methodologies, animals also have been identified as important sources of injuries through a variety of other studies, including several case-based studies (Cogbill et al., 1985; Mason & Earle-Richardson, 2002; Rasmussen, Carstensen, & Lauritsen, 2000; Saar, Dimich-Ward, Kelly, & Voaklander, 2006; Hendricks & Adekoya, 2001; Sprince et al., 2003).

Although a majority of the injured persons in the current study received some form of healthcare, a very small percentage required hospitalization; for all injury events combined, only 5% in either age group (<20, 20+) was hospitalized. This has implications for surveillance that focuses only on hospitalized cases. Despite not being hospitalized, the vast majority of the injured persons in this study required some form of healthcare (80%–90%). Both the earlier OATS (Gerberich et al., 1991) and RRIS-I (Gerberich et al., 1993) research efforts reported similar trends in injury severity and healthcare needs, although those findings addressed agricultural injury, in general, versus animal-related. From the British Columbia study, Saar et al. (2006) reported 1,407 hospitalizations between 1991/1992 and 1999/2000; reportedly, the number of hospitalizations started to increase after 1996/1997 ($r=0.72$, $p<0.05$), primarily due to an increase in the number of animal-related injuries ($r=0.63$, $p<0.05$).

By examining measures of activity restriction, the impact that animal-related injuries can have on an agricultural household and operation, and the industry in general, was highlighted. Among the events identified for age groups <20 and 20^{+} years of age, 85% and 82% respectively, had some activity restriction; 29% and 30%, respectively, involved one week to three or more months restriction. Previous studies indicated that 92% of the agriculture-related injury cases involved some degree of restriction; injuries involving one month or more of restriction were primarily associated with animals (54%); however, these findings addressed agricultural injuries among children only (Gerberich et al., 2001). Restrictions such as these can affect the productivity of the operation, resulting in financial impacts, especially on small family operations that have few people to manage the required tasks.

In the current study, animal-related injuries for those <20 and 20+ years of age were most frequently associated with beef (24%, 42%), dairy (13%, 20%), and horses (32%, 18%). Previous studies have identified horses as the leading cause of animal-related agricultural injuries among all ages (Johns, Farrant, & Civil, 2004; Hendricks & Adekoya, 2001).

From research in Central Wisconsin, regarding animal-related injuries incurred on agricultural operations that required Medical or Chiropractic Care during a two-year period, Layde et al. (1996) identified a total of 71 animal-related injury cases among the 3,186 adults (18 years and older); among those, cows were responsible for the majority of the injuries (87%, n=61). From the Canadian surveillance program identified previously, Dimich-Ward et al. (2004) reported that, ın general, animals (37%) were the most common source of non-machinery related injuries involving crushing or being struck by animals; for females and males, respectively, 65% and 38% were caused by horses and 30% and 56% by cows.

The present study found that the principal activities associated with animal-related injuries were herding/moving, feeding, riding animals, and working with animals NEC. A previous study indicated that the principal activities associated with agriculture-related injuries, in general, were animal care (47%), which included herding, cleaning, feeding, and milking, although these findings addressed agricultural injuries only among children (Gerberich et al., 2001). Based on a case-control study, Boyle (1995) and colleagues (Boyle et al., 1997) reported that milking was the greatest risk for injury specific to cattle operations (RR=10.9 for 21–30 hours; RR=20.6 for 31–63 hours). From the U.S. survey, Hendricks and Adekoya (2001) reported that herding or moving cattle was responsible for most of the cattle related injuries.

Through multivariate analyses, potential risk factors were identified in the current study. According to state of residence, children were at increased risk of animal-related injury in all other states, compared with Minnesota; for adults, this risk was less pronounced. Compared with those children aged 0–4 years, all others groups were at increased risk, with the age group 10–14 years at greatest risk, which has implications for targeting prevention efforts**.** For adults, compared with those 35–45 years, all other age groups were at reduced risk. For children, reduced risk was also found where the head of household's age was 25–35 years, compared with 55+ years.

By gender, no difference in risk was identified among children in the current study, while adult males were at increased risk. Similarly, Layde et al. (1996) reported that males had more than twice the rate of animal-related injuries per 1,000 person-years than females (15 vs. 7). Many studies of agricultural injury have found males at higher risk than females (Pickett et al., 2001; Hendricks, Layne, Goldcamp, & Myers, 2001; Rivara, 1997; Langley, 2005); however, it is important to note that, when controlling for work time, the effect between males and females is typically eliminated or greatly diminished (Gerberich et al., 2001, 2003, 2004; Nordstrom et al., 1995). Hendricks and Adekoya (2001) reported that, among youth, 46% (n=2,958) and 25% (n=1,635) of the animal-related injuries occurred to males and females, respectively. From an analysis of animal-related fatalities in the United States from 1991 to 2001, Langley (2005) reported that males had a risk 2.5 times greater than females for non-venomous animal-related fatality.

The present study found that risk increased with increasing hours worked by both children and adults. From an analysis of injuries associated with agricultural animals in Central Wisconsin, from May 1990 to April 1992, Layde et al. (1996) reported that the primary factor for animal-related injuries was the number of hours worked per week (3% increased risk per hour, based on rates per 1,000,000 hours worked). From a study specific to dairy cattle-related injuries, Boyle et al. (1997) reported increased injury rates with increased hours spent milking, with the rate ratio for those milking 31–63, compared with zero hours per week, more than 20 times higher.

High risks associated with prior versus no agricultural injury history were identified both for children (3.6) and adults (3.1) in this research effort. Browning, Truszczynska, Reed, and McKnight (1998) also reported that prior injury was associated with risk of new farm injury (OR=2.4; 95% CI=1.01–5.71), although those findings addressed agricultural injuries, in general, among agricultural workers 55 years and older. Elkington's (1990) case-control study, using a matched analysis, derived from the Olmsted Agricultural Trauma Study (1991), identified an increased risk of all agricultural injury, based on prior history of agricultural injury (O.R.=2.4).

As with any study, there is a potential for bias. The potential for recall bias, from the utilization of CATI 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 six-month recall periods, instead of a 12-month recall period for each of the two phases of data collection (1999 and 2001). This approach was based on the OATS validation data, which resulted in recommendations for using two six-month reporting periods and designating the female head of household as the preferred respondent for injury and demographic information, to enhance quality of reporting (Gerberich et al., 1990). In addition, a study that assessed a three-year recall of self-reported injury found that self-reporting was adequate to enumerate injuries occurring in a six-month period (Braun, Gerberich, & Sidney, 1994). Another method of reducing potential recall bias in this effort was the inclusion of follow-up letters and booklets that were sent to participants prior to each full interview; each household was provided with information about the injury definition, types of injuries that were of interest, and forms on which they could record injury information throughout the study period.

Another potential limitation to the present study is misclassification of the type of injury that occurred. This bias was minimized in RRIS-II by allowing an injury to be coded with more than one source to ensure capture of all relevant sources.

Selection bias due to non-response is also a concern. It is possible that more animal-related events occurred than those included, and it is unknown if they may have been similar in nature to those that were included. However, very high response rates were obtained for those eligible in RRIS-II, in each phase, so the present study had the advantage of utilizing data surrounding the vast majority of animal-related injuries 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 ListFrame (Horvitz & Thompson, 1952). To account for unknown eligibility among non-respondents, probability of eligibility was estimated from these same characteristics (Mongin, 2001).

Despite some potential limitations, this study provided unique comprehensive data on animal-related injuries in a Midwest agricultural population. Findings from this effort indicate that these injuries represent a significant impact on agricultural operations, based on injury rates, consequences of injury, and potential risk factors. Because animal-related injuries are common and often severe, preventive efforts should target this particular source of injury. Most importantly, this effort serves as a basis for animal-related agricultural injury research to identify more specific risk factors that can further serve as a basis for development of relevant intervention efforts.

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