

The Association Between Parents' Past Agricultural Injuries and Their Children's Risk of Injury

Analyses From the Regional Rural Injury Study—II

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Objective: To examine associations between parents' and children's agricultural injuries in a cohort of farming and ranching households.

Design: Analyses from a population-based, nested case-control study.

Setting: The 1999 Regional Rural Injury Study—II, involving a cohort of 3765 agricultural households. Demographic, injury, and exposure data were collected for household members for 1 year.

Participants: A total of 203 injured children (cases) and 755 randomly selected control children were identified for the study.

Main Exposure: Children's risk of injury was estimated in reference to individual and combined parental injury experience. Two periods were evaluated, separately and in combination.

Main Outcome Measures: Odds ratios (ORs) and 95% confidence intervals (CIs) were calculated by using lo-

gistic regression; directed acyclic graphs guided selection of potential confounders.

Results: When controlling for potential confounders, children whose fathers were injured before the study year had twice the risk of injury of those whose fathers were not injured (OR, 2.1; 95% CI, 1.5-3.0). Children had increased risk of injury if their mothers were injured before the study (OR, 2.5; 95% CI, 1.7-3.8) or during the study (OR, 2.0; 95% CI, 0.9-4.2). Children whose parents both reported agricultural injuries before the study had a 4-fold increase in injury risk over those with neither parent injured (OR, 4.2; 95% CI, 2.6-6.9).

Conclusions: Positive associations between parents' and children's injuries were observed, with a potential additive effect if both parents were injured. These results indicate a need for further research into the social and/or physical environments driving these associations so that appropriate interventions for pediatric injury can be determined.

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INJURY, THE LEADING CAUSE OF death among children,¹ results in substantial costs in terms of disability, rehabilitation, and lost productivity.² Children working on farming and ranching operations are at a particularly high risk of fatal and nonfatal

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injury.^{3,4} Injury-related mortality and morbidity rates for the agricultural trade are among the highest of all US industries.^{5,6} For farming and ranching families, the proximity between the household and the operation makes hazardous exposures nearly unavoidable, even for children not actively engaged in operation-related tasks.⁷ In response to this issue, a national initiative for

the reduction of agricultural injury among children was established.⁸

Injuries are not distributed randomly among populations at risk. Positive associations between one's prior injuries and risk of subsequent injury have been observed in studies of sports,^{9,10} occupational,¹¹ and agricultural^{12,13} injuries and for medically attended injuries among adults and children.¹⁴⁻¹⁶ Risk also appears to be associated within families; sibling injury was shown to be associated with at least a short-term increase in children's risk of injury.^{17,18} Individuals' past injuries may increase their vulnerability to future injuries,¹² and the association between sibling injuries could be related to periods of heightened familial stress after initial injuries.^{17,18} Another likely explanation is that certain environments are inherently more

hazardous than others and continue to be so even after an injury occurs.

An area that remains to be examined is the association between parents' and children's injuries. A positive association might be expected, given the theories that increased familial stress or sustained hazardous environments or both lead to multiple injuries within households. However, parents' injuries might lead to implementation of preventive measures for their children. Improved understanding of the effect of parents' injury experiences on children's risk may help practitioners identify high-risk populations and exposures as well as effective interventions. The objective of this study was to determine whether an association exists between parents' agricultural injuries and children's risk of injury among farm and ranch households.

METHODS

STUDY DESIGN

This study was based on data from the 1999 Regional Rural Injury Study-II,¹⁹ a prospective, population-based cohort study of agricultural households in Minnesota, North Dakota, South Dakota, Nebraska, and Wisconsin. We conducted a nested case-control study of agricultural injuries involving children younger than 20 years. The University of Minnesota Institutional Review Board Human Subjects Committee approved the protocol for this study.

STUDY POPULATION

A random sample of 16 000 agricultural operations was generated ($n=3200$ from each state) by using the US Department of Agriculture's National Agricultural Statistics Service Master ListFrame of Farming Operations.²⁰ Eligible operations had to have produced \$1000 or more of agricultural goods during 1998 and/or have land enrolled in a Conservation Reserve Program, and they had to be actively engaged in farming or ranching as of January 1, 1999. In addition, the operator's household had to be associated with the farm or ranch and include children younger than 20 years in residence as of January 1, 1999.

Of the 16 000 sampled operations, 12 677 were screened successfully, of which 8288 (51.8%) were found ineligible. Of the 4402 (27.5%) households identified as eligible, 3765 (85.5%) participated in the first 6-month interview, and 3677 (83.5%) participated in both full interviews. Demographic and injury data were collected for 16 538 household members, including 8488 children. An agricultural injury was defined as any event resulting from activities or objects associated with the family agricultural operation leading to restriction of normal activities for 4 hours or more, loss of consciousness or awareness or amnesia for any length of time, and/or treatment by a health professional.

DATA COLLECTION

Subsequent to introductory mailings, computer-assisted telephone interviews were conducted to obtain informed consent, establish eligibility, and enroll households. As an incentive to participate, all sampled operations were eligible for a drawing that provided at least a 1 in 32 probability of receiving a \$100 US savings bond.

Participating households received packets containing study details and materials to facilitate collection of information dur-

ing each of 2 full-length interviews. The interviews occurred in July 1999 and January 2000, and information was collected about each 6-month recall period of 1999 (January through June and July through December). Nonrespondents for whom eligibility status was not established were sent a 1-page survey to ascertain eligibility of the household. Copies of the materials used, including interview instruments, are available on a Web site.²¹

The female head of household was the primary respondent for demographic and injury data, whereas the male head of household was preferred for operation exposure information. With parents' permission, children 12 years and older were requested to be their own respondents. The proxy for those who refused, and children younger than 12 years, was the female head of household.

IDENTIFICATION OF CASES AND CONTROLS

Cases were all agricultural injury events sustained by children younger than 20 years on their own operation during the reporting periods. The control population came from households randomly sampled to achieve a minimum ratio of 3 controls per case on the basis of injury rates from a previous study.³ An incidence-density sampling scheme was used to sample from the agricultural injury-free person-time experience (months) of children younger than 20 years in residence on the operation. One child with at least 1 agricultural injury-free month was selected randomly from each control household. The exposure experience was collected for the month before the month of injury for cases and the month before an agricultural injury-free month for controls, sampled to reflect expected monthly incidence rates.³ This method allowed cases to be sampled as controls for months in which they did not sustain an agricultural injury. The final population included 203 (91.0%) of 223 eligible case events and 755 (97.0%) of 778 sampled eligible controls.

PARENTAL INJURY

Agricultural injury data also were collected for respondents identified as the children's mothers and fathers. Parents were asked whether they had incurred an agricultural injury before or during the study year. Use of the 6-month recall periods is key for validity of injury reporting;^{22,23} in this study, this method also was expected to decrease the potential for exposure (parents' injuries) misclassification.

Children were categorized as having a father, a mother, or both parents injured any time before or during the study period. For the analyses to address the temporal nature of the study question, parents' injuries had to have occurred before the case injury month. For controls, parents' injuries had to have occurred before a randomly selected target month. In addition, each parent's injury experiences were combined to reflect their overall injury history through both periods.

DATA ANALYSIS

Multivariable logistic regression was used to estimate risk of agricultural injury to children, subsequent to parental agricultural injury, while controlling for potentially confounding covariates.²⁴ To determine potential confounders, we used a causal model²¹ to guide the design and use of directed acyclic graphs, according to the methods in Greenland et al²⁵ and Hernan et al.²⁶ These methods facilitated identification of covariates that may introduce bias if included in the statistical models and reduced potential of overfitting the models. For parent-related covariates, data specific to fathers or mothers were used for the respective analyses of fathers' and mothers' injuries. For analyses of combined parental injury history, mothers' data were included, assuming these factors have a greater effect on children's risk.

Table 1. Characteristics of Case and Control Subjects Younger Than 20 Years: 1999 Regional Rural Injury Study—II

Characteristic	No. (%)	
	Cases (n = 203)	Controls (n = 755)
Sex		
Male	136 (67.0)	429 (56.8)
Female	67 (33.0)	326 (43.2)
Age, y		
<5	13 (6.4)	95 (12.6)
5-9	33 (16.3)	160 (21.2)
10-14	88 (43.3)	222 (29.4)
15-19	69 (34.0)	276 (36.6)
Missing/unknown/refused	0	2 (0.3)
Type of agricultural operation requiring most work time		
Beef cattle	56 (27.6)	178 (23.6)
Dairy cattle	47 (23.2)	97 (12.8)
Other animals	25 (12.3)	67 (8.9)
Field, forage, or specialty crops or Conservation Reserve Program	71 (35.0)	384 (50.9)
Nothing during month of inquiry, or missing/unknown/refused	4 (2.0)	29 (3.8)
Household hours worked per week on agricultural operation		
≤40	11 (5.4)	100 (13.2)
41-80	41 (20.2)	242 (32.1)
81-120	66 (32.5)	205 (27.2)
121-160	33 (16.3)	124 (16.4)
>160	52 (25.6)	84 (11.1)
No. of children in household		
1	34 (16.7)	208 (27.5)
2	73 (36.0)	288 (38.1)
3	50 (24.6)	163 (21.6)
≥4	46 (22.7)	94 (12.5)
Unknown/missing/refused	0	2 (0.3)

Results were adjusted for within-household correlation by using generalized estimating equations.²⁷ To account partially for selection bias, we addressed nonresponse at the household level by weighting observed responses with inverse probabilities of response²⁸ on the basis of characteristics from the Master ListFrame (operation state, operation type, annual revenue by quintile). To account for unknown eligibility for nonrespondents, we estimated probability of eligibility for these same characteristics and used them to adjust weights.²⁹ Parents' injury status was unknown for 4% to 6% of children in each analysis; a separate exposure level was evaluated for these missing data in each model.

RESULTS

Among the 203 cases and 755 controls, agricultural injuries before the study period were reported for 118 (58.1%) and 306 (40.5%) fathers and 63 (31.0%) and 112 (14.8%) mothers, respectively. During the study period, injuries were identified for 18 (8.9%) and 59 (7.8%) fathers and 15 (7.4%) and 29 (3.8%) mothers, respectively.

PARTICIPANT CHARACTERISTICS

Case vs control children more often resided in households affiliated with dairy operations (23.2% and 12.8%); controls were more often associated with field, forage,

Table 2. Risk of Children's Agricultural Injury According to Fathers' and Mothers' Injury Histories: 1999 Regional Rural Injury Study—II

Parent Injury Status	No. (%)		Multivariable Analyses Odds Ratio* (95% Confidence Interval)
	Cases (n = 203)	Controls (n = 755)	
Father's injury status†			
Injured before study			
Yes	118 (58.1)	306 (40.5)	2.1 (1.5-3.0)
No	74 (36.5)	419 (55.5)	1.0
Missing	11 (5.4)	30 (4.0)	1.3 (0.5-3.3)
Injured during study			
Yes	18 (8.9)	59 (7.8)	1.0 (0.5-1.9)
No	175 (86.2)	667 (88.3)	1.0
Missing	10 (4.9)	29 (3.8)	0.8 (0.3-2.0)
Ever injured			
One time period	108 (53.2)	298 (39.5)	2.0 (1.4-2.9)
Both time periods	14 (6.9)	33 (4.4)	1.8 (0.8-4.1)
Neither time period	70 (34.5)	394 (52.2)	1.0
Missing	11 (5.4)	30 (4.0)	1.3 (0.5-3.3)
Mother's injury status‡			
Injured before study			
Yes	63 (31.0)	112 (14.8)	2.5 (1.7-3.8)
No	131 (64.5)	600 (79.5)	1.0
Missing	9 (4.4)	43 (5.7)	1.2 (0.5-3.1)
Injured during study			
Yes	15 (7.4)	29 (3.8)	2.0 (0.9-4.2)
No	178 (87.7)	683 (90.5)	1.0
Missing	10 (4.9)	43 (5.7)	1.3 (0.5-1)
Ever injured			
One time period	58 (28.6)	125 (16.6)	2.0 (1.3-3.0)
Both time periods	10 (4.9)	8 (1.1)	8.0 (2.5-25.4)
Neither time period	125 (61.6)	579 (76.7)	1.0
Missing	10 (4.9)	43 (5.7)	1.4 (0.6-3.4)

*Adjusted for within-household correlation by using generalized estimating equations²⁷ and weighted for nonresponse.^{28,29}

†Models included state, enterprise, number of children in the household, father's age and education level, and total household hours worked on the operation.

‡Models included state, enterprise, number of children in the household, mother's age and education level, and total household hours worked on the operation.

or specialty crop operations or Conservation Reserve Programs (50.9% and 35.0%, respectively) (**Table 1**). Compared with control households, case households worked more hours per week on their operations: 25.6% vs 11.1% worked 160 hours or more. Nearly 23% of case households had 4 or more children in residence, compared with 12.7% of control households. Control households more often had only 1 child in residence (27.6% vs 16.8%). There were no differences between cases and controls in parents' age or educational status.

MULTIVARIABLE ANALYSES

When controlling for potential confounders, children of fathers who sustained an agricultural injury before the study period had twice the risk of injury as those whose fathers did not report an injury (odds ratio [OR], 2.1; 95% confidence interval [CI], 1.5-3.0) (**Table 2**). Children whose fathers were injured during the study were no more or less likely to be injured (OR, 1.0; 95% CI, 0.5-1.9) than children whose fathers were not injured. Children whose

Table 3. Risk of Children's Agricultural Injury According to Parents' Combined Injury History: 1999 Regional Rural Injury Study-II

Parent Injury Status*	No. (%)		Multivariable Analyses Odds Ratio† (95% Confidence Interval)
	Cases (n = 203)	Controls (n = 755)	
Before study			
Both injured	55 (27.1)	71 (9.4)	4.2 (2.6-6.9)
One injured	71 (35.0)	268 (36.0)	1.5 (1.0-2.2)
Neither injured	65 (32.0)	369 (48.9)	1.0
Missing	12 (5.9)	47 (6.2)	2.0 (0.8-4.8)
During study			
Both injured	1 (0.5)	9 (1.2)	0.4 (0.04-4.4)
One injured	30 (14.8)	68 (9.0)	1.5 (0.8-2.5)
Neither injured	160 (78.8)	632 (83.7)	1.0
Missing	12 (5.9)	46 (6.1)	1.5 (0.7-3.5)
Either time period			
Both injured	60 (29.6)	87 (11.5)	3.5 (2.2-5.7)
One injured	69 (34.0)	281 (37.2)	1.4 (0.9-2.0)
Neither injured	61 (30.0)	340 (45.0)	1.0
Missing	13 (6.4)	47 (6.2)	2.3 (1.0-5.2)

*Models included state, type of agricultural operation, number of children in the household, mother's age and education level, and total household hours worked on the operation.

†Adjusted for within-household correlation by using generalized estimating equations²⁷ and weighted for nonresponse.^{28,29}

fathers were injured during both periods had a greater, albeit imprecise, risk of injury than children whose fathers were never injured (OR, 1.8; 95% CI, 0.8-4.1).

The risk of injury among children whose mothers were injured before the study period was more than twice that for children whose mothers did not sustain an injury (OR, 2.5; 95% CI, 1.7-3.8) (Table 2). A more modest association was observed for mothers' agricultural injuries during the study (OR, 2.0; 95% CI, 0.9-4.2). The highest risk was observed among children whose mothers reported injuries both before and during the study year (OR, 8.0; 95% CI, 2.5-25.4).

Compared with those with neither parent injured before the study period, increased risks of agricultural injury were observed for children with one (OR, 1.5; 95% CI, 1.0-2.2) or both (OR, 4.2; 95% CI, 2.6-6.9) parents injured (Table 3). Similarly, if both parents were injured during either time period analyzed, the children's risk was also increased (OR, 3.5; 95% CI, 2.2-5.7) compared with children with neither parent ever injured.

Although data were too sparse to evaluate all exposures of interest, the effect of parents' injuries on children varied slightly according to sex. For example, the relative risks of injury for boys and girls whose fathers reported an injury before the study period were 1.9 (95% CI, 1.2-3.0) and 2.5 (95% CI, 1.3-4.7), respectively. For those whose mothers reported injuries before the study period, relative risks were 2.4 (95% CI, 1.3-4.2) and 3.2 (95% CI, 1.7-6.0).

COMMENT

Results of this study showed a positive association between parents' history of agricultural injury and chil-

dren's risk of subsequent injury. Although the underlying reasons for this association cannot be identified from the data, 2 explanations are plausible: (1) certain agricultural environments may be inherently more hazardous than others, regardless of operation type, and (2) behavioral characteristics of some families may lead to increased high-risk exposure. No matter the cause, this association indicates that interventions to prevent childhood injury can be targeted specifically to families with injured parents (ie, parents treated by health professionals can be sentinel events for prevention efforts).

Although it is postulated that prior injury is associated with risk perception³⁰ and that risk perception may lead to improved preventive practices and reduced likelihood of injuries,³¹ results of this study indicate that parents' experiences with agricultural injuries, alone, do not convey a lower risk to children. Results of studies conducted with other populations support these findings. A recent analysis of self-reported hospital emergency department visits indicated that increased parental emergency department use was associated with increased child emergency department use.³² Further studies showed that parents rarely alter the environment or change safety behaviors to prevent reinjury among children,^{33,34} and relatively few parents who perceive their agricultural operations as high risk make safety-related changes to mediate this risk.³⁵ These findings may be partly due to parents' beliefs that children's injuries are unpreventable or a normative part of child development.^{34,36-39}

Although fathers and mothers may perceive injuries as a normal part of childhood, mothers relay more conservative perceptions of injury,³⁹ which may explain the greater awareness and focus on safety-related behaviors among mothers.^{40,41} In the current study, mothers' injuries appeared to be associated more strongly with children's risk than fathers' injuries were. It is unknown whether this is influenced by the divergence between mothers' and fathers' perceptions of injury or by distinct gender roles among parents on agricultural operations. The latter could explain the strength of association between mothers' and children's injuries. For example, mothers may have been working on their operation while also caring for children. Supervision by a caregiver engaged in farmwork, compared with that in the home, is associated with increased risk of injury among children.⁴² The associations observed in the current study could result from the tendency of mothers and children to share environments that potentiate injury risk.

A unique finding was the apparent additive effect of parents' agricultural injuries on children's risk of injury. Children whose parents were both injured before the study were 4 times more likely to be injured, and children whose parents both had a lifetime history of injury (either before or during the study) were 3.5 times more likely to be injured. This finding may be attributable to inherent hazard levels of certain operations. The type of operation, however, was controlled in the multivariable analyses to address this problem, although residual confounding cannot be ruled out. A second rationale for this finding is the possible modeling of parental behaviors by children, particularly pertaining to risk awareness. For example, children are more likely to practice safety pre-

cautions, such as using personal protective equipment, when such precautions are modeled by their parents.⁴³ The current finding emphasizes the potential benefit of clinic-based injury prevention measures targeted to parents treated for agricultural injuries.

Limitations of this study should be considered when interpreting the results. For example, some families may be better reporters of injuries than others, which could lead to misinterpretation of the observed associations. Furthermore, because of the self-reported nature of the data, the results are susceptible to information bias. However, the use of 6-month recall periods, which improves injury reporting validity,^{22,23} was expected to minimize reporting bias for the injuries occurring in the study year. Also, a particular strength of this study was the large number of participating households (3765 [85.5%] of 4402 eligible). Although the high participation rate should reduce the potential for selection bias to affect study results, an attempt to control such bias also was made through adjustments for nonresponse and within-household correlation.

The complexity of agricultural operations limits our ability to fully account for environmental characteristics in multivariable analyses. Agricultural injuries result from multiple and complex causal pathways. Although this study is one of the largest of its kind and contains a substantial amount of detailed data, we could not identify single pathways or circumstances that may explain intrafamilial risk of injury. Despite this limitation, these findings are useful in the context of identifying families at higher risk to whom interventions might be targeted, particularly in a clinical setting. Future studies of the shared physical and social environments contributing to such risk may lead to more effective population-based injury prevention measures.

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