

# INTERIM REPORT

R01 OH008046

## *Removing the HOOA Family Farm Exemption: Impact on Injury*

*submitted to:*

Division of Extramural Activities Support, OER  
National Institutes of Health  
6705 Rockledge Drive, Room 2207, MSC 7987  
Bethesda, MD 20892-7987



*submitted by:*

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December 13, 2006

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Reference: Grant Award Number R01 OH008046

Enclosed is the original and one (1) copy of the interim progress report for the above referenced grant entitled *Removing the HOOA Family Farm Exemption: Impact on Injury*.

Please contact me if you need further information.

Sincerely,

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Enclosures

Principal Investigator/Program Director (Last, First, Middle): Marlena, Barbara L.

## PROGRESS REPORT SUMMARY

GRANT NUMBER

R01 OH008046

PERIOD COVERED BY THIS REPORT PRINCIPAL

INVESTIGATOR OR PROGRAM DIRECTOR

FROM

THROUGH

Barbara L. Marlena

3/30/05

11/30/06

APPLICANT ORGANIZATION

Marshfield Clinic Research Foundation

TITLE OF PROJECT (Repeat title shown in Item 1 on first page)

Removing the HOOA Family Farm Exemption: Impact on Injury

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A. Human Subjects (Complete Item 6 on the Face Page)

Involvement of Human Subjects

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to Change Since Previous Submission

☐ Change

B. Vertebrate Animals (Complete Item 7 on the Face Page)

Use of Vertebrate Animals

to Change Since Previous Submission

☐ Change

C. Select Agent Research

to Change Since Previous Submission

☐ Change

D. Multiple PI Leadership Plan

to Change Since Previous Submission

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SEE PHS 2590 INSTRUCTIONS.

WOMEN AND MINORITY INCLUSION: See PHS 398 Instructions. Use Inclusion Enrollment Report Format Page and, if necessary, Targeted/Planned Enrollment Format Page.

**A. Specific Aims** The aims of study are as actually funded and have not been modified.

## **B. Studies and Results**

### Primary Study: Changing the Child Labor Laws for Agriculture: Impact on Injury

**Objective.** We evaluated the potential for preventing the occurrence of pediatric farm injuries by changing the United States Federal Child Labor Laws, Hazardous Occupations Order for Agriculture (Hazardous Orders).

**Methods.** A retrospective case series of 1193 pediatric farm injury cases from the United States and Canada was assembled. The Hazardous Orders were systematically applied to each individual case and preventability was estimated.

**Results.** A total of 286/1193 (24%) cases involved family members engaged in farm work. Of these, one-third of children younger than 16 years and 36% of the 16- and 17-year-olds were performing work prohibited under the Hazardous Orders.

**Conclusions.** Study findings suggest that removing the family farm exemption from the Hazardous Orders and changing the age restriction from 16 to 18 years would be efficacious in preventing the most serious injuries experienced by pediatric family workers and would meet Healthy People 2010 goals for reducing traumatic injury in the agricultural sector.

### Secondary Study 1: Adult Supervision and Pediatric Injuries in the Agricultural Worksite

**Objective.** Better supervision is recommended as a strategy to prevent pediatric farm injuries, yet virtually nothing is known about the quality of adult supervision on farms or the nature of supervision at the time of injury. The purpose of the study was to explore the nature of adult supervision among pediatric farm injury cases using three theoretically relevant dimensions of supervision: 1) attention, 2) proximity, and 3) continuity.

**Results.** Approximately two-thirds of the injured children (231/334; 69%) had an adult supervisor available (**attention**). The supervisor was in close **proximity** of the child in only about half the cases (169/334; 51 %) and it was even less common for the supervision to be **continuous** (37%). Thus, many injuries occurred when children were inadequately supervised. However, one-third of the injured children (112/334; 34%) had what would typically be considered **adequate** adult supervision at the time of their injury event, defined as having supervision available, proximal, and continuous.

**Conclusions.** Children on farms are seriously injured even in the presence of **adequate** adult supervision defined according to accepted theoretical criteria. These findings suggest that there is a need to develop a new definition of **adequate** adult supervision within the context of the agricultural work environment or to consider restricting young children from the agricultural worksite entirely.

### Secondary Study 2: Pediatric Fall Injuries in Agricultural Settings

**Objective.** Children on farms experience high risks for fall injuries. This study characterized the causes and consequences of fall injuries in this pediatric population using a new matrix to classify each fall according to initiating mechanisms and injuries sustained upon impact.

**Results.** Fall injuries accounted for 41% (484/1193) of the case series. Twenty-one percent of the fall injuries were into the path of a moving hazard (complex falls), and 91 % of complex falls were related to farm production. Sixty-one percent of complex falls from heights occurred while children were not working. Fatalities and hospitalized injuries were over-represented in the complex falls.

**Conclusions.** Pediatric fall injuries were common. This analysis provides a novel look at this occupational injury control problem.

### Secondary Study 3: A New Approach to Understanding Pediatric Farm Injuries

**Objective.** The goal of this study was to assess **interactions** between risk factors for injury. Information about pediatric farm injuries to children in three age groups (<6 years, 6-12 years, 13+ years) was coded with respect to **children's behavior** (Did unexpected child behavior contribute to injury?), **predictability of injury risk** (Based on what the child had been doing, was the nature or occurrence of injury unexpected?), **environmental events** (Did unexpected environmental events contribute to injury?), and **level of environmental risk** (low, high).

**Results.** In high-risk environments, unexpected child behavior was coded more frequently when children 6 years and under were injured than for older children, whereas in low-risk environments unexpected child behavior had less impact on injury risk and showed no such age variation. With increasing age, the predictability of injury increased in a high-risk context, confirming that youth engage in increasingly hazardous activities as they develop. Consistent with this interpretation, unexpected environmental events increasingly contributed to injury in a high-risk context in the oldest age groups.

**Conclusions.** The observed variations in risk factors suggest that interactions between behavioral and environmental factors are important to consider in studies of the etiology of pediatric farm injuries.

### **C. Significance**

The primary study demonstrates that removal of the family farm exemption from the Hazardous Orders has the potential to eliminate one-third of the occupational injuries experienced by children less than 16 years of age who are working on their parents' farms. Removal of the family farm exemption in combination with a change in the age restriction for hazardous work could lead to similar reductions among youth 16-17 years of age. If implemented and enforced, these changes could also lead to reductions in injury rates that meet or exceed national health objectives recommended in the Healthy People 2010 initiative.

### **D. Plans**

At a minimum, we plan to complete one more secondary analysis focused on neurotrauma and develop a manuscript for publication. Please see Appendix A for Inclusion Enrollment Report.

### **E. Publications** (see Appendix B)

Marlenga B, Berg RL, Linneman JG, Brison RJ, Pickett W. Changing the child labor laws for agriculture: Impact on injury. *American Journal of Public Health* (accepted).

Morrongiello BA, Pickett W, Berg RL, Linneman JG, Brison RJ, Marlenga B. Adult supervision and pediatric injuries in the agricultural worksite: What constitutes adequate supervision? *Journal of Rural Health* (submitted).

Pickett W, Dostaler S, Berg RL, Linneman JG, Brison, RJ, Marlenga B. Pediatric fall injuries in agricultural settings: a new look at a common injury control problem. *Journal of Occupational and Environmental Medicine* (submitted).

Morrongiello BA, Marlenga B, Berg RL, Linneman JG, Pickett, W. A new approach to understanding pediatric farm injuries. *Social Science and Medicine* (submitted).

**F. Project-Generated Resources** There have been no project resources generated for sharing with other investigators.

## APPENDIX A

### Inclusion Enrollment Report

**Inclusion Enrollment Report**

This report format should NOT be used for data collection from study participants.

Study Title: Removing the HOOA Family Farm Exemption: Impact on InjuryTotal Enrollment: 1193 Protocol Number: n/aGrant Number: R01 OH008046-03**PART A. TOTAL ENROLLMENT REPORT: Number of Subjects Enrolled to Date (Cumulative)  
by Ethnicity and Race**

| Ethnic Category                               | Sex/Gender |       |                         | Total |
|-----------------------------------------------|------------|-------|-------------------------|-------|
|                                               | Females    | Males | Unknown or Not Reported |       |
| Hispanic or Latino                            | 23         | 61    | 0                       | 84    |
| Not Hispanic or Latino                        | 72         | 235   | 26                      | 333   |
| Unknown (individuals not reporting ethnicity) | 176        | 600   | 0                       | 776   |
| Ethnic Category: Total of All Subjects*       | 271        | 896   | 26                      | 1193  |
| <b>Racial Categories</b>                      |            |       |                         |       |
| American Indian/Alaska Native                 | 24         | 53    | 0                       | 77    |
| Asian                                         | 2          | 10    | 0                       | 12    |
| Native Hawaiian or Other Pacific Islander     | 0          | 0     | 0                       | 0     |
| Black or African American                     | 9          | 22    | 0                       | 31    |
| White                                         | 96         | 373   | 26                      | 495   |
| More Than One Race                            | 0          | 0     | 0                       | 0     |
| Unknown or Not Reported                       | 140        | 438   | 0                       | 578   |
| Racial Categories: Total of All Subjects*     | 271        | 1896  | 26                      | 1193  |

**PART B. HISPANIC ENROLLMENT REPORT: Number of Hispanics or Latinos Enrolled to Date (Cumulative)**

| Racial Categories                                  | Females | Males | Unknown or Not Reported | Total |
|----------------------------------------------------|---------|-------|-------------------------|-------|
| American Indian or Alaska Native                   | 0       | 0     | 0                       | 0     |
| Asian                                              | 0       | 0     | 0                       | 0     |
| Native Hawaiian or Other Pacific Islander          | 0       | 0     | 0                       | 0     |
| Black or African American                          | 0       | 0     | 0                       | 0     |
| White                                              | 3       | 9     | 0                       | 12    |
| More Than One Race                                 | 0       | 0     | 0                       | 0     |
| Unknown or Not Reported                            | 20      | 52    | 0                       | 72    |
| Racial Categories: Total of Hispanics or Latinos** | 23      | 61    | 0                       | 84    |

\* These totals must agree.

\*\* These totals must agree.

## APPENDIX B

Publications  
(Accepted and Submitted)

# **Changing the Child Labor Laws for Agriculture: Impact on Injury**

Word count: 181 abstract, 3309 text, 2 tables, 2 figures; 1 Appendix

*Objective.* The child labor laws are intended to protect working youth from the most dangerous jobs. However, children who work on their parents' farms are exempt from these laws. We evaluated the potential for preventing the occurrence of pediatric farm injuries by changing the United States Federal Child Labor Laws, Hazardous Occupations Order for Agriculture (Hazardous Orders).

*Methods.* A retrospective case series of 1193 pediatric farm injury cases from the United States and Canada was assembled. The Hazardous Orders were systematically applied to each individual case and preventability was estimated.

*Results.* A total of 286/1193 (24%) cases involved family members engaged in farm work. Of these, one-third of children younger than 16 years and 36% of the 16- and 17-year-olds were performing work prohibited under the Hazardous Orders.

*Conclusions.* Study findings suggest that removing the family farm exemption from the Hazardous Orders and changing the age restriction from 16 to 18 years would be efficacious in preventing the most serious injuries experienced by pediatric family workers and would meet Healthy People 2010 goals for reducing traumatic injury in the agricultural sector.

Child labor laws were designed to protect the most vulnerable workers from unsafe and unhealthy work and work environments. In the United States, these federal child labor laws limit the hours and times of day that children younger than age 16 may work and set minimum age standards for various types of work.<sup>12</sup> They also identify hazardous jobs (Hazardous Orders) that cannot be performed by children younger than 18 years in nonagricultural occupations, and younger than 16 years in agricultural occupations. However, children who work on their parents' farms are explicitly exempted from these federal child labor laws. To illustrate, "a child of any age may be employed by his or her parent or person standing in place of the parent at any time in any occupations on a farm owned or operated by that parent or person standing in place of that parent.<sup>12</sup>

Agriculture is the most hazardous industry in the United States for youth workers.<sup>3</sup> Nearly half of all youth work-related fatalities occur in agriculture<sup>3</sup> with a risk for fatal injury that is three to four times that of youth workers in other occupational settings.<sup>4,5</sup> Further, 76% of fatally injured agricultural workers under the age of 16 years were working in a family business that was exempt from the child labor laws.<sup>3</sup>

Existing approaches to the prevention of pediatric farm injuries have emphasized education and training with little consideration of public policy approaches.<sup>6</sup> However, public health professionals and child safety advocates are recommending policy-oriented approaches as more efficacious alternatives for prevention purposes.<sup>7,8</sup>

The National Research Council/Institute of Medicine (NRC/IOM) recommended two policy changes related to children and agriculture in their 1998 report on the health and safety implications of United States child labor: (1) establishment of a minimum age of 18 years for all hazardous work regardless of whether the adolescent is working in an agricultural or

nonagricultural job, and (2) compulsory compliance with the Hazardous Orders "whether the minor is employed by a stranger or by a parent or other person standing in for the parent."<sup>7</sup> Before initiating these changes in policy, it would be helpful to investigate their potential efficacy.

### **Study Goals and Objectives**

The goal of this study was to evaluate the NRC/IOM policy recommendations with respect to their potential efficacy for injury prevention. Our objectives were to review existing cases of traumatic pediatric farm injury and (1) describe the characteristics of the injured children by worker status, (2) identify farm jobs covered and not covered by the Hazardous Orders that are most often associated with injuries, (3) estimate the proportion of work-related injuries that could potentially be prevented if the family farm exemption was removed from the Hazardous Orders (because the child would be restricted from doing the hazardous job), and (4) estimate the proportion of work-related injuries that could potentially be prevented if the age standard for the Hazardous Orders were changed from 16 to 18 years (because the child would be restricted from doing the hazardous job).

### **Hazardous Orders**

The Hazardous Orders are authorized by the Fair Labor Standards Act (FLSA) of 1938<sup>2</sup> and are contained at Subpart E-1 of Regulations, 29 CFR Part 570. The FLSA was amended in 1966 to address youth working in agriculture. The final regulations became effective in 1970<sup>9</sup> and have been virtually unchanged since that time. The hazardous agricultural activities that were identified as prohibited for minors under the age of 16 years are listed in Appendix 1.2

## **METHODS**

This evaluation involved a primary review of four retrospective case series of pediatric farm injuries. The latter were assembled to represent fatal injuries, hospitalized injuries, and two forms of restricted activity injuries (among the general farm population and the minority farm population). Our ethics committees approved the study protocol.

### **Definitions**

Pediatric farm injuries were generically defined as injuries to children younger than 18 years that occurred at a farm work site and/or during activities related to the operation of a farm (excluding injuries in the farm residence). Examination of both work and non-work related injury cases and a broad range of ages enabled us to estimate both the proportion of all childhood farm injuries that may potentially be prevented by changing the Hazardous Orders, as well as the proportion of work-related injuries that may be preventable.

### **Data Sources**

#### *Fatalities*

In the United States, there is no comprehensive national database of pediatric agricultural fatalities. Fatality data were obtained using methods developed by the Canadian Agricultural Injury Surveillance Program (CAISP). CAISP contains a comprehensive, population-based fatal injury dataset from a neighboring country with farming practices and child labor laws that are analogous to that observed in much of the United States.<sup>10</sup> Canadian fatalities are considered to be broadly representative of the full spectrum of pediatric agricultural fatalities experienced in

North America. An enhanced database was developed that contained every known case of an agricultural-related, fatal childhood injury experienced in Canada between 1990 and 2000 (n = 226). The Canadian fatality case series data were supplemented with 17 United States occupational fatality case reports from the National Institute for Occupational Safety and Health (NIOSH) Fatal Assessment and Control Evaluation program for the years 1992-2000," for a total of 243 fatality cases.

### *Hospitalized Injuries*

In the United States, there is also no comprehensive national database of hospitalized pediatric agricultural injuries. Similar to fatalities, a national registry of hospitalized farm injury cases has been developed in Canada.<sup>10</sup> We used the CAISP case identification approach to identify injured children treated at five regional pediatric hospitals and two general hospitals in Canada. These hospitals were from the provinces of Alberta and Ontario. A study period of 1990-2000 was used for the hospitalized injury portion of this study (n = 361).

### *Restricted Activity Injuries*

Data files from the 1998 Childhood Agricultural Injury Survey (n = 330)<sup>12</sup> and 2000 Childhood Agricultural Injury Survey on Minority-Operated Farms (n = 259)<sup>13</sup> were obtained electronically from NIOSH, for a total of 589 restricted activity injury cases. Injuries identified within these surveys represent a spectrum of pediatric farm injuries that resulted in at least 4 hours of restricted activity with 10.4% (61/589) requiring hospitalization, 78.3% (461/589) requiring treatment in the emergency department or by an outpatient provider, and 11.4% (67/589) not requiring medical treatment. Data for both surveys were collected by telephone

interview from random samples of United States farm operators. Analogous data were not available in Canada.

### **Instrument**

A standardized data abstraction instrument was developed in consultation with a child labor expert from the Department of Labor. A study glossary was developed in concert with the instrument detailing the exact specifications and circumstances under which each Hazardous Orders prohibited job category would apply. The ability of the investigators to apply the instrument in a valid and reliable manner was assessed through iterative testing with actual cases (as described below). Data elements covered within the instrument included case demographics, detailed descriptions of the injury event, and applicability of the Hazardous Orders prohibited job categories.

### *Assumptions*

Given the specificity of the Hazardous Orders, several assumptions guided our coding of prohibited work. For HO1, we considered all tractors operated by children to be greater than 20 horsepower unless the horsepower was specified or the youth was operating a "lawn tractor." For HO5, we considered all work with timber to involve a butt diameter of more than 6 inches. For HO6, we considered work from the top of a silo and work on a barn roof to be working at a height over 20 feet, unless a lower height was specified. For HO9, we considered all work with chemicals to be hazardous.

**Data Abstraction and Coding**

Using a standard protocol, two investigators independently abstracted and coded all cases involving youth performing farm work at the time of injury. The protocol was developed through a series of validation exercises. In each exercise, 10 randomly selected cases were reviewed and inter-rater agreement was assessed. All disagreements were resolved through discussion with the study team, including consultation with the child labor expert for specific interpretation of the Hazardous Orders job categories, and the protocol was updated. Agreement reached 90% in the third exercise and the final case review proceeded. Any subsequent disagreements were resolved by consensus.

**Data Analysis**

The analyses are descriptive and standard summary statistics are presented.

**RESULTS****Full Case Series**

The characteristics of the full case series of 1193 injured children as they relate to the Hazardous Orders are presented in Figure 1. The majority of injured children were younger than 16 years (1029/1193; 86%) and were not working at the time of their injury (836/1193; 70%). A total of 286/1193 (24%) cases involved family members engaged in farm work. Very few of the injured children were designated as hired workers on the farm (37/1193; 3%).

**How Often were the Hazardous Orders Applicable?**

Approximately one-third (33% for <16 years, 36% for 16-17 years) of the working family farm children were engaged in jobs prohibited by the Hazardous Orders at the time of their injuries. This percentage varied by data source with children who were fatally injured being the most likely to be performing prohibited jobs (Figure 2). HO1, operating a tractor over 20 horsepower, and H02, operating or assisting to operate farm machinery, were the leading hazardous job categories for both youth younger than 16 years and for youth 16-17 years (Table 1).

**How Many Injuries Could Potentially be Prevented by Removing the Family Farm Exemption?**

If the Hazardous Orders were implemented and enforced on family farms, 33% (71/213) of pediatric work injuries to children younger than 16 years could hypothetically have been prevented as children would have been restricted from being engaged in these hazardous jobs (Table 1).

**How Many Injuries Could Potentially be Prevented if the Family Farm Exemption was Removed and the Age Standard Changed to 18 Years?**

If the Hazardous Orders were implemented and enforced on family farms **and** the age restriction for hazardous work changed from 16 years to 18 years, 36% (26/73) of the work injuries to 16- and 17-year-old youth could hypothetically have been prevented (Table 1). Overall, with both changes to the Hazardous Orders, 34% (97/286) of the work injuries could potentially be preventable.

**What Work Injuries are not Covered by the Hazardous Orders?**

The Hazardous Orders do not cover the majority of jobs that lead to work-related injury to youth less than 18 years of age (189/286; 66%). Leading categories of work not covered by the Hazardous Orders (Table 2) include: (1) working with animals in situations not covered by HO4 (40%), (2) farm work with other machinery not covered in H02 and H03 (25%), and (3) farm maintenance in situations not covered by H06 (13%). The leading specific jobs associated with injury were: (1) farm work with all-terrain vehicles (12%), (2) feeding large animals (10%), (3) farm work on horseback (9%), and (4) working with other farm machinery (9%). The severity of these work injuries varied with 8% (15/189) fatal, 31% (59/189) requiring hospitalization, 52% (99/189) requiring treatment in the emergency department or by an outpatient provider, and 8% (16/189) not requiring medical treatment.

**DISCUSSION**

This study demonstrates that removal of the family farm exemption from the Hazardous Orders has the potential to eliminate one-third of the occupational injuries experienced by children less than 16 years of age who are working on their parents' farms. Removal of the family farm exemption in combination with a change in the age restriction for hazardous work could lead to similar reductions among youth 16-17 years of age. These policy changes were recommended by the NRC/IOM in their 1998 report on child labor in the United States,<sup>7</sup> but have never been implemented by Congress through an amendment to the FLSA. If implemented and enforced, these changes could also lead to reductions in injury rates that meet or exceed national health objectives recommended in the Healthy People 2010 initiative being led by the United States Department of Health and Human Services.<sup>4</sup>

Youth working in agriculture continue to have the highest rate of fatal work injuries when compared to youth in other work environments, with the preponderance of these fatal injuries occurring on farms that are family owned and operated.<sup>3</sup> Protection from physical harm is a fundamental human right for children<sup>15</sup> and it is well recognized that children require higher standards of protection than adults.<sup>7</sup> These facts are not recognized in existing occupational health and safety legislation aimed at family farms, which is perplexing given the magnitude of the pediatric farm injury problem. Given these observations and in light of our research findings, there is a clear need for at least minimum safety standards to protect children from harm on family farms.

The Hazardous Orders should be considered the minimum safety requirement for all working youth, as our findings show that the Hazardous Orders do in fact cover many of the most serious traumatic injury circumstances that affect working farm children (Figure 2) and are thus likely to be efficacious. However, removing the family farm exemption from the Hazardous Orders and changing the age standard will be insufficient to ensure that the farm work performed by youth is safe. Our study findings build upon the National Institute for Occupational Safety and Health recommendations for changes to the Hazardous Orders<sup>16</sup> and provide additional objective evidence that can assist in the revision of the content of the Hazardous Orders so that they are more relevant to contemporary farm environments and practices. With respect to children at work, this should include: (1) identification of high-risk activities that impose risks for blunt animal trauma, and (2) replacement of out-of-date lists of farm machinery with ones that reflect modern agricultural practice. There is an obvious need to improve the Hazardous Orders and there is an additional need for further evaluation of their content and implementation.

The adoption of changes in the Hazardous Orders will clearly require a paradigm shift within farm society and the health and safety professionals that serve the agricultural population. Existing injury prevention initiatives aimed at farmers have traditionally favored voluntary over regulatory approaches to prevention.<sup>6,17</sup> However, we believe that a shift towards policy-oriented approaches is inevitable, and will be guided by the known lack of efficacy of educational approaches to injury prevention,<sup>18-20</sup> the inadequacy of voluntary engineering controls,<sup>21,22</sup> the magnitude of the pediatric farm injury problem,<sup>8,10,23</sup> and the political will of national public health and medical organizations.

Beyond the Hazardous Orders, study results suggest a need for other measures that address the physical safety of children on farms. The study findings clearly put the burden of occupational injuries to children on farms into a broader context. Assuming that the Hazardous Orders are efficacious, implementation and enforcement of these policies would still have no impact on the majority of farm injuries experienced by children who were present in the farm worksite, but were not themselves engaged in farm work. New occupational policies and other preventive initiatives are required to address these injury patterns, which are heavily concentrated in the very young.<sup>6,24,25</sup> These common and often lethal injury events are not addressed in any existing regulations.

### **Generalizability**

An important concern surrounding our analysis was whether patterns of pediatric farm injury observed in Canada could be generalized to the United States. National, record-level data describing pediatric farm fatalities exist for the United States,<sup>26</sup> but are not available to

researchers operating outside the federal government due to confidentiality restrictions (personal

communication, Ryan Smith, Office of Safety and Health Statistics, Bureau of Labor Statistics, August 8, 2005). Hospital medical records are also not available for similar reasons. Hence, our study relied heavily upon Canadian injury records and an obvious concern is the generalizability of Canadian injury patterns to the United States context. In the United States, leading causes of pediatric farm injury include tractor-related injuries, farm machinery (including power-take-off) injury, livestock injury, falls from structures, chemical burns, and poisonings.<sup>27</sup> Leading causes of traumatic injury in the present case series were very similar, which provides some assurance as to the generalizability of our findings. Second, although regional differences exist, the leading types of crops and livestock produced on United States and Canadian farms are similar,<sup>28 30</sup> suggesting more similarities than differences in agricultural practices between our countries. Finally, similar to the United States situation surrounding the Hazardous Orders, children who live on Canadian farms are exempt from most provincial occupational health and safety legislation that would prohibit their participation in hazardous work activities.<sup>31</sup> Thus, our findings are likely generalizable to United States pediatric farm populations.

### **Strengths and Limitations**

This is one of the first studies to evaluate the potential impact of one component of a public policy on the reduction of pediatric farm injuries. We have used an accepted evaluative approach<sup>22</sup> and have taken steps to ensure reliability and validity of our data collection methods and case interpretations. While data limitations required that we review injuries from Canada and rely on similarities in agricultural practices in the United States and Canada, there are substantially more farms in the United States with the likelihood of many more pediatric work-

related farm injuries. Thus, the impact of these policy changes for prevention would be even greater than the injury numbers in this study suggest.

Although our study examined a large case series, additional limitations associated with our sources of injury data warrant recognition. First, irrespective of our arguments about the generalizability of Canadian injury patterns to the United States context, the absence of trauma data from United States is an important limitation that could not be overcome, given existing restrictions on data access. Second, our hospital data were subject to patient referral biases in that the pediatric hospitals are tertiary centers providing regional pediatric trauma care. Hence, severe injuries and injuries requiring diagnostic (e.g., head injuries requiring advanced imaging) and trauma procedures (e.g., certain orthopedics) are likely to be over-represented. Third, because our case retrieval process centered around "traumatic injury," we are likely to have poor coverage of pediatric farm injuries involving three of the Hazardous Orders: H09, toxic agricultural chemicals, H010, blasting agents, and H011, anhydrous ammonia.

## **Synopsis and Conclusion**

This novel evaluation addressed a leading public health problem on North American farms, the occurrence of injuries to populations of working children. Through this analysis we demonstrated that the Hazardous Orders, if implemented and enforced, have the potential to prevent one-third of work-related injuries sustained by working farm children. Within the agricultural sector, this would exceed the population health goals espoused in the Healthy People 2010 initiative.<sup>14</sup>

Findings from our evaluation also provide strong and objective evidence in support of (1) elimination of the existing exemption of family farms to be in compliance with these

Hazardous Orders, and (2) harmonization of the minimum age standards for agricultural Hazardous Orders with those of other work environments. There is also an obvious need to revise the Hazardous Orders to be relevant to contemporary agriculture, along with a continuing need to address injuries to non-working children on farms, especially the very young.

Policy-oriented approaches to pediatric farm injury prevention have historically met with opposition from agricultural organizations, mainly for financial (costs to the farm enterprise) and cultural (e.g., traditional work practices) reasons.<sup>7</sup> Agriculture is exempt from much existing occupational health and safety legislation for these reasons. While it is recognized that changes to the Hazardous Orders may lead to new labor practices and safety requirements for farm operations, and some of these will have financial implications, public health practice obligations and specifically the need for protection of children on farms should supercede such economic/cultural arguments.

Creative policy-oriented solutions that tackle the occurrence of pediatric farm injuries in a direct manner are clearly the next step in the amelioration of this ongoing pediatric injury problem, if we are committed to meeting the Healthy People 2010 national goals. From a public health perspective, there is no logical argument to prevent a movement to implementation of such policy solutions in the face of existing evidence.

**References**

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[http://www.osha.gov/pls/epub/wageindex.download?p\\_file=F1\\_0862/WH- 1295 CHILD LABOR BULLETIN 102.pdf](http://www.osha.gov/pls/epub/wageindex.download?p_file=F1_0862/WH-1295_CHILD_LABOR_BULLETIN_102.pdf). Accessed August 30, 2005.
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ABLE 1—Hazardous Orders Job Categories Associated with Injury In Pediatric Family Workers by Age

|                                                                                   | Fatalities<br>n | Hospitalized<br>Injuries<br>n | Restricted<br>Activity<br>n | Total<br>n   | %    |
|-----------------------------------------------------------------------------------|-----------------|-------------------------------|-----------------------------|--------------|------|
| Age < 16                                                                          |                 |                               |                             |              |      |
| 101: Tractor                                                                      | 9               | 16                            | 12                          | 37           | 174  |
| 102: Farm machinery                                                               | 4               | 13                            | 3                           | 20           | 94   |
| X03: Other machinery                                                              | 0               | 1                             | 0                           | 1            | 05   |
| 104: Animals                                                                      | 0               | 0                             | 2                           | 2            | 09   |
| 105: Timber                                                                       | 1               | 1                             | 1                           | 3            | 14   |
| 106: Working from heights                                                         | 0               | 2                             | 2                           | 4            | 19   |
| X07: Transportation                                                               | 3               | 4                             | 2                           | 9            | 42   |
| X09: Chemicals                                                                    | 0               | 1                             | 0                           | 1            | 05   |
| Total children age < 16 working in <u>one or more</u><br>hazardous job category*  | 17/28 (60.7%)*  | 34/75 (45.3%)*                | 20/110 (18.2%)*             | 71/213 33.3' |      |
| Age 16-17                                                                         |                 |                               |                             |              |      |
| H01: Tractor                                                                      | 4               | 5                             | 5                           | 14           | 19.2 |
| H02: Farm machinery                                                               | 1               | 5                             | 5                           | 11           | 15.1 |
| H06: Working from heights                                                         | 0               | 0                             | 3                           | 3            | 4.1  |
| H8: Working in storage units                                                      | 1               | 0                             | 0                           | 1            | 1.4  |
| H9: Chemicals                                                                     | 0               | 0                             | 1                           | 1            | 1.4  |
| Total children age 16-17 working in <u>one or more</u><br>hazardous job category* | 5/9 (55.6%)*    | 9/16 (56.3%)*                 | 12/48 (25.0%)*              | 26/73 35.6*  |      |

\* Number of job categories does not necessarily dictate number of children performing job, as the child may have been performing a job that entailed more than one category (i.e., adding column totals may or may not equal total children).

TABLE 2—Jobs Not Prohibited Under the Hazardous Orders Involving Injury to Family Workers Age &lt;18 Years

| Description of Job                | Fatalities<br>n | Hospitalized<br>Injuries<br>n | Restricted<br>Activity<br>n | Total<br>n       |       |
|-----------------------------------|-----------------|-------------------------------|-----------------------------|------------------|-------|
| Working with animals              | 3               | 17                            | 56                          | 76               | 40.2  |
| Feeding horses and cattle         | 1               | 5                             | 12                          | 18               | 9.5   |
| Farm work on horseback            | 1               | 1                             | 15                          | 17               | 9.0   |
| Herding livestock                 | 0               | 4                             | 10                          | 14               | 7.4   |
| Leading/grooming                  | 0               | 3                             | 6                           | 9                | 4.8   |
| Branding/breeding/vaccinating     | 0               | 1                             | 3                           | 4                | 2.1   |
| Catching/holding a pig            | 0               | 0                             | 3                           | 3                | 1.6   |
| Milking with pipeline             | 0               | 0                             | 2                           | 2                | 1.1   |
| Other animal                      | 1               | 3                             | 5                           | 9                | 4.8   |
|                                   | 8               | 9                             | 30                          | 47               | 24.9  |
| Farm work with machinery          |                 |                               |                             |                  |       |
| ATV operation                     | 2               | 1                             | 19                          | 22               | 11.6  |
| Other machinery                   | 3               | 8                             | 6                           | 17               | 9.0   |
| Tractor repair or maintenance     | 1               | 0                             | 3                           | 4                | 2.1   |
| Farm truck                        | 2               | 0                             | 2                           | 4                | 2.1   |
| Farm maintenance                  | 2               | 8                             | 14                          | 24               | 12.7  |
| Repairing fence                   | 1               | 3                             | 6                           | 10               | 5.3   |
| Burning brush/garbage             | 0               | 3                             | 2                           | 5                | 2.6   |
| Cleaning animal enclosures        | 1               | 0                             | 4                           | 5                | 2.6   |
| Building maintenance              | 0               | 2                             | 2                           | 4                | 2.1   |
| Farm work with hand tools         | 0               | 1                             | 6                           | 7                | 3.7   |
| Loading or unloading hay          | 0               | 4                             | 2                           | 6                | 3.2   |
| Pruning or hand harvesting        | 0               | 0                             | % 3                         | 3                | 1.6   |
| Other or insufficient information | 2               | 9                             | 15                          | 26               | 13.8  |
| Total                             | 15              | 48                            | 126*                        | 189 <sup>t</sup> | 100.0 |

Hospitalized as inpatient (11/126; 8.7%), emergency department/outpatient medical treatment (99/126; 78.6%), Not formally treated (16/126; 12.7%)

<sup>t</sup> Family workers <16 years of age 142 (75%), 16-17 years of age 47 (25%)

## **FIGURE LEGENDS**

**FIGURE 1**—Flow chart of pediatric farm injuries under study.

**FIGURE 2**—Percentage of pediatric family workers performing a job prohibited under the Hazardous Orders at the time of injury occurrence by age group and data source.

## Appendix 1—Jobs Prohibited by Hazardous Occupations Order for Agriculture for Youth &lt;16 Years

- HO1 Operating a tractor of over 20 power-take-off (PTO) horsepower, or connecting or disconnecting an implement or any of its parts to or from such a tractor
- HO2 Operating or assisting to operate (including starting, stopping, adjusting, feeding or any other activity involving physical contact associated with the operation) any of the following machines: corn picker, cotton picker, grain combine, hay mower, forage harvester, hay baler, potato digger, mobile pea viner; feed grinder, crop dryer, forage blower, auger conveyer, or the unloading mechanism of a nongravity-type self-unloading wagon or trailer; or power post hole diggers, power post driver, or nonwalking type rotary tiller
- HO3 Operating or assisting to operate (including starting, stopping, adjusting, feeding, or any other activity involving physical contact associated with the operation) any of the following machines: trencher or earth moving equipment; forklift; potato combine; power-driven circular, band, or chain saw
- HO4 Working on a farm in a yard, pen, or stall occupied by a: (i) bull, boar, or stud horse maintained for breeding purposes; (ii) a sow with suckling pigs, or a cow with a newborn calf (with umbilical cord present)
- HO5 Felling, bucking, skidding, loading, or unloading timber with butt diameter of more than 6 inches
- HO6 Working from a ladder or scaffold (painting, repairing, or building structures, pruning trees, picking fruit, etc.) at a height of over 20 feet
- HO7 Driving a bus, truck, or automobile when transporting passengers or riding on a tractor as a passenger or helper
- HO8 Working inside: a fruit, forage, or grain storage designed to retain an oxygen deficient or toxic atmosphere; an upright silo within 2 weeks after silage has been added or when a top unloading device is in operating position; a manure pit; a horizontal silo while operating a tractor for packing purposes
- HO9 Handling or applying toxic agricultural chemicals (including cleaning or decontaminating equipment, disposal or return of empty containers, or serving as a flagman for aircraft applying such chemicals); such toxic chemicals are identified by the word "poison," or "warning," or are identified by a "skull and crossbones" on the label
- HO10 Handling or using a blasting agent, including but not limited to, dynamite, black powder, sensitized ammonium nitrate, blasting caps, and primer cord

Full case series of pediatric  
farm injuries available for study  
(N=1193)  
Age <16 (N=1029)  
Age 16-17 (N=164)

1) Was the child known  
to be working at the time  
of injury  
occurrence?

Yes No

Children not known to be  
working at time of injury  
occurrence (N=836)\*  
Age <16 (N=776)  
Age 16-17 (N=60)

Children working at time of injury  
occurrence (N=357)  
Age <16 (N=253)  
Age 16-17 (N=104)

3) Was the child a  
family worker?

Yes No

Hired workers (N=37)  
Age <16 (N=16)  
Age 16-17 (N=21)  
Other workers (N=34)<sup>t</sup>

Family workers (N=286)  
Age <16 (N=213)  
Age 16-17 (N=73)

5) Was the family  
worker performing a job  
prohibited under the  
Hazardous Orders?

Yes

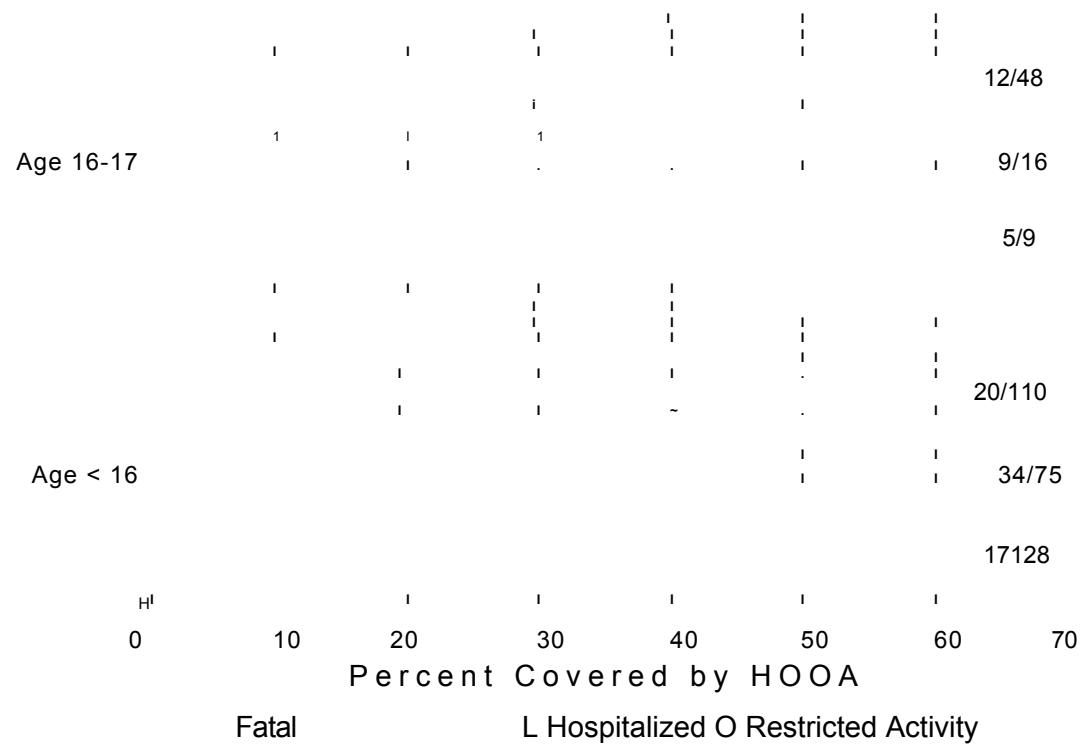
No

Family workers performing jobs  
not prohibited under the  
Hazardous Orders at time of  
injury occurrence (N=189)  
Age <16 (N=142)  
Age 16-17 (N=47)

Family workers performing jobs  
prohibited under the Hazardous  
Orders at time of injury  
occurrence (N=97)  
Age <16 (N=71)  
Age 16-17 (N=26)

\*Includes 111 cases where the work status of the child could not be determined.

<sup>t</sup>Includes visitors, neighbors, relatives of hired workers, and other workers where relationship is unknown.



# Adult Supervision and Pediatric Injuries in the Agricultural Worksite: What Constitutes Adequate Supervision?

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Short running head: Adult Supervision and Pediatric Injuries

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**Acknowledgements.** This study was sponsored by the Centers for Disease Control and Prevention/National Institute for Occupational Safety and Health (R01 OH008046), the Social Sciences and Humanities Research Council of Canada, and the Canadian Institutes of Health Research. The authors extend their gratitude to all the individuals who helped access the data for this case series including the National Agricultural Statistic Service, John Myers at NIOSH, and the following Provincial Coroners' Offices and Hospitals: Office of the Chief Medical Examiner, Province of Manitoba; Chief Coroner's Office of Saskatchewan; Office of the Chief Medical Examiner of Alberta; Terry Smith, Chief Coroner, and Tej Sidhu, Office of the Chief Coroner, Province of British Columbia; Dr. Serge Turmel, Coroner, Province of Quebec; Dr. Barry McLellan, Deputy Chief Coroner of Forensic Services, and June Lindsell, Office of the Chief Coroner of Ontario; Pediatrics Emergency Department, Children's Hospital of Western Ontario; Health Records, London Health Sciences Centre and St. Joseph's Health Care; Morag MacKay, Director Plan-it Safe, and Department of Health Records at the Children's Hospital of Eastern Ontario; Dr. William Mounstephen, Division of Pediatric Emergency Medicine, and Health Records Department, Hospital for Sick Children, Toronto, Ontario; Patient Information Services and Division of Emergency Medicine, University of Alberta Hospital, Edmonton, Alberta; Health Records, Foothills Medical Centre, Calgary, Alberta; Health Records, Alberta Children's Hospital, Calgary, Alberta; and Dr. Cheri Nijssen-Jordan and Trudy Senger, Alberta Children's Hospital, Calgary, Alberta. The authors thank Dr. Louise Pare, St.-Ferreol-les-Neiges, Quebec for assistance with translation of the documents at the Coroner's office in Quebec. The authors thank Marshfield Clinic Research Foundation for its support through the assistance of Linda Weis and Alice Stargardt in the preparation of this manuscript. For further information, contact: Barbara Marlenga, PhD, National Children's Center for Rural and Agricultural Health and Safety, Marshfield Clinic Research Foundation, 1000 North Oak Avenue, Marshfield, WI 54449, USA; phone: 715-389-3021; fax: 715-389-4996; e-mail: [marlenga.barbara@marshfieldclinic.edu](mailto:marlenga.barbara@marshfieldclinic.edu).

*ABSTRACT: Context: Better supervision is recommended as a strategy to prevent pediatric farm injuries, yet virtually nothing is known about the quality of adult supervision on farms or the nature of supervision at the time of injury. Purpose: To explore the nature of adult supervision among pediatric farm injury cases using three theoretically relevant dimensions of supervision: 1) attention, 2) proximity, and 3) continuity. Methods: We examined a retrospective case series of 334 pediatric farm injury cases from Canada and the United States that resulted in death or required hospitalization. Patterns of supervision were coded. Findings: Approximately two-thirds of the injured children (231/334; 69%) had an adult supervisor available (attention). The supervisor was in close proximity of the child in only about half the cases (169/334; 51 %) and it was even less common for the supervision to be **continuous** (37%). Thus, many injuries occurred when children were inadequately supervised. However, one-third of the injured children (112/334; 34%) had what would typically be considered adequate adult supervision at the time of their injury event, defined as having supervision available, proximal, and continuous. Conclusions: Children on farms are seriously injured even in the presence of adequate adult supervision defined according to accepted theoretical criteria. These findings suggest that there is a need to develop a new definition of adequate adult supervision within the context of the agricultural work environment or to consider restricting young children from the agricultural worksite entirely.*

*Keywords. Agriculture, Child, Parenting, Safety, Supervision, Wounds and injuries.*

**A**gricultural injuries to children on farms have long been recognized as an important problem for public health. Farm children continue to experience high rates of premature mortality,<sup>2,3,4</sup> morbidity,<sup>6,7</sup> and disability<sup>8</sup> due to injury. Each year more than 100 children die from agricultural injuries<sup>1</sup> and nearly 23,000 children sustain agricultural injuries that require medical treatment or restrict their activity.<sup>1</sup> Elevated risks observed in the United States are shared by populations of children internationally, for example among farm children in Canada,<sup>4</sup> Australia, Finland,<sup>10</sup> and India.<sup>11</sup> However, very little is understood about the etiology of these injury events beyond the mechanisms that lead to trauma. One prevention recommendation that is often cited is the need for parents to provide "more" or "better" supervision of children in the agricultural worksite.<sup>12,13,14,15,16</sup> Yet, there is virtually nothing known about the quality of adult supervision on the farm or the nature of supervision at the time of injury.

In the general pediatric injury literature there has been increasing interest in studying supervisory behaviors by caregivers and relating these behaviors to child injury risk.<sup>17</sup> Although there is little agreement among professionals about what constitutes adequate supervision to prevent childhood injury,<sup>18</sup> prospective study designs have recently been used to track home injuries to children and to identify patterns of supervision associated with increased risk of children.<sup>19,20,21</sup> Based on this research, three dimensions of supervisory behaviors have emerged as important: 1) attention to the child (watching, listening), 2) proximity of the supervisor (close proximity to the child allows for greater readiness to intervene), and 3) continuity of supervisory behaviors in time (extent of sustained attention and proximity to the child over time). Thus, supervision refers to behaviors that index attention (watching and listening) in interaction with proximity (within arm's reach, beyond arm's reach) examined over time to index continuity.

This supervision framework posits that as attention, proximity, and continuity increase, the quality of supervision increases and the risk of injury presumably decreases.<sup>7'22</sup>

Building on these findings, the purpose of this study was to explore the nature of adult supervision among pediatric farm injury cases using the supervision dimensions of attention, proximity, and continuity. Our specific objectives were to review existing cases of traumatic pediatric farm injury and 1) describe the patterns of supervision by age of the child, gender of the child, child activity, and location of the injury event, and 2) determine whether patterns of supervision observed in association with these injury events were consistent with the existing principles used to describe adequate adult supervision in the general pediatric injury literature.

## **Methods**

**Study Design.** A review of two retrospective case series of pediatric agricultural injuries that had been previously assembled for a study on the efficacy of the child labor laws for injury prevention was conducted.<sup>23</sup> The case series represented fatal and hospitalized injuries from Canada, as well as fatal work-related injuries from the United States.

**Definitions.** For the purpose of this study, pediatric farm injuries were defined as any injuries to children (younger than 18 years) that 1) occurred during activities related to agricultural production and/or 2) involved any operational hazard or activity associated with the agricultural worksite. Injury cases with no information on adult supervision were excluded (197/531, 37%) .

#### Data Sources

**Fatal Injuries.** All fatal pediatric agricultural injuries for the calendar years 1990-2001 were identified by personnel at each of the 10 provincial coroners' and medical examiners' offices in Canada, using all available registries (e.g., vital statistics, ministry of labor, coroner's registry, farm safety associations). Written investigation reports and death certificates were reviewed on-site at each provincial coroner's office. The Canadian fatality case series was supplemented with 13 occupational fatality case reports from the United States that were investigated by the National Institute for Occupational Safety and Health, Fatal Assessment and Control Evaluation program for the years 1992-2000.<sup>24</sup>

**Hospitalized Injuries.** Research agreements were established with five regional pediatric hospitals (three in Ontario, two in Alberta) and one general hospital (Alberta) in Canada to permit access to individual medical records for pediatric agricultural injuries for the years 1989-2002. The hospitals identified cases using both inpatient and emergency department based registries. Medical records were reviewed on-site after ethics review at each institution.

**Instrument.** A standardized instrument and study glossary for coding supervision were developed incorporating the theoretical dimensions of 1) attention, 2) proximity, and 3) continuity.<sup>17</sup> For this study, we operationally defined *attention* to mean that an adult was available to supervise the child. *Proximity* was operationalized to mean that the adult supervisor was within arm's reach of the child (e.g., in the tractor cab with the adult) or near the child (e.g., in the vicinity of the adult who is operating equipment). There were no formal measures of distance taken, rather proximity was judged based on the narrative information provided about the circumstances of the injury (e.g., location of child relative to others). *Continuity* was assumed

to exist unless there was documented evidence in the record that there was a break in the continuity of adult supervision (e.g., parent reported "only taking their eyes off the child for a minute") prior to injury.

The 6-item supervision instrument was pilot tested by two study investigators through independent review of multiple sets of sample cases. All discrepancies were identified and the instrument and study glossary were refined to improve clarity and consistency.

**Data Collection.** The original case series of pediatric farm injuries was already assembled from a previous study<sup>23</sup> and was available electronically. Two investigators reviewed these cases and applied the supervision instrument. When disagreements in coding occurred, they were resolved by discussion in order to ensure consistency in applying the coding template across all injury cases. Data quality checks were established to ensure that data were collected and entered accurately.

**Data Analysis.** Descriptive statistics were used to characterize the injury cases and the patterns of supervision.

## Results

Full Case Series. There were 334 injured children in the full case series (Table 1) and more than half were 6 years or younger (172/334, 51%). The majority of injured children were male (264/334, 79%), lived on the farm (260/334, 78%), and were the children of the farm owner/operator (254/334, 76%). Most (228/334, 68%) were not involved in farm work at the time of injury.

Attention (Availability of an Adult Supervisor). An adult supervisor was available for the majority of pediatric farm injury cases (Table 2). However, for nearly one-third of the injured children (103/334, 31%), there was no adult supervisor available at the time of injury. Even 20% (34/172) of the children 6 years and younger were unsupervised at the time of injury.

Proximity. Roughly one-half of the time (169/334, 51%), the adult supervisor was proximal to the child at the time of injury (Table 2), and this percentage was somewhat higher for children 6 years or younger (104/172, 60%). By farm location, the supervisor was proximal to the child most often for injury events that occurred in the crop field (42/55, 76%). Approximately one-half of these crop field injuries involved children as extra riders on farm tractors (data not shown). The supervisor was less often proximal to the child if the injury occurred in the barn (17/62, 27%).

Continuity. Despite our conservative interpretation of *continuity*, continuous adult supervision was present in only 37% (123/334) of the full case series (Table 2). This finding was consistent regardless of the child's age, gender, activity, or location on the farm, with the

exception of the crop field, where supervision was continuous in 56% (31/55) of the cases. Similar to the findings for *proximity*, approximately half of these crop field injuries involved children who were extra riders on tractors (data not shown).

**Adequacy of Adult Supervision.** For the full case series, one-third of the children had what would typically be defined as *adequate* adult supervision at the time of their injury event (supervision available, proximal, and continuous) and this was consistent across age, gender, and child activity (Table 2). By farm location, only 19% (12/62) of children injured in the barn had *adequate* supervision, while 55% (30/55) of children injured in the crop field had *adequate* supervision, again reflecting the preponderance of extra rider injuries.

**Possible Compromises to Adequate Adult Supervision.** Table 3 further describes the supervision circumstances among the 231 cases where an adult supervisor was available. In the overwhelming majority of cases (193/231, 84%), the adult supervisor was simultaneously engaged in farm work while supervising the injured child (48% of the cases with *adequate* supervision, data not shown) and this was quite consistent across age, gender, child activity, and location on the farm. In 26% (59/231) of cases, the adult supervisor was simultaneously supervising multiple children. Interestingly, in 16% (37/231) of cases, there were multiple adult supervisors available at the time of injury to the child. However, this often reflected their working together on chores and clearly did not result in greater supervision and protection of the child.

## Discussion

## ..... Agriculture ....

Drawing on recent research in the general pediatric injury literature, this study examined three aspects of supervision (attention, proximity, continuity) in order to assess the nature of adult supervision at the time of pediatric farm injury occurrence and determine if emerging conceptualizations of *adequate* adult supervision apply to the farm context." Our findings showed that among cases of injured children, the quality of adult supervision was frequently compromised. Yet, even in the presence of what would typically be defined as *adequate* adult supervision (supervision available, proximal, and continuous) children exposed to the agricultural worksite were still seriously injured or killed.

Attention (Availability of an Adult Supervisor). Although we did not code actual *attention* to the child per se, availability of an adult supervisor provides for the opportunity of attention to the child. In two previous studies of pediatric farm injuries, investigators also coded whether or not a supervisor was present at the time of injury. Their results revealed that children were often in the vicinity of potential supervisors when injured.<sup>25,26</sup> Thus, it was poor quality of supervision and not the absence of a supervisor that posed risk for injury. Our findings replicate and extend these results. We found that 69% of the injured children were in the presence of a potential adult supervisor at the time of injury. Moreover, having more than one adult supervisor available did not necessarily protect children from injury. Across the age groups, 10-20% of injuries occurred when there were multiple potential supervisors present. Further, in the vast majority of injury cases, the potential supervisor was engaged in farm work at the time the child was injured.<sup>26</sup> In fact, Pryor et al<sup>25</sup> found that children were significantly more likely to experience an injury when supervised by a caregiver engaged in farm work than when supervised by a caregiver at home. This pattern of findings suggests that adult supervisors cannot

simultaneously be involved in farm work and provide the level of *attention* that is needed to protect children in a hazardous work environment.

**Proximity.** The most striking finding surrounding the *proximity* dimension of supervision was the paradoxical nature of this dimension. In approximately 50% of the injury cases, the adult supervisor was too far away from the child to intervene to prevent the injury and this supports the importance of *proximity* as a key dimension in defining *adequate* supervision. However, in the other 50% of the injury cases (Table 2, all cases), it was the adult supervisors' *proximity* to the child that contributed to the injury event via exposure to hazardous situations, such as the child being an extra rider on a tractor. The fact that supervisors were engaged in farm work could explain why, despite the supervisor's *proximity* to the child, the supervisor was unable to intervene to protect the child from injury. Thus, while research shows that *proximity* to an adult supervisor is protective in non-farm contexts,'<sup>9,2021</sup> our findings suggest that it can actually serve as a risk factor for childhood injury in the agricultural worksite, particularly if the supervisor is engaged in farming activities.

**Continuity.** Our measure of *continuity* was admittedly atypical in that we assumed *continuity* and coded for discontinuity, only when there was clear evidence for this based on the narrative in the case record. Nonetheless, in nearly two-thirds of the cases there was an obvious break in the *continuity* of adult supervision before the child was injured. This finding highlights the difficulty of providing continuous supervision in the agricultural worksite.

Adequacy of Adult Supervision. The present analysis clearly demonstrates that the quality of supervision was inadequate in a substantial number of pediatric farm injury cases. Compromises to *adequate* supervision included a range of circumstances from the absence of an adult supervisor to distractions that resulted in breaks in *continuity* of supervision.

Perhaps even more revealing was the number of pediatric farm injuries and fatalities that occurred in the presence of what would typically be defined as *adequate* adult supervision (supervision available, proximal, and continuous). Thus, in order to protect children from injury in the agricultural worksite, we either need different standards for defining *adequate* supervision *or* we need to restrict children's access to this hazardous work environment.<sup>4,27</sup> Further research is needed to identify typical patterns of adult supervision on farms and how these patterns impact injury risks. However, there is considerable evidence herein to suggest that restricting children's access to work environments on farms may be essential to reduce their risk of injury.

Strengths and Limitations. To our knowledge, this study is the first to explore the nature of adult supervision in the agricultural worksite and it fills a critical gap in the literature. Further, we used a theoretical model of supervision that has shown utility in the general pediatric injury literature. Nonetheless, several potential limitations should be considered in interpreting the findings and planning for future research on this topic.

First, we evaluated adult supervision in cases of injury, not supervision on farms in general, so we are in fact looking at cases where adult supervision failed. Thus, our findings cannot speak to the more general issue of whether and under what conditions supervision impacts to serve as a protective function regarding children's risk of injury on farms. We need studies to establish baseline levels of supervision (e.g., what patterns of supervision are *routinely*

provided by adults on farms), so that one can then differentiate those patterns that are associated with child injury from those that are not.

Second, our data were based upon records collected for other purposes and the lack of detail surrounding the description of adult supervision at the time of the pediatric injury event constrained our ability to apply more rigorous indices of supervisory behaviors. Thus, we can only discuss availability of a potential adult supervisor but do not know whether or not the supervisor was actually attending to the child. Similarly, based on the fact that discontinuity or breaks in adult supervision before the child was injured were noted in the case information, we assumed that failure to note this in the record indicated *continuity* of adult supervision at the time the child was injured. However, this assumption certainly merits further study.

Third, our findings are heavily based upon Canadian pediatric injury records because these data were not available in the United States. However, leading causes of traumatic injury in this case series are very similar across countries. In addition, although regional differences exist, the leading types of crops and livestock produced on farms are also similar.<sup>28,29</sup> Thus, our findings are likely generalizable to the United States pediatric farm population.

Finally, the research to date that has provided a foundation for developing a definition of *adequate* adult supervision (attention, proximity, continuity) has focused exclusively on children under 6 years of age.<sup>9,20,21</sup> Thus, our application of this definition of *adequate* adult supervision to children 6 years and older has been previously untested. Moreover, the current findings suggest that it is also essential that one consider the context in which this supervision is provided to evaluate whether supervisory patterns serve a risk or protective function for childhood injury. Clearly, the present results suggest that what constitutes *adequate* supervision in a non-farm context<sup>21</sup> does not necessarily serve the same function in an agricultural context.

## **Conclusion**

Inadequate adult supervision was common among our case series of pediatric farm injuries. Nonetheless, even in the presence of what traditionally would be defined as *adequate* adult supervision according to accepted theoretical criteria (attention, proximity, continuity), children exposed to the agricultural worksite still were seriously injured or killed. Thus, we either need to develop new standards for defining *adequate* adult supervision in the agricultural worksite or we need to restrict children, especially the very young, from this hazardous worksite.

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**Table 1. Description of Injured Children Under Study**

|                                  | Fatal Injuries<br>(No. = 175) |      | Hospitalized Injuries<br>(No. = 159) |      | Total<br>(No. = 334) |      |
|----------------------------------|-------------------------------|------|--------------------------------------|------|----------------------|------|
|                                  | No.                           | %    | No.                                  | %    | No.                  | %    |
| Age in years                     |                               |      |                                      |      |                      |      |
| < 6                              | 90                            | 51.4 | 82                                   | 51.6 | <b>172</b>           | 51.5 |
| 7-12                             | 38                            | 21.7 | 48                                   | 30.2 | 86                   | 25.7 |
| 13-17                            | 47                            | 26.9 | 29                                   | 18.2 | 76                   | 22.8 |
| Gender                           |                               |      |                                      |      |                      |      |
| Male                             | 141                           | 80.6 | 123                                  | 77.4 | 264                  | 79.0 |
| Female                           | 34                            | 19.4 | 36                                   | 22.6 | 70                   | 21.0 |
| Child lives on farm?             |                               |      |                                      |      |                      |      |
| Yes                              | 126                           | 72.0 | 134                                  | 84.3 | 260                  | 77.8 |
| No                               | 32                            | 18.3 | 23                                   | 14.5 | 55                   | 16.5 |
| Unknown                          | 17                            | 9.7  | 2                                    | 1.3  | 19                   | 5.7  |
| Relationship to owner            |                               |      |                                      |      |                      |      |
| Child of owner                   | 121                           | 69.1 | 133                                  | 83.6 | 254                  | 76.0 |
| Other relative of owner          | 15                            | 8.6  | 10                                   | 6.3  | 25                   | 7.5  |
| Child/relative of hired employee | 4                             | 2.3  | 1                                    | 0.6  | 5                    | 1.5  |
| Visitors to farm                 | 10                            | 5.7  | 7                                    | 4.4  | 17                   | 5.1  |
| Other/unknown                    | 25                            | 14.3 | 8                                    | 5.0  | 33                   | 9.9  |
| Child engaged in farm work       |                               |      |                                      |      |                      |      |
| Yes                              | 53                            | 30.3 | 47                                   | 29.6 | 100                  | 29.9 |
| No                               | 121                           | 69.1 | 107                                  | 67.3 | 228                  | 68.3 |
| Unknown                          | 1                             | 0.6  | 5                                    | 3.1  | 6                    | 1.8  |
| Adult supervisor available       |                               |      |                                      |      |                      |      |
| Yes                              | 128                           | 73.1 | 103                                  | 64.8 | 231                  | 69.2 |
| No                               | 47                            | 26.9 | 56                                   | 35.2 | 103                  | 30.8 |

**Table 2. Description of Patterns of Child Supervision Observed in Farm Injury Events by Four Standard Criteria for Adequate Child Supervision**

|                           | Description of Adult Supervision (% of Cases) |                |           |     |      |     |                     |               |      |
|---------------------------|-----------------------------------------------|----------------|-----------|-----|------|-----|---------------------|---------------|------|
|                           | Cases                                         | Attenti<br>on* | Proximal† |     |      |     | Conti<br>nuou<br>s§ | Adequ<br>ate5 |      |
|                           |                                               |                | No.       | %   | No.  | %   |                     | No.           | %    |
| All cases                 | 334                                           | 231            | 69.2      | 169 | 50.6 | 123 | 36.8                | 112           | 33.5 |
|                           |                                               |                |           |     |      |     |                     |               |      |
| Age in years              |                                               |                |           |     |      |     |                     |               |      |
| ≤ 6                       | 172                                           | 138            | 80.2      | 104 | 60.5 | 65  | 37.8                | 62            | 36.0 |
| 7-12                      | 86                                            | 56             | 65.1      | 38  | 44.2 | 33  | 38.4                | 27            | 31.4 |
| 13-17                     | 76                                            | 37             | 48.7      | 27  | 35.5 | 25  | 32.9                | 23            | 30.3 |
|                           |                                               |                |           |     |      |     |                     |               |      |
| Gender                    |                                               |                |           |     |      |     |                     |               |      |
| Male                      | 264                                           | 179            | 67.8      | 132 | 50.0 | 95  | 36.0                | 87            | 33.0 |
| Female                    | 70                                            | 52             | 74.3      | 37  | 52.9 | 28  | 40.0                | 25            | 35.7 |
|                           |                                               |                |           |     |      |     |                     |               |      |
| Child activity            |                                               |                |           |     |      |     |                     |               |      |
| Engaged in farm work      | 100                                           | 61             | 61.0      | 42  | 42.0 | 38  | 38.0                | 33            | 33.0 |
| Not engaged in farm work  | 228                                           | 165            | 72.4      | 123 | 53.9 | 82  | 36.0                | 76            | 33.3 |
| Unknown                   | 6                                             | 5              | 83.3      | 4   | 66.7 | 3   | 50.0                | 3             | 50.0 |
|                           |                                               |                |           |     |      |     |                     |               |      |
| Farm location (top three) |                                               |                |           |     |      |     |                     |               |      |
| Farm yard                 | 88                                            | 59             | 67.0      | 43  | 48.9 | 24  | 27.3                | 23            | 26.1 |
| Barn (inside)             | 62                                            | 39             | 62.9      | 17  | 27.4 | 15  | 24.2                | 12            | 19.4 |
| Crop field, orchard       | 55                                            | 46             | 83.6      | 42  | 76.4 | 31  | 56.4                | 30            | 54.5 |

Adult supervisor was available.  
† Supervisor within arm's reach or near to the child.  
§ No evidence of a break in continuity of supervision.  
|| Criteria 1, 2, 3 met.

**Table 3. Description of Possible Compromises to the Quality of Child Supervision Among 231 Cases Where Adult Supervisor was Available**

|                           | Cases<br>No. | Supervisor Engaged in<br>Farm Work |      | Supervising<br>Multiple<br>Children |      | Multiple Supervisors |      |
|---------------------------|--------------|------------------------------------|------|-------------------------------------|------|----------------------|------|
|                           |              | No.                                | %    | No.                                 | %    | No.                  | %    |
| All cases                 | 231          | 193                                | 83.5 | 59                                  | 25.5 | 37                   | 16.0 |
| Age in years              |              |                                    |      |                                     |      |                      |      |
| < 6                       | 138          | 118                                | 85.5 | 38                                  | 27.5 | 25                   | 18.1 |
| 7-12                      | 56           | 44                                 | 78.6 | 17                                  | 30.4 | 6                    | 10.7 |
| 13-17                     | 37           | 31                                 | 83.8 | 4                                   | 10.8 | 6                    | 16.2 |
| Gender                    |              |                                    |      |                                     |      |                      |      |
| Male                      | 179          | 154                                | 86.0 | 48                                  | 26.8 | 26                   | 14.5 |
| Female                    | 52           | 39                                 | 75.0 | 11                                  | 21.2 | 11                   | 21.2 |
| Child activity            |              |                                    |      |                                     |      |                      |      |
| Engaged in farm work      | 61           | 57                                 | 93.4 | 8                                   | 13.1 | 7                    | 11.5 |
| Not engaged in farm work  | 165          | 132                                | 80.0 | 49                                  | 29.7 | 28                   | 17.0 |
| Unknown                   | 5            | 4                                  | 80.0 | 2                                   | 40.0 | 2                    | 40.0 |
| Farm location (top three) |              |                                    |      |                                     |      |                      |      |
| Farm yard                 | 59           | 50                                 | 84.7 | 25                                  | 42.4 | 11                   | 18.6 |
| Barn (inside)             | 39           | 23                                 | 59.0 | 7                                   | 17.9 | 6                    | 15.4 |
| Crop field, orchard       | 46           | 45                                 | 97.8 | 12                                  | 26.1 | 9                    | 19.6 |

# **Pediatric Fall Injuries in Agricultural Settings: A New Look at a Common Injury Control Problem**

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This study was funded by the Centers for Disease Control and Prevention/National Institute for Occupational Safety and Health (R01 OH008046).

The authors thank Marshfield Clinic Research Foundation for its support through the assistance of Linda Weis and Alice Stargardt in the preparation of this manuscript.

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## Abstract

*Objectives: Children on farms experience high risks for fall injuries. This study characterized the causes and consequences of fall injuries in this pediatric population. Methods: A retrospective case series was assembled from registries in Canada and the United States. A new matrix was used to classify each fall according to initiating mechanisms and injuries sustained upon impact. Results: Fall injuries accounted for 41% (484/1193) of the case series. Twenty-one percent of the fall injuries were into the path of a moving hazard (complex falls), and 91 % of complex falls were related to farm production. Sixty-one percent of complex falls from heights occurred while children were not working. Fatalities and hospitalized injuries were over-represented in the complex falls. Conclusions: Pediatric fall injuries were common. This analysis provides a novel look at this occupational injury control problem.*

Keywords: agriculture; children; safety; wounds and injuries

falls are among the most common types of injury experienced in North American populations and are the leading cause of non-fatal childhood injury.<sup>1-4</sup> In most pediatric settings, fall injuries are generally experienced while children are walking, running, or engaged in recreational activities. Falls from heights are also common and typically involve children falling from stairs, beds and playground equipment.' Falls involving children rarely result in death. Those that do typically involve children falling from excessive heights and landing on surfaces that impart major trauma to the head.<sup>4,6,7</sup>

In a recent policy statement, the American Academy of Pediatrics described common fall injury patterns and presented a number of recommendations for prevention. The latter focused on falls from heights such as windows, balconies and roofs,<sup>4</sup> and mainly cited evidence from urban-based studies. Pediatric falls in other settings (eg, rural settings, occupational environments) were not presented nor discussed. This may have occurred due to a lack of contextual evidence about falls involving some pediatric populations. In occupational settings, existing labor laws generally restrict children from entering the workplace and as a result pediatric falls may not be perceived to be a problem. This may also be the perception for children in farm settings. However, farms are an occupational setting where many fall injury hazards are present and potentially accessible to large populations of children.<sup>8</sup>

Underlying causes of pediatric fall injuries in the farm environment can be complex. Studies that describe the epidemiology of falls in agricultural settings do exist,<sup>9-11</sup> yet most existing studies have not characterized the multifactorial nature of fall injury events. Mechanisms associated with different types and severities of fall injury in these settings are not well documented. Combinations of farm worksite hazards that result in more serious types of pediatric fall injuries have also not been identified. This presents a challenge for the ongoing

planning of fall injury prevention programs on farms, but also an opportunity for a more in-depth investigation.

We had the opportunity to use an existing registry of traumatic farm injuries to profile the occurrence of fall-related injuries to children on farms. Individual fall injury events were classified using a new matrix that considers both the initiating mechanisms of falls and the types of hazards that lead to injury upon impact. We used this analysis to identify specific patterns of pediatric fall injuries that differentially lead to serious forms of injury. Our hope was that this analysis would provide foundational information to inform prevention efforts, as well as the ongoing study of pediatric fall injuries on farms and in other settings.

## **Methods**

The study involved a primary review of a registry of pediatric farm injuries totaling 1,193 injury events from four data sources. The latter were assembled to represent fatal injuries, hospitalized injuries, and two forms of restricted activity injuries (among the general farm population and the minority farm population). Our ethics committees approved the study protocol.

## **Definitions**

Pediatric farm injuries were defined as injuries to children younger than 18 years that occurred at a farm work site (including the farm house yard) and/or during activities related to the operation of a farm. Injuries that occurred inside the farm residence were excluded.<sup>12</sup> Pediatric farm injuries involving falls were defined inclusively as any injury event that involved: 1) a fall on the same level (including slips/trips), or, 2) a fall from a height, irrespective of the

location that children fell from. Falls were identified from pre-existing codes in combination with narrative descriptions of injury events.

### Fall Matrix

A matrix was developed to classify fall injuries according to both the initiating fall mechanism (four categories: falls from stationary objects on the same level, falls from moving objects on the same level, falls from stationary heights, or falls from moving heights), as well as the type of physical injury sustained upon impact (four categories: blunt, penetrating, submersion, or complex fall injuries). For classification purposes, blunt, penetrating, and submersion injuries were coded using standard categories used in the trauma literature.<sup>13</sup> Complex fall injuries were operationally defined as those where the child fell into the path of a moving or operating hazard(s), and were subsequently injured in any manner.

The complete fall matrix is presented as Table A (supplementary). Because falls from moving objects on the same level ( $n = 5$ ) and penetrating injuries ( $n = 8$ ) were both uncommon in our registry, some cells from the matrix were merged for the present analysis. The working matrix used in the current analyses therefore was represented using a 3 by 3 structure (Table 1).

### Data Sources

#### *Fatalities*

Fatality data were obtained using methods developed by the Canadian Agricultural Injury Surveillance Program (CAISP).<sup>14</sup> CAISP contains a comprehensive, population-based fatal injury dataset. Canada has farming practices and child labor laws that are analogous to that observed in much of the United States,<sup>15-17</sup> and Canadian fatalities are considered to be typical of

the spectrum of pediatric agricultural fatalities experienced in North America. An enhanced database was developed that contained every known case of a fatal agricultural childhood injury experienced in Canada between 1990 and 2000. The Canadian fatality case series data were supplemented with 17 United States occupational fatality case reports from the National Institute for Occupational Safety and Health Fatal Assessment and Control Evaluation program for the years 1992-2000.<sup>18</sup>

### *Hospitalized injuries*

Similar to fatalities, a national registry of hospitalized farm injury cases has been developed in Canada.<sup>19</sup> We used the CAISP case identification approach to identify injured children treated at five regional pediatric hospitals and two general hospitals in Canada. These hospitals were from the provinces of Alberta and Ontario. A study period of 1990-2000 was used for the hospitalized injury portion of this study.

### *Restricted activity injuries*

Data files from the 1998 Childhood Agricultural Injury Survey<sup>20</sup> and 2000 Childhood Agricultural Injury Survey on Minority-Operated Farms<sup>21</sup> were obtained electronically from the National Institute of Occupational Safety and Health. Injuries identified within these surveys represent a spectrum of pediatric farm injuries that resulted in at least 4 hours of restricted activity or required medical care. Data for both surveys were collected by telephone interview from random samples of United States farm operators. Analogous data were not available in Canada.

## Instrument

A standardized data abstraction instrument was developed. This instrument was informed by existing literature and occupational injury classification systems that included falls.<sup>22-27</sup> A study glossary was developed to support application of the instrument. This detailed the exact specifications and circumstances under which fall injury events were to be coded. Data elements covered within the instrument included case demographics, detailed descriptions of the injury event, factors associated with the initiation of the fall injury event (narrative description of where children fell from: documented evidence of falls from height vs. falls on the same level, documented evidence of falls from a moving vs. stationary hazard), and factors associated with the impact of the fall injury event (narrative description, documented evidence of blunt, penetrating, submersion, complex injury).

## Case Identification

Using a standard protocol, three investigators independently abstracted and coded all 1,193 cases according to whether a fall was involved in the injury event. We took a liberal approach to the identification of fall injuries and included all events where there was direct evidence of a fall injury mechanism, as per our operational definitions. An initial series of 50 cases was selected purposefully to represent a variety of potential mechanisms of pediatric farm injury. Three raters coded each of the 50 cases according to whether a fall was involved. Discrepancies in inclusions/exclusions among these 50 cases were resolved by consensus, and the coding exercise was repeated with a second series of 50 cases and written decision rules. This resulted in almost perfect agreement on inclusions/exclusions. The full case series was then coded, resulting in the identification of 484 fall injury events (40.6% of the full case series).

### Classification of Fall Injury Events

A second coding protocol was developed using a series of validation exercises. In each exercise, 20 randomly selected cases were reviewed and coded by the three raters according to the fall matrix and associated instrument. Inter-rater agreement was then assessed. All disagreements were resolved through discussion, and the coding protocol and study glossary were updated. This process was repeated 3 times, and agreement reached 90% in the third exercise and the final case review proceeded. Any subsequent uncertainties in coding were resolved by consensus.

### Data Analysis

We profiled the fall injury case series according to data source, demographic factors, and fall-related study variables. Subsequent analyses described these injuries according to the fall matrix and other salient descriptors (age group, location of injury, activity leading to injury, data source, nature/anatomical site of injury). All analyses were descriptive.

### Prevention Priorities

Priorities for injury prevention were identified based upon an *a priori* criterion. We first described patterns of injury using the new matrix. For each of the nine cells in the matrix, we calculated percentages of injuries within that cell that had a particular characteristic, and compared those percentages with the percentage expected if the characteristic was randomly distributed. For example, one important descriptor is the age group of children injured by falls. We therefore calculated the percentage of injured children described in each cell for a particular

age group, and compared the cell proportions to the overall proportion of children in the particular age group. A fall injury priority was chosen if the proportion within the cell of the matrix was greater than the expected overall proportion for that characteristic.

## Results

### Overview

Results include description of the fall injury events according to the working version of the fall matrix (Table 1) and other major descriptors (Table 2). Next, illustrative versions of the fall matrix are presented with shaded cells identifying priorities for prevention for young children (Table 3) and child activities associated with work and production hazards (Table 4). Finally, leading natures and anatomical sites of injury associated with different cells of the matrix are summarized (Table 5). The observed patterns of fall injury lead to a number of summary observations.

#### *Falls are a relatively common form of injury experienced by children on farms*

Fall injuries accounted for 484/1193 (40.6%) of the injuries contained in the registry, a proportion that was consistent across data sources. The case series included 100 fatalities, 155 hospital admissions, and 229 restricted activity injuries.

#### *A number of hazards on farms are commonly associated with fall injuries to children*

Farm children fall in a number of different places and from a variety of associated hazards.

Although some variations were observed by data source (Table 2), leading locations of fall injury

included farm yards and barns. Children fell most commonly from horses, ground surfaces, and tractors. Approximately three-quarters of the falls were onto the ground or floor surfaces.

*Fall injury prevention priorities differ by age group and activity*

Priorities were selected by comparing observed versus expected percentages in cells of the fall injury matrix. To illustrate, priorities in the youngest (ages 0-6) children were falls from heights, submersion injuries, and complex falls (Table 3). Among 7-12 year olds, all forms of blunt injuries were identified as priorities, while among 13-17 year olds, blunt and complex injuries from falls on the same level were identified (data not shown; see supplementary Table B). Few injuries from a stationary height were experienced in this older age group.

There were also varying priorities identified by child activity (Table 4; see also supplementary Table C). Approximately 70% (333/484) of the fall injury events happened in the farm production environment, yet two-thirds of these cases (222/333; 66.6%) happened when the child was not working. Complex falls were almost exclusively associated with production activities (90/99; 90.9%). Initiating events associated with children who were working typically happened on the same level (12/15; 80.0%), whereas the initiating events for children injured while not working were primarily from heights (51/84; 60.7%). Submersions most often happened to children who were not working (30/35; 85.7%). However, these injuries were frequently associated with farm production hazards (eg, manure lagoons). Non-production hazards and activities accounted for approximately one-quarter of the case series. The latter hazards were not associated with complex injuries (5/99; 5.1%) and more often resulted in submersions (11/35; 31.4%) and blunt/penetrating injury (109/350; 31.1%).

*Fall injuries to children on farms can have serious consequences. Some mechanisms are lethal.*

Blunt/penetrating, injuries were common in all three categories of initiating events. However, these injuries were typically non-fatal (see supplementary Table D). The vast majority of submersion injuries were fatal (32/35; 91.4%). Complex mechanisms of injury typically involved production hazards (90/99; 90.9%) and resulted in fatality (52/99; 52.5%) or hospitalization (39/99; 39.4%). Complex mechanisms of injury rarely occurred in non-worksite environments (5/125; 4.0%). The relative severities of the different fall injury mechanisms are reflected in the natures and anatomical sites of injury sustained (Table 5). Blunt injuries from falls on the same level typically resulted in lacerations and soft tissue injuries, with fractures becoming more common with the involvement of heights. All submersion injuries involved asphyxiation. The more complex injury mechanisms were dominated by major injuries to the head, chest, and lower limbs, reflecting a relatively high level of severity compared with the purely blunt mechanisms.

## **Discussion**

This study profiles patterns of pediatric fall injuries that are unique to the farm worksite, and the medical consequences of these pediatric fall injury events. A new fall injury matrix was developed and proved useful in the delineation of prevention priorities. The results illustrate the importance and unique severity of this common pediatric injury control problem, and the observed patterns provide foundational information that can be applied to the development of injury prevention strategies surrounding known occupational hazards. The matrix itself could also be applied to the study of causes and consequences of fall injuries in other research contexts.

The operational definition of a fall injury used in this analysis was not constrained by traditional definitions. This meant that we included all pediatric injury events that involved a fall

mechanism, irrespective of the fact that these events might not be viewed as falls in existing coding systems.<sup>1-28</sup> Using this approach, we observed that 4 in 10 traumatic injuries on farms were caused by falls, a substantial proportion that exceeded prior estimates. Examples of the types of falls that might have been excluded previously included falls involving animals, falls from operating vehicles and agricultural machinery, and some asphyxiations that involved a fall. We would argue that the magnitude of the fall injury problem may have been underestimated in past work, which in turn limited prevention efforts surrounding this problem.

Our case series described a number of conventional types of falls that resulted in serious consequences because of the innately hazardous nature of the farm production environment. Examples include falls from structures (haylofts; ladders) that involved significant heights, falls into the path of animals, and complex falls involving operating machinery. The latter are especially traumatic, typically resulting in lower limb fractures, intracranial injuries, and major crush injuries. While there is no evidence to suggest that children on farms have a propensity to fall more often than other children, the consequences of a fall in the farm worksite can be especially severe due to the hazards present in the farm work environment. In some circumstances, such as those involving children falling into the path of operating machinery, the injury consequences appear to be so severe that complete avoidance is the safest option.' The fall itself is not the full problem; it is the hazardous environment that the child is permitted to occupy whether he/she is at work or at play that compounds the traumatic injury.

The fall matrix developed for this analysis provides a useful tool for the characterization of fall injury events. It does this by considering circumstances associated with the initiation of the fall, as well as the nature of the injuries sustained, due to hazards associated with its impact. Both dimensions are important. Clearly, the height, movement, and exact nature of the hazards that

children are falling from are important determinants of injury type and severity that inform primary prevention efforts. Knowledge of what children are falling onto or into is also important because the nature of these hazards may also dictate both the types and consequences of injuries sustained. This is of relevance to both secondary (minimizing the impact of fall events) and tertiary (treatment related) prevention strategies.<sup>29</sup>

With respect to primary prevention strategies, rules that restrict children from gaining access to heights<sup>30</sup> or mechanized hazards,<sup>31</sup> as well as the installation of passive safety barriers for younger children,<sup>32</sup> are most likely to be effective. Secondary prevention strategies that minimize the potential for physical injury once a fall injury event has occurred include the use of helmets for common recreational pursuits on farms,<sup>33</sup> automated warning and braking systems on farm vehicles that limit the opportunity for a falling person to be injured by moving equipment,<sup>34</sup> and development of practical, impact-resistant surfaces that can be installed surrounding structural fall hazards. Finally, identification of the common types of injury experienced under different fall circumstances assists in the planning of tertiary strategies. These include optimization of first aid training and development of diagnostic and treatment protocols for ambulatory and hospital-based medical care.

Strengths and limitations of this analysis warrant recognition. The study is unique in that it profiles the occurrence of fall injuries to children in an occupational setting. This is one of only a few existing analyses that have examined this problem specifically and comprehensively within the agricultural sector. We used a novel descriptive approach and developed a new matrix that can be used to profile the occurrence of fall injuries. Although developed using pediatric data, the matrix is likely applicable to the description of fall injuries in other demographic groups. It is also portable to other occupational settings with mechanical and height-related risk factors. We

took steps to ensure the reliability and validity of our data collection methods and case interpretations. With respect to limitations, although our study examined a large case series, we were restricted to available data sources and the data sources were likely to have poor coverage of minor fall events. The absence of estimates of person-years of exposure to various activities also precluded the calculation of rates and associated estimates of effect.

## **Conclusion**

This novel study addressed an unappreciated public health problem on North American farms, the occurrence of fall injuries to populations of children. This was accomplished through descriptive analyses as well as the development of a new matrix used to characterize important patterns of fall injuries. Findings from our study provide strong and objective evidence in support of the following: 1) fall injuries are common among children on farms, 2) the farm worksite possesses a unique set of operational hazards that make exposed children especially vulnerable to serious fall injuries, and 3) the medical consequences of specific types of fall injury events (complex injuries) are particularly severe. Overall, the results present a compelling case that falls are a common and traumatic injury control problem for children on farms. This pediatric health issue is not fully recognized in clinical circles, and is certainly worthy of additional prevention efforts that focus on farm environments.

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### **Key Messages**

- Approximately 40% of injuries to children sustained in farm occupational environments are attributable to falls.
- While some of these fall injury events involve children at work, they more typically happen when non-working children are present in the farm occupational worksite.
- The natures and severities of injuries sustained by children differ according to combinations of initiating mechanisms and the specific environmental hazards that children impact upon as a result of a fall.

We present a new matrix to assist in the classification of falls for research and prevention purposes.

Medical consequences are especially traumatic for falls involving specific farm production hazards, including structural heights, fall-related submersions, and falls into the path of moving machinery or animals.

### **Implications for Policy**

The magnitude and severity of the pediatric fall injury problem on farms need to be recognized as health priorities by public health professionals.

Prevention efforts need to focus on policies and engineered solutions that keep children physically separated from fall injury hazards.

Solutions to some of the observed injury patterns (eg, complex injuries where young children fall into the path of operating machinery) will ultimately involve policies that aim to remove children from the farm worksite.

**TABLE I**  
Distribution of Pediatric Fall Injuries in the Case Series According to the 3 by 3 Working Version of the Fall Injury Matrix

| Initiation of Fall     | Impact of Fall           |                   |                     | Total |
|------------------------|--------------------------|-------------------|---------------------|-------|
|                        | Blunt/Penetrating Injury | Submersion Injury | Complex Fall Injury |       |
| <b>On</b> same level   | 53                       | 10                | 15                  | 78    |
| From stationary height | 135                      | 22                | 9                   | 166   |
| From moving height     | 162                      | 3                 | 75                  | 240   |
| Total                  | 350                      | 35                | 99                  | 484   |

The full matrix is available as a supplemental file [insert website address]

Table 2

**TABLE 2**  
Overall Description of Injury Circumstances Associated with Pediatric Fall Injuries

| Injury                    | Fatalities |       | Hospitalized |       | Restricted Activity |       | Total |       |
|---------------------------|------------|-------|--------------|-------|---------------------|-------|-------|-------|
|                           | No.        | %     | No.          | %     | No.                 | %     | No.   |       |
| Total Case <b>Series</b>  | 243        | 100.0 | 361          | 100.0 | 589                 | 100.0 | 1193  | 100.0 |
| Non-fall-related          | 143        | 58.8  | 206          | 57.1  | 360                 | 61.1  | 709   | 59.4  |
| Fall related              | 100        | 41.2  | 155          | 42.9  | 229                 | 38.9  | 484   | 40.6  |
| Fall-Related Total        | 100        | 100.0 | 155          | 100.0 | 229                 | 100.0 | 484   | 100.0 |
| Gender                    |            |       |              |       |                     |       |       |       |
| Male                      | 82         | 82.0  | 105          | 67.7  | 158                 | 69.0  | 345   | 71.3  |
| Female                    | 18         | 18.0  | 50           | 32.3  | 60                  | 26.2  | 128   | 26.4  |
| Unknown                   | 0          |       | 0            |       | 11                  | 4.8   | 11    | 2.3   |
| Age group                 |            |       |              |       |                     |       |       |       |
| 1-6 years                 | 50         | 50.0  | 55           | 35.5  | 41                  | 17.9  | 146   | 30.2  |
| 7-12 years                | 25         | 25.0  | 70           | 45.2  | 111                 | 48.5  | 206   | 42.6  |
| 13-17 years               | 25         | 25.0  | 30           | 19.4  | 77                  | 33.6  | 132   | 27.3  |
| Fell from                 |            |       |              |       |                     |       |       |       |
| Height                    | 85         | 85.0  | 137          | 88.4  | 184                 | 80.3  | 406   | 83.9  |
| Same level                | 15         | 15.0  | 18           | 11.6  | 45                  | 19.7  | 78    | 16.1  |
| Leading location of fall  |            |       |              |       |                     |       |       |       |
| Farm or house yard        | 30         | 30.0  | 21           | 13.5  | 99                  | 43.3  | 150   | 30.0  |
| Barn (inside)             | 5          | 5.0   | 51           | 32.9  | 25                  | 10.9  | 81    | 16.7  |
| Crop field/orchard        | 21         | 21.0  | 17           | 11.0  | 17                  | 7.4   | 55    | 11.4  |
| Pasture                   | 3          | 3.0   | 5            | 3.2   | 44                  | 19.2  | 52    | 10.7  |
| Farm or public road/drive | 16         | 16.0  | 3            | 1.9   | 22                  | 9.6   | 41    | 8.5   |
| Leading hazards fell from |            |       |              |       |                     |       |       |       |
| Horse or pony             | 4          | 4.0   | 11           | 7.1   | 60                  | 26.2  | 75    | 15.5  |
| Ground surface            | 22         | 22.0  | 14           | 9.0   | 33                  | 14.4  | 69    | 14.3  |
| Farm Tractor              | 33         | 33.0  | 19           | 12.3  | 11                  | 4.8   | 63    | 13.0  |
| Farmstead equipment       | 7          | 7.0   | 30           | 19.4  | 16                  | 7.0   | 53    | 11.0  |
| Height in barn or silo    | 5          | 5.0   | 41           | 26.5  | 4                   | 1.7   | 50    | 10.3  |
| Hay bales                 | 0          | 0.0   | 18           | 11.6  | 3                   | 1.3   | 21    | 4.3   |
| Bicycle                   | 2          | 2.0   | 0            | 0.0   | 19                  | 8.3   | 21    | 4.3   |
| Play structure            | 0          | 0.0   | 3            | 1.9   | 16                  | 7.0   | 19    | 3.9   |
| All-terrain vehicle       | 1          | 1.0   | 1            | 0.6   | 15                  | 6.6   | 17    | 3.5   |
| Leading hazards fell onto |            |       |              |       |                     |       |       |       |
| Ground                    | 50         | 50.0  | 84           | 54.2  | 159                 | 69.4  | 293   | 60.5  |
| Floor                     | 5          | 5.0   | 41           | 26.5  | 25                  | 10.9  | 71    | 14.7  |
| Roadway                   | 8          | 8.0   | 4            | 2.6   | 31                  | 13.5  | 43    | 8.9   |
| Water or liquid           | 28         | 28.0  | 4            | 2.6   | 1                   | 0.4   | 33    | 6.8   |
| Machinery                 | 5          | 5.0   | 13           | 8.4   | 4                   | 1.7   | 22    | 4.5   |

**TABLE 3**  
Percentages of Different Types of Fall Injury Among Young Children (0 to 6 Years) According to the Fall Matrix\*

| Initiation of Fall     | Impact of Fall           |                   |                     |
|------------------------|--------------------------|-------------------|---------------------|
|                        | Blunt/Penetrating Injury | Submersion Injury | Complex Fall Injury |
| On same level          | 17.0%                    | 90.0%             | 20.0%               |
| From stationary height | 34.8%                    | 63.6%             | 77.8%               |
| From moving height     | 14.8%                    | 0%                | 44.0%               |

\*Observed percentage of total fall injuries with similar initiation impact experienced by children in the age group. Shading indicates that the observed percentage exceeded that expected.

**TABLE 4**  
Percentages of Different Types of Fall Injury Experienced During Two Types of Child Activities According to the Fall Matrix\*

| Initiation of Fall                                                         | Impact of Fall           |                    |                     |
|----------------------------------------------------------------------------|--------------------------|--------------------|---------------------|
|                                                                            | Blunt/Penetrating Injury | Submersion Injury  | Complex Fall Injury |
| Children Directly Involved in Farm Work Activity No. = 111(22.9%)          |                          |                    |                     |
| On same level                                                              | 34.0%                    | 10.0%              | 80.0%               |
| From stationary height                                                     | 15.6%                    | 13.6%              | 22.2%               |
| From moving height                                                         | 19.8%                    | 0%                 | 29.3%               |
| Non-working Children Exposed to a Farm Production Hazard No. = 222 (45.9%) |                          |                    |                     |
| <b>On</b> same level                                                       | 22.6%                    | 40.0%              | 20.0%               |
| From stationary height                                                     | 51.1%                    | 59.1%              | 66.7%               |
| From moving height                                                         | 42.0%                    | 66.7% <sup>t</sup> | 60.0%               |

\*Observed percentage of all fall injuries with similar initiation/impact experienced by children engaged in the activity

<sup>t</sup>Total number of submersion injuries from moving heights = 3.  
Shading indicates that the observed percentage exceeded that expected.

Table 5

**TABLE 5**  
Leading Natures and Anatomical Sites of Pediatric Fall Injury Observed Within each Category of the Fall Injury Matrix\*

| Initiation of Fall     | Impact of Fall           |     |                   |      |                       |     |
|------------------------|--------------------------|-----|-------------------|------|-----------------------|-----|
|                        | Blunt/Penetrating Injury |     | Submersion Injury |      | Complex Fall Injury   |     |
| On same level          | Laceration               | 40% | Asphyxia          | 100% | Intracranial injury   | 27% |
|                        | Soft tissue injury       | 13% |                   |      | Crushing injury       | 27% |
| From stationary height | Fracture—upper limb      | 34% | Asphyxia          | 100% | Fracture — lower limb | 56% |
|                        | Intracranial injury      | 20% |                   |      | Asphyxia              | 22% |
| From moving height     | Fracture—upper limb      | 27% | Asphyxia          | 100% | Intracranial injury   | 36% |
|                        | Soft tissue injury       | 24% |                   |      | Crushing injury       | 29% |

\*Percentage of fall injuries with similar initiation/impact that resulted in type of injury

SUPPLEMENTARY TABLE A (for web publication only)  
Matrix Developed to Describe Pediatric Farm Injuries by Initiation and Impact of Fall Injury Events

| Initiation of Fall        | Impact of Fall |                    |                   |                     |
|---------------------------|----------------|--------------------|-------------------|---------------------|
|                           | Blunt Injury   | Penetrating Injury | Submersion Injury | Complex Fall Injury |
| On same level, stationary | 44             | 5                  | 10                | 14                  |
| On same level, moving     | 4              | 0                  | 0                 | 1                   |
| From stationary height    | 132            | 3                  | 22                | 9                   |
| From moving height        | 162            | 0                  | 3                 | 75                  |

SUPPLEMENTARY TABLE B (for web publication only)  
 Percentages of Different Types of Fall Injury Within Three Pediatric Age Groups\*

| Initiation of Fall                   | Impact of Fall           |                    |                     |
|--------------------------------------|--------------------------|--------------------|---------------------|
|                                      | Blunt/Penetrating Injury | Submersion Injury  | Complex Fall Injury |
| 0-6 Years <b>No. = 146 (30.2%)</b>   |                          |                    |                     |
| On same level                        | 17.0%                    | 90.0%              | 20.0%               |
| From stationary height               | 34.8%                    | 63.6%              | 77.8%               |
| From moving height                   | 14.8%                    | 0%                 | 44.0%               |
| 7-12 Years <b>No. = 206 (42.6%)</b>  |                          |                    |                     |
| On same level                        | 43.4%                    | 0%                 | 26.7%               |
| From stationary height               | 47.4%                    | 22.7%              | 22.2%               |
| From moving height                   | <u>50.0%</u>             | 33.3% <sup>t</sup> | 34.7%               |
| 13-17 Years <b>No. = 132 (27.3%)</b> |                          |                    |                     |
| On same level                        | 39.6%                    | 10.0%              | 53.3%               |
| From stationary height               | 17.8%                    | 13.6%              | 0%                  |
| From moving height                   | 35.2%                    | 66.7% <sup>t</sup> | 21.3%               |

\*Observed percentage of all fall injuries with similar initiation/impact experienced by children in the age group

<sup>t</sup>Total number of submersion injuries from moving heights = 3.

Shading indicates that the observed percentage exceeded that expected.

# Supplementary Table C

## SUPPLEMENTARY TABLE C (for web publication only)

Percentages of Different Types of Fall Injury Experienced During Farm Work Activities, Non-work Activities Involving Production Hazards, and Non-work Activities Not Involving Production Hazards\*

| Initiation of Fall                                        | Impact of Fall           |                    |                     |
|-----------------------------------------------------------|--------------------------|--------------------|---------------------|
|                                                           | Blunt/Penetrating Injury | Submersion Injury  | Complex Fall Injury |
| <b>Farm Work</b> No. = 111 (22.9%)                        |                          |                    |                     |
| <b>On same level</b>                                      | <b>34.0%</b>             | 10.0%              | <b>80.0%</b>        |
| <b>From stationary height</b>                             | 15.6%                    | 13.6%              | 22.2%               |
| From moving height                                        | 19.8%                    | 0%                 | <del>29.3%</del>    |
| <b>Non-work, Production Hazards</b> No. = 222 (45.9%)     |                          |                    |                     |
| <b>On same level</b>                                      | 22.6%                    | 40.0%              | 20.0%               |
| <b>From stationary height</b>                             | 51.1%                    | 59.1%              | 66.7%               |
| <b>From moving height</b>                                 | <b>42.0%</b>             | 66.7% <sup>t</sup> | <b>60.0%</b>        |
| <b>Non-work, Non-production Hazards</b> No. = 125 (25.8%) |                          |                    |                     |
| <b>On same level</b>                                      | 43.4%                    | 40.0%              | 0%                  |
| From stationary height                                    | 21.5%                    | 27.3%              | 0%                  |
| From moving height                                        | 35.2%                    | 33.3% <sup>t</sup> | 6.7%                |

\*Observed percentage of all fall injuries with similar initiation/impact experienced by children engaged in the activity.

<sup>t</sup>Total number of submersion injuries from moving heights = 3.

Shading indicates that the observed percentage exceeded that expected.

# Supplementary Table D

SUPPLEMENTARY TABLE D (for web publication only)  
Percentages of Different Types of Fall Injury that Resulted in Fatality, Hospitalization and Restricted Activity\*

| Initiation of Fall                             | Impact of Fall           |                   | Complex Fall Injury |
|------------------------------------------------|--------------------------|-------------------|---------------------|
|                                                | Blunt/Penetrating Injury | Submersion Injury |                     |
| Fatal Injuries No. = 100 (20.7%)               |                          |                   |                     |
| On same level                                  | 0%                       | 80.0%             | 46.7%               |
| From stationary height                         | 3.0%                     | 95.5%             | 33.3%               |
| From moving height                             | 7.4%                     | <u>100%t</u>      | <u>56.0%</u>        |
| Hospitalized Injuries No. = 155 (32.%)         |                          |                   |                     |
| <b>On</b> same level                           | 15.1%                    | 20.0%             | 53.3%               |
| From stationary height                         | 57.8%                    | 4.5%              | 66.7%               |
| From moving height                             | 16.7%                    | 0%                | 33.3%               |
| Restricted Activity Injuries No. = 229 (47.3%) |                          |                   |                     |
| On same level                                  | 84.9%                    | 0%                | 0%                  |
| From stationary height                         | 39.3%                    | 0%                | 0%                  |
| From moving height                             | 75.9%                    | 0%                | 10.7%               |

\*Observed percentage of all fall injuries with similar initiation/impact that resulted in the outcome.

<sup>t</sup>Total number of submersion injuries from moving heights = 3.

Shading indicates that the observed percentage exceeded that expected.

***A New Approach to Understanding Pediatric Farm Injuries***

**Running Head:** Pediatric Farm Injuries

**Key Words:** children, farm injuries, risk factor interactions

### *Abstract*

The objective of this study was to examine a large case series of pediatric farm injuries in order to assess *interactions* between risk factors for injury. Information about pediatric farm injuries to children in three age groups (< 6 years, 6-12 years, 13+ years) was coded with respect to *children's behavior* (Did unexpected child behavior contribute to injury?), *predictability of injury risk* (Based on what the child had been doing, was the nature or occurrence of injury unexpected?), *environmental events* (Did unexpected environmental events contribute to injury?), and *level of environmental risk* (low, high). The reliability of coding between independent raters was excellent ( $\kappa = .83$ ) for the 330 cases providing complete data. Results revealed that, in high-risk environments, unexpected child behavior was coded more frequently when children 6 years and under were injured than for older children, whereas in low-risk environments unexpected child behavior had less impact on injury risk and showed no such age variation. With increasing age, the predictability of injury increased in a high-risk context, confirming that youth engage in increasingly hazardous activities as they develop. Consistent with this interpretation, unexpected environmental events increasingly contributed to injury in a high-risk context in the oldest age groups. The observed variations in risk factors suggest that interactions between behavioral and environmental factors are important to consider in studies of the etiology of pediatric farm injuries.

### *A New Approach to Understanding Pediatric Farm Injuries*

Injuries to children on farms are commonplace and tragic, with many resulting in death or permanent disability (Reed & Claunch, 2000; Rivara, 1997). Prevention of such injuries has long been recognized as a major challenge for injury-control (Pickett, Brison, & Hoey, 1995; Rivara, 1997). To date, most research on pediatric farm injuries has involved descriptive studies that aim to elucidate the nature and scope of these injuries, and describe the circumstances surrounding the injury event (Reed et al., 2000). The identification of individual risk factors for injury (e.g., *activities* such as using equipment; *locations* such as young children near water sources or animals) is important but may not provide sufficient understanding of risk processes to support the development of effective prevention strategies. For example, the unpredictable behavior of a two year old (e.g., spontaneously jumping on one foot) might pose less of a threat for injury to the child in a low-risk (hazard free) environment (e.g., on their front lawn) than the same behavior exhibited in a high-risk (hazard rich) environment (e.g., standing near moving equipment that they might fall against or into). Thus, child behavior likely interacts with environmental factors to affect risk for injury. On farms, where hazards are plentiful, this may be especially true. Surprisingly, however, study of *interactions* between risk factors and the occurrence of injury is notably lacking in the literature on pediatric farm injuries.

Research on childhood injury in non-farm contexts has begun to examine these more complex interactive models of injury risk (Schwebel & Barton, 2005), as well as how factors interact in the prevention of injury (Morrongiello, 2005). For example, in a prospective study of mothers' home-safety practices, Morrongiello and her colleagues

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found that mothers evaluate both child attributes (e.g., age, personality) and the child's location (e.g., bathroom versus playroom) in deciding how best to manage risks for injury (Morrongiello, Ondejko, & Littlejohn, 2004a; Morrongiello, Ondejko, & Littlejohn, 2004b). In contexts the parent rates as low in risk (i.e., few potential hazards), parents teach safety rules that children are expected to follow in order to ensure the child's safety. In contrast, in high-risk contexts with many hazards, parents supervise more closely or implement environmental changes to decrease children's access to hazards. Thus, parents consider *child x situational* interactions in planning for injury prevention. Similarly, children's risk for injury can arise from interactions among child attributes and situational factors. For example, children with difficult temperaments (i.e., impulsive, aggressive, undercontrolled) who are typically at increased risk for injury (Bijur, Golding, Haslum, & Kurzon, 1988; Matheny, Jr., 1986; Schwebel & Plumert, 1999) show uncharacteristic cautiousness in certain social environments (Schwebel, Brezaussek, Ramey, & Ramey, 2004; Schwebel & Bounds, 2003). Thus, research on children's risk for injury has begun to focus on the importance of interactions between risk factors.

The aim of the present study was to explore the application of this conceptual approach for the purpose of better understanding children's risk of injuries in farm contexts. Using an existing registry of traumatic injury events, this exploratory study was conducted to assess the notion that child and environmental factors would interact to affect injury risk, and vary with developmental level.

### *Method*

#### *Study Design*

A primary review was conducted of two retrospective case series of pediatric agricultural injuries that had been previously assembled for studies of the efficacy of work guidelines (North American Guidelines for Children's Agricultural Tasks, NAGCAT; (Marlenga, Pickett, & Berg, 2002) and child labor laws for injury prevention (Marlenga, Berg, Linneman, Brison, & Pickett, in press). The case series represented fatal and hospitalized injuries from Canada, as well as fatal work-related injuries from the United States. The ethics committees of Marshfield Clinic Research Foundation and Queen's University each approved the original study protocol.

#### *Definitions*

For the purpose of this study, pediatric farm injuries were defined as any injuries to children (younger than 18 years) that (1) occurred during activities related to agricultural production and/or (2) involved any operational hazard or activity associated with the agricultural worksite.

#### *Data Sources*

*Fatal Injuries.* All fatal pediatric agricultural injuries for the calendar years 1990 through 2001 were identified by personnel at each of the 10 provincial coroners' and medical examiners' offices in Canada, using all available registries (e.g., vital statistics, ministry of labor, coroner's registry, farm safety associations). Written investigation reports and death certificates were reviewed on-site at each provincial coroner's or medical examiner's office. The Canadian fatality case series was supplemented with 13

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occupational fatality case reports from the United States that were investigated by the National Institute for Occupational Safety and Health, Fatal Assessment and Control Evaluation program for the years 1992-2000 (US Department of Health and Human Services, 2003).

*Hospitalized Injuries.* Research agreements were established with five regional pediatric hospitals (three in Ontario, two in Alberta) and one general hospital (Alberta) in Canada to permit access to individual medical records for pediatric agricultural injuries admitted to hospital for the years 1989-2002. The hospitals identified cases using both inpatient and Emergency Department based registries. Medical records were reviewed on-site after ethics review at each institution.

### *Data Coding and Reliability*

There were 374 injury cases available for coding. Following elimination of cases for which there was insufficient information to code each of the four characteristics outlined below ( $N = 44$ ) there were 330 cases with complete data.

Based on a review of all available narrative information, each injury case was coded according to four dimensions (see details below; the coding scheme is available from the first author): (1) unexpected child behaviors, (2) predictability of injury risk based on the child's ongoing activity, (3) unexpected environmental events, and (4) level of environmental risk based on child's location. Two independent coders classified each case and reliability across the four categories was excellent ( $M = 90\%$  agreement,  $kappa = .83$ ), with disagreement resolved by a third independent scorer or by discussion.

*Unexpected Child Behaviors.* Based on narrative descriptions of what was

occurring before the injury, the behavior of the child that led to injury was evaluated relative to what the child was doing before this. Child behavior was coded into one of two categories: (1) *Same or Related* behavior: what the child had been doing remained unchanged when the injury occurred (e.g., they had been standing on the tractor and fell off the tractor from this standing position; they had been working on the fence and suddenly fell on the fence; they had been jumping on the haystack and were still doing so at the time they fell off and got injured) or was related and logically followed from what they had been doing (e.g., child was playing with a ball and then chased this ball behind a moving tractor), or (2) *Different* if the child was doing one activity (e.g., collecting rocks in the field) and then unexpectedly changed to do something different that immediately led to injury (e.g., tried to climb on the back of the tractor going by).

*Predictability of Injury Risk.* The aim here was to determine if coders could reliably distinguish activities that posed some inherently elevated risk for injury from other activities that did not do so. Toward this aim, coders considered what the child had been doing beforehand and judged whether or not the occurrence or nature of the injury that resulted might have been expected considering what the child had been doing. Specifically, for each case, coders reviewed what the child was doing before they did whatever led to the injury and assigned each injury to one of two categories: (1) would not have expected this injury to occur based on what the child had been doing (e.g., child was playing on the lawn and a car-related explosion occurred on the road sending a projectile that hurt the child), or (2) might have expected this injury to occur given what the child was doing (e.g., swinging from a rope in the barn and child fell; riding on the fender of a car and fell off). Based on prior

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identification of factors associated with acute farm injury events (Pickett et al., 1995; Rivara, 1997), if the child was on equipment, machinery, or near animals the case was coded as >predictable= injury risk (i.e., category 2 above).

*Unexpected Environmental Events.* Based on descriptions of the circumstance of injury each event was coded according to whether or not there was mention of some unexpected environmental event that directly contributed to the occurrence of the injury (e.g., barn collapsed, animal kicked, tractor wheel hit a hole that was covered by grass and tipped over). Unexpected events were coded as such only if the person reporting on the injury specifically mentioned this as a contributor to the injury event.

*Level of Environmental Risk.* Based on the child's location, environmental risk was coded as either: (1) low (i.e., no obvious hazards were mentioned; e.g., playing in the front yard, walking to the house on the lawn) or (2) high (i.e., obvious hazards were mentioned; including: being on or near machinery, equipment, or animals, or playing/working at a height, such as in the loft or on the roof). For children under 13 years of age, being near a large water source (e.g., skating on a semi-frozen pond, playing near a lagoon) was also coded as high risk due to the potential for drowning. In coding for level of risk, unless the specific environmental hazards indicated above were mentioned, a low risk environment was assumed.

### *Data Analysis*

Descriptive statistics were used to characterize the number and percentage of injuries occurring in each age group under low and high levels of environmental risk as a function of child behavior (same/related, different), whether the injury was unexpected based

on the child's prior activity (yes, no), and the occurrence of unexpected environmental events that contributed to injury occurrence (yes, no). Based on inspection of the data and because of our interest in interactions among these risk factors, select sub-sets (cells) of data were analyzed, rather than analyzing all possible sub-sets (cells) of data. Chi Square analyses were used when comparing proportions. Log-linear analysis was used to test higher-order models of interactions between variables. We note that some of the analyses reported involve expected frequencies less than five, however, Howell (2002) notes that there is no need for concern as long as all cells have expected frequencies greater than 1 and no more than 20% of cells have expected frequencies less than five, which was true in our case. Also, low expected frequencies invariably contribute more to lowered power than to spurious significant effects (Howell, 2002). Hence, low expected frequencies would have limited our capacity to find effects, leading to a conservative evaluation of interaction effects. Effects are deemed statistically significant at the 5% level ( $p < 0.05$ ).

### *Results*

#### *Child Behavior x Level of Environmental Risk*

Table 1 shows the percentage of injuries in each age group for which the action of the child that immediately led to injury was the *same/related* versus *different* relative to what s/he had been doing beforehand. These data are shown as a function of level of environmental risk (low, high).

Children in all three age groups experienced more injuries in the high-risk than low-risk context. However, interactive effects involving child behavior, level of environmental risk, and child age were also indicated by the data. Specifically, the impact of child behavior

on injury risk varied with level of environmental risk for children under 6 years of age ( $\chi^2 = 10.03$ ,  $p < .01$ ) and children 6 – 12 years ( $\chi^2 = 4.63$ ,  $p < .05$ ), but not for children 13 years and older ( $p > .05$ ).

The pattern of results indicated interactions between level of environmental risk, child behavior, and age. For the youngest children, 22% of injuries occurred in a high-risk context when the child did something unexpected that resulted in him/her interacting with a nearby injury hazard, whereas only 7% of injuries were related to unexpected child behavior in a low-risk context ( $\chi^2 = 10.00$ ,  $p < .01$ ). Differences between the number of injuries related to unexpected child behavior in low- versus high- risk contexts were not significant for the two older age groups ( $p > .05$ ). Thus, level of environmental risk interacted with child behavior to differentially impact on injury and this varied with age of the child, being most notable for the youngest age group.

There also was evidence of an interaction between age and child behavior in high-risk contexts. With increasing age, there was a steady decline in the percentage of injuries that resulted from the child doing something unexpected (22%, 9%, 5% for ages < 6, 6-12 and 13+, respectively) in the high-risk context ( $\chi^2 = 25.27$ ,  $p < .01$ ), whereas there was no significant age-related variation in the number of injuries related to the child doing something unexpected in a low-risk context ( $p > .05$ ). Thus, particularly for young children who are likely to behave in unexpected ways due to their developmental level, being in a hazard-rich environment is likely to increase risk for injury.

In sum, the pattern of findings provides support for the notion that child behavior interacts with level of environmental risk to differentially influence children's risk of injury

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on farms, and these effects vary with children's developmental level.

### *Predictability of Injury Risk x Level of Environmental Risk*

Table 2 shows the percentage of injuries in each age group that was coded as predictable or not, based on the nature of the child's activity. Again, these data are shown as a function of level of environmental risk.

These data also indicate that child behavior interacts with level of environmental risk to differentially influence injury risk. Specifically, in low-risk contexts, injuries deemed unpredictable were infrequent, particularly in the two youngest age groups (1% and 0%, respectively). In contrast, in high-risk contexts the prevalence of unpredictable injuries varied with age ( $\chi^2 = 34.10$ ,  $p < .01$ ) dropping from 29% in the youngest age group to 15% in the 6-12 year group and down to 5% in the oldest age group.

In addition, in the high-risk context, as the age of children increased, more of the injuries were judged to be predictable based on the nature of the child's activity: for children under 6 years of age there were 59% of such injuries compared with 92% of such injuries in the 13+ group ( $\chi^2 = 21.50$ ,  $p < .01$ ). This finding probably reflects age-related increases in children's participation in chores and farm work. Nonetheless, even in the youngest age group, 59% of injuries were judged as expected based on the child's activities, many of which were play activities that clearly posed risk of serious injury in this high-risk context (e.g., swinging from ropes at heights in a barn; jumping from haystack to haystack; touching farm animals). Thus, not only do children engage in higher-risk activities when in higher-risk contexts but risks for injury based on these activities are greater and increase with age. This supports the notion that child activity interacts with level of environmental

risk to differentially influence children's risks for injury, and these effects vary with developmental level.

### *Unexpected Environmental Events x Level of Environmental Risk*

Table 3 shows the percentage of injuries to children in each age group for which an unexpected environmental event contributed to the injury event. These data are shown both for low and high conditions of environmental risk.

For all age groups, being in the vicinity of hazards (i.e., animals, machinery, equipment, heights) was associated with more injuries due to unexpected environmental events than was true for a low-risk environment. However, relations between unexpected environmental events and injury vary between age groups in high-risk contexts (see Table 3),  $\chi^2 = 14.30$ ,  $p < .01$ . For the two youngest age groups, unexpected environmental events were reported for about 30% of injuries. In contrast, for the oldest age group, 45% of injuries in high-risk contexts were associated with unexpected environmental events. Thus, at all age groups the unpredictability of environmental events when in the vicinity of hazards (high-risk context) contributes to injury risk, however, this pattern becomes more evident with increasing age.

### *Discussion*

Study findings confirm that children at all ages are at increased risk for injury on farms when the level of environmental risk is high (e.g., near equipment, animals, working or playing at heights, etc). However, the results also indicate that interactions among risk factors help to explain *how* this occurs, and the process *varies* depending on developmental level.

For children under 6 years of age, the unpredictability of their behavior fosters interactions with hazards, particularly in high-risk settings. Closer supervision is not likely to be sufficient to prevent such natural tendencies of young children to spontaneously change their behavior without warning. In fact, proximity to a supervising adult actually has been shown to *elevate* young children=s risk of injury on farms (Morrongiello et al., 2006). Similarly, retrospective reviews of child-pedestrian injury reports reveal that supervisor presence did not guarantee protection (i.e., 36% of these injuries occurred when a supervisor was present and the child presumably did something unexpected that resulted in being hit by a vehicle; (Wills et al., 1997). Thus, because of the nature of how young children typically behave, the best strategy to moderate their risk of injury on farms is to keep them out of high-hazard environments altogether. Supervision is not likely to reduce risk of injury in high-risk farm contexts for these young children.

For children 6 years and older, the nature of the tasks and chores is changing and exposure to high hazard situations seems to increase across this age range due to these changes in tasks and activities(Marlenga, Pickett, & Berg, 2001a; Marlenga, Pickett, & Berg, 2001b). Thus, injury risk for older children arises more from the nature of the task per se (e.g., increased exposure to moving equipment) than unexpected aspects of the child=s behavior. This explains why unexpected *environmental* events increasingly contribute to injury as children age (see Table 3). Moreover, this finding also explains why increased training is not likely to address this injury-risk issue for older children. Simply put, no amount of training can prevent unexpected environmental events from happening and causing injury. Thus, just as for younger children, reducing injury risk at these older ages

necessitates reducing exposure to high-hazard situations. However, in this case the issue is not so much removing the child from the situation per se but changing the nature of the tasks and activities of older children on farms. Hence, across this broad developmental age range the concern must be with reducing risk exposure, however, the means by which one does so needs to vary with developmental level. For younger children this means keeping them out of the actual situation, whereas for older children this necessitates eliminating their participation in chores and activities that increase risk exposure.

### *Limitations and Future Research*

The present study illustrates how a focus on interactions among risk factors can broaden our understanding of injury events in ways that are important for intervention planning. Moreover, not only did interactions between risk factors emerge, but the patterns of these interactions often varied with developmental level of the child. Despite these advancements in our knowledge, however, there are a few limitations that merit consideration in future research. First, this sample included only children who had experienced an injury. Thus, we do not know to what extent the identified risk factors routinely occur but do not result in injury to children on farms. A better understanding of such risk-exposure issues is necessary and merits attention in future research. Second, because these case studies were gathered for different purposes, there was limited information about some aspects of the injury context that might have been useful to know about in conceptualizing about risk. For example, more detailed information about whether peers or siblings were present at the time of injury might have helped in determining if social context impacts on risk, and if this varies with developmental status of the child. Thus, a

number of important issues remain to be addressed in future research.

### *Conclusions*

Results from this study highlight how much more understanding of risk processes can be obtained by considering how factors interact to effect injury and assessing risk within a developmental context. Children at all ages may be at elevated risk of injury on farms, particularly in high-risk situations. However, the best solution to reduce this risk seems to vary with developmental stage due to age-related differences in interactions among risk factors. For children under 6 years of age, keeping them out of hazard-rich contexts is essential. In contrast, at increasingly older ages, risk arises more from the nature of their tasks and activities, which makes them more vulnerable to unpredictable environmental events leading to injury. Although one may argue that increased supervision and/or training will be sufficient to address these risk issues, respectively, these preliminary findings suggest otherwise.

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Table 1

*Percentage (N) of injuries to children at a given age (in years) for which the action of the child that immediately led to injury was the same or related (SIR) versus completely different (D) compared to what s/he was doing previously, as a function of level of environmental risk.*

| Age  | N   | Level of Environmental Risk |        |         |         |
|------|-----|-----------------------------|--------|---------|---------|
|      |     | Low                         |        | High    |         |
|      |     | SIR                         | D      | SIR     | D       |
| <6   | 139 | 4 (6)                       | 7 (10) | 67 (93) | 22 (30) |
| 6-12 | 112 | 3(3)                        | 2(2)   | 87(97)  | 9(10)   |
| 13+  | 80  | 4 (3)                       | 0 (0)  | 91(73)  | 5 (4)   |

Table 2

*Percentage (N) of injuries to children at a given age (in years) that were judged to be predictable (yes) or not predictable (no) based on what the child had been doing before the injury, as a function of level of environmental risk.*

| Age  | N   | Level of Environmental Risk |         |         |         |
|------|-----|-----------------------------|---------|---------|---------|
|      |     | Low                         |         | High    |         |
|      |     | Yes                         | No      | Yes     | No      |
| <6   | 139 | 1 (1)                       | 11 (15) | 59(82)  | 29(41)  |
| 6-12 | 112 | 0(0)                        | 4(5)    | 80 (90) | 15 (17) |
| 13+  | 80  | 2 (2)                       | 1 (1)   | 91(73)  | 5 (4)   |

Table 3

*Percentage (N) of injuries to children at a given age (in years) for which there was an unpredictable (yes) environmental event, as a function of level of environmental risk.*

| Age  | N   | Level of Environmental Risk |        |         |         |
|------|-----|-----------------------------|--------|---------|---------|
|      |     | Low                         |        | High    |         |
|      |     | Yes                         | No     | Yes     | No      |
| <6   | 139 | 1(2)                        | 10(14) | 29(40)  | 60(83)  |
| 6-12 | 112 | 1 (1)                       | 4(4)   | 33(37)  | 63(70)  |
| 13+  | 80  | 3 (2)                       | 1 (1)  | 45 (36) | 51 (41) |

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