

# **HIGH RISK ENVIRONMENTS AND AGRICULTURAL INJURIES IN CHILDREN, YOUTH, AND YOUNG ADULTS**

by

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## Abstract

**Background:** Children who live on farms experience high rates of fatality, morbidity, and disability when compared to children from the general population. There is an existing body of research describing injury rates and common patterns of agricultural injuries in pediatric populations in Canada; however, these studies are dated. Few contemporary studies have focused on the etiology of pediatric agricultural injury, particularly in a Canadian context.

**Objectives:** This study provides updated epidemiological information on agricultural injury in Canadian children and youth and investigates relationships between high-risk farm activities and the occurrence of agricultural injuries in youth and young adults on farms.

**Methods:** Manuscript 1 describes the incidence and patterns of pediatric agricultural fatalities and hospitalizations in the provinces of Ontario and Saskatchewan using surveillance data from the Canadian Agriculture Injury Reporting System. Manuscript 2 involved performance of cross-sectional analyses of written questionnaire data from 1135 youth and young adults from the Saskatchewan Farm Injury Cohort, an on-going study of active farm populations.

**Results:** In manuscript 1, the overall age-adjusted annual rates of agricultural injuries per 100,000 persons were: 7.8 (95%CI: 6.2-10.0) for Saskatchewan fatalities, 6.9 (95%CI: 5.6-8.5) for Ontario fatalities, 80.2 (95%CI: 73.9-87.1) for Saskatchewan hospitalizations, and 74.5 (95%CI: 69.9-79.4) for Ontario hospitalizations. Leading mechanisms of injury in both provinces were: falls from heights, animal-related mechanisms, machine entanglements, machine runovers and rollovers, and drowning. In manuscript 2, the prevalence of farm injury was estimated at 4.9%/year (95%CI: 3.7-6.2). After adjustment for important covariates relative to baseline (<10 hours/week), duration of farm work was strongly associated with the occurrence of injury [RR 8.0 (95%CI: 1.7-36.7) for 10-34 hours/week vs. baseline; RR 10.3 (95%CI: 2.2-47.5) for those working 35+ hours/week]. Tractor maintenance, tractor operation, chores with large animals, herd maintenance activities, and veterinary activities were identified as risk factors.

**Conclusions:** Together, these manuscripts demonstrate that there is a considerable burden of agricultural injury among children, youth, and young adults on farms and that experiences of injury are related to the amounts and type of exposure to farm work and related occupational hazards.

## **Co-Authorship**

This thesis is the work of Yvonne DeWit in collaboration with her supervisors, Dr. William Pickett from Queen's University, and Dr. Joshua Lawson from the University of Saskatchewan. For Manuscript 2 (Chapter 4) there was one additional co-author: Dr. James Dosman from the Canadian Centre for Agricultural Safety and Health, University of Saskatchewan.

The rationale, conceptualization, and design of both manuscripts were developed collaboratively. Ms. DeWit conducted the supporting literature review, planned and executed data analyses, interpreted results, drafted all chapters, and was responsible for all revisions. Dr. Pickett and Dr. Lawson provided guidance, assisted in the interpretation of results, and provided editorial feedback on written materials.

For Manuscript 2 (Chapter 4), entitled "Associations between Exposure to High-Risk Farm Activities and Agricultural Injuries in Youth and Young Adult Workers," Dr. James Dosman also played a role in developing the rationale, design, and methodology used in the Saskatchewan Farm Injury Cohort study and provided a critical review of the manuscript.

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## **List of Abbreviations**

ATV: All-terrain vehicle

CAIR: Canadian Agricultural Injury Reporting

CAIS: Childhood Agricultural Injury Survey

CI: Confidence Interval

EHLASS: European Home and Leisure Accident Surveillance System

ICD: International Classification of Diseases

NAGCAT: The North American Guidelines for Children's Agricultural Tasks

OR: Odds ratio

RR: Relative risk or if specified, rate ratio

SFIC: Saskatchewan Farm Injury Cohort

# **Chapter 1**

## **Introduction**

### **1.1 General Overview**

Farms and other agricultural settings are often thought of as wholesome and beneficial environments for children to grow up in; however, living on a farm is not without risks. Children who live on farms experience higher rates of premature death, injury-related morbidity, and disability due to injury along with their associated healthcare costs when compared to children from the general population.<sup>1,2</sup> In Canada, from 1990-2008, there were 344 fatal agricultural injuries experienced by children under the age of 20 years, accounting for 17.4% of all agricultural deaths related to trauma.<sup>3</sup> In addition, children and youth under the age of 20 accounted for 19.0% of all hospitalized agricultural injuries from 1990 to 2000 within Canada.<sup>4</sup> Agricultural injuries in children and youth are clearly an important public health concern.

Few comprehensive studies have profiled the characteristics of agricultural injuries among children and youth in Canada. There are also a limited number of investigations that have focused on the etiology of pediatric farm injuries while employing strong epidemiologic designs.<sup>5-13</sup> In terms of descriptive patterns, leading mechanisms of hospitalized pediatric agricultural injuries include blunt animal trauma, machinery entanglements, falls from heights, machinery runovers, and being pinned or struck by a machine.<sup>4</sup> Beyond descriptive analyses, there is little research assessing how exposure to different types of physical farm environments and other contexts relate to these mechanisms, and hence contribute to the etiology of pediatric agricultural injury.

### **1.2 Rationale**

Children and youth experience a substantial burden of agricultural injuries in Canada. Consequently, the prevention of pediatric agricultural injuries needs to be a leading concern for

public health efforts focused upon rural areas. However, research in this area is limited. Aside from the obvious medical expenses, costs attributed to pediatric agricultural injuries also include short-term and long-term child and parental work loss, reduction in household productivity, and impacts on quality of life.<sup>14</sup> Given that pediatric agricultural injuries occur early in life, the resulting burdens in terms of person-years of lost life or quality-adjusted life years lost are high. For example, a national study in the United States found an annual loss of 4,322 quality-adjusted life years due to non-fatal agricultural injury in children and youth under the age of 19 years.<sup>14</sup> This demonstrates that non-fatal agricultural injuries in children have ongoing effects, such as temporary and permanent disability, that can impact the quality of life of those injured. Such risks are rarely experienced by other populations of children in Canada, making such populations of farm children unique.

The economic burden associated with agricultural injuries is also high. In 2004, preventable farm-related injuries cost the Canadian economy \$373 million dollars.<sup>15</sup> Based on inflation rates, 373 million 2004 Canadian dollars is \$437 million today<sup>16</sup>, meaning that the current economic losses from farm injury are likely \$400-\$500 million annually. Although no Canadian estimates of the economic costs specific to pediatric agricultural injuries were identified, a national study of pediatric agricultural injuries in the United States from 2001-2006 found an annual economic cost of \$1.423 billion per year in 2005 dollars (95% CI: \$1.333 billion, \$1.513 billion).<sup>17</sup> Consequently, these pediatric injury costs are substantial, and the prevention of agricultural injuries would not only improve the health and well-being of rural populations, but could hypothetically benefit Canada economically.

While descriptive studies have identified preventable patterns of agricultural injury, the surveillance data used in these reports is over a decade old.<sup>4,18</sup> Due to potential changes in technology and farming practices, findings from studies with older surveillance data may not reflect current patterns. Additionally, existing studies rarely compare the experiences of different

geographic regions. Moreover, there are few studies that investigate potential risk factors for pediatric agricultural injury.<sup>5-12</sup> The existing body of analytic literature aimed at farm children and their injury experiences is limited in methodology and scope. Little is known about how the amounts of farm work exposure contribute to the burden of pediatric agricultural injuries. Also, the majority of the analytic research in this field is conducted using samples from American farm populations. There is one contemporary analytic study of pediatric agricultural injury in Canada from our own research group that investigated the effects of long parent work hours; but the outcome measured was children's exposure to farm hazards instead of injury.<sup>13</sup> Therefore, more research is required to provide foundational information about the rates, characteristics, and risk factors for pediatric agricultural injuries in Canada to inform into future preventive efforts and targeting of interventions.

### **1.3 Objectives and Hypotheses**

#### **1.3.1 Study Aims**

The aim of this thesis is to address identified gaps in the applied literature in order to inform and direct future efforts to prevent the burden of pediatric agricultural injuries. The thesis includes two manuscripts. The first investigates the incidence and characteristics of agricultural injuries in children and youth from two provinces of Canada. The second investigates associations between exposures to high-risk environments and contexts on farms with the occurrence of agricultural injury in youth and young adult farm dwellers. By necessity, these two manuscripts were developed using different sets of data. Together, these complementary manuscripts intend to quantify and describe the current burden of pediatric agricultural injuries as well as provide further etiological understanding of this problem to assist with the targeting of future preventive efforts.

### **1.3.2 Manuscript 1 Objectives**

The first manuscript aimed to address the gaps in the descriptive literature by using two decades of provincial agricultural injury surveillance data to: 1) describe fatal and hospitalized agricultural injuries in children and youth under the age of 20 years in the provinces of Ontario and Saskatchewan; and 2) identify common patterns and potential causes of preventable agricultural injuries.

### **1.3.3 Manuscript 2 Objectives**

To address existing gaps in analytic research, the second manuscript used data from a preexisting sample of Canadian farm dwellers from the province of Saskatchewan to: (1) describe characteristics of injuries that occurred in a sample of youth and young adult farm workers aged 12 to 29 years; (2) describe exposures to specific farm work tasks in this sample using multiple categories; and (3) investigate the association between exposures to high-risk farm environments and activities, and the occurrence of agriculture injuries. It was hypothesized that increased engagement in specific high-risk work tasks would result in a concomitant increase in injuries in youth and young adults.

## **1.4 Scientific and Societal Importance**

Manuscript 1 builds upon the existing descriptive analyses of pediatric agricultural injury in Canada by providing an epidemiological update of the occurrence and patterns of agricultural injury in the provinces of Saskatchewan and Ontario, using more contemporary surveillance data. Findings from Manuscript 1 also compare the two provinces which are representative of agricultural regions with different characteristics such as farm size and type of operation.<sup>19</sup>

Manuscript 2 adds to the existing body of research about risk factors for pediatric agricultural injury by using survey data to investigate the relationship between high-risk farm work exposures and the occurrence of injury in a Canadian context. Furthermore, the findings contribute to further understanding the risk associated with farm work exposures by investigating



the dose-response effect between the amounts of time spent engaged in farm work and the risk for injury.

Together, the research presented in this thesis can be used to inform future preventive efforts through targeted interventions. Based on the research findings, Manuscript 1 recommends strategies for interventions for pediatric agricultural injury including targeting of interventions towards high-risk groups and contexts. Manuscript 2 further justifies the targeting of interventions by quantifying the risk for injury associated with specific farm work exposures. Furthermore, the estimates of risk presented in both manuscripts can be used in a wide spectrum of prevention initiatives including education, regulatory and other options to improve awareness in the agriculture community about the injury risks associated with farm work exposures. Together findings of the two manuscripts also provide evidence to policy-makers and planners, which can be used to support and identify priorities for occupational health and safety regulation reform for this vulnerable population.

## **1.5 Thesis Outline**

This thesis conforms to the Queen's University School of Graduate Studies and Research guideline "General Forms of Thesis".<sup>20</sup> The second chapter is a literature review summarizing the existing body of research on pediatric agricultural injuries and prevention in this population. The third chapter and fourth chapters are the previously described Manuscript 1 and Manuscript 2, respectively. Manuscript 1 was formatted for submission to the international journal, *Pediatrics* and Manuscript 2 was formatted for the *American Journal of Industrial Medicine*. Chapter 5 contains a summary of key findings and a general discussion including the epidemiological strengths and weaknesses of the research and implications for research and prevention.

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## **Chapter 2**

### **Literature Review**

#### **2.1 Scope of Literature Review**

This chapter will explore the existing literature on pediatric agricultural injuries with a particular focus on research investigating potential risk factors. The chapter will start with a list of key definitions. The chapter continues with a description of the magnitude of problem of agricultural injury in Canada including associated injury rates and costs. Next, common patterns of pediatric agricultural injury identified from the descriptive literature are described. A conceptual framework for risk factors for agricultural injuries in children and youth is then presented. Next, I summarize and critically review the analytic research investigating risk factors for pediatric agricultural injuries. The main risk factors under investigation are individual and area-level exposures to high-risk farm environments and (mainly work-related) activities. I then provide an overview of prevention strategies for agricultural injury in these populations, including a summary of the evidence surrounding existing strategies. Next, I present an overview of agricultural injuries in young adults, as the scope of the second manuscript includes young adults aged 20 to 29 years old. Lastly, I summarize the key findings of the literature review and my synthesis of gaps in the scientific evidence.

#### **2.2 Key Definitions**

For the purpose of this report the term *children* will be used to refer to persons under the age of 20 years.<sup>1</sup> The term *youth* will be used to describe children that are between the ages of 12-19 years.<sup>2</sup> *Young adults* will be used to describe 20 to 29 year olds.<sup>3</sup>

*Agricultural injuries* are defined as “any unintentional injuries that occur during activities related to the operation of a farm or ranch including injuries that occur during agricultural work that took place off the farm or ranch (i.e. driving a tractor on a public road) and/or involve any

hazard of a farm or ranch environment and/or injuries that occur because a third party is engaged in agricultural work.”<sup>1</sup> *Agricultural fatalities* are agricultural injuries that result in death. *Pediatric agricultural injuries and fatalities* will refer to agricultural injuries and fatalities that occur in children and youth under the age of 20 years.

For the purpose of this thesis, a *farm* refers to “a farm, ranch or other agricultural operation producing agricultural products for sale.”<sup>4</sup> Agricultural products include: crops, livestock, poultry, animal products, or other agricultural products such as Christmas trees, greenhouse or nursery products, mushrooms, sod, honey, bees, and maple syrup products.<sup>4</sup>

### **2.3 Methods Surrounding the Review of the Literature**

The literature review was conducted during the months of May 2013 to July 2014. Literature searches involved the use of the following bibliographic databases: Pub Med, Google Scholar, and the Summon search engine for the Queen’s University library. I also used the Google search engine to search for reports published by agricultural health and safety organizations and other agencies that monitor agricultural injuries. These searches were restricted to articles and reports published since 1990 to capture contemporary patterns of agricultural injuries as farming practices and technology have changed vastly over the years. Different combinations of the following search terms were used: “injury” (and derivatives), “fatality” (and derivatives), “accident”, “prevention”, “intervention”, “safety”, “farm”, “ranch”, “agricultural”, “rural”, “pediatric”, “children”, “youth”, and “young adult”. Searches yielded thousands of results. The abstracts for the first 50 results from each of the many searches were reviewed. The literature search also used the “snowball” technique of identifying additional manuscripts and other academic sources from the reference list of included articles. Research papers that focused on pediatric agricultural injuries in the developing world were not included due to large differences in farming practices and technology, which made such articles and associated population experiences not generalizable to the Canadian agricultural population. As such, the

literature search mainly included papers published in English from North America, Australia, New Zealand, and Europe.

## **2.4 Pediatric Agricultural Injury in Canada**

As of the 2006 Census of Agriculture, there were approximately 700,000 permanent residents living on Canadian farms or ranches, of which 35% (approximately 245,000 thousand) were under the age of 25 years.<sup>5</sup> As such, there is a large population of children, youth, and young adults at risk for agricultural injuries in Canada. The following sections quantify the burden and characteristics of agricultural injury in this population by discussing incidence rates, costs and common patterns observed in these populations. I will also compare pediatric agricultural injuries in Canada to other countries.

### **2.4.1 Injury Rates**

The most comprehensive source of information about the incidence of agricultural injuries in Canada is the Canadian Agriculture Injury Reporting system (CAIR).<sup>6</sup> CAIR is a surveillance program that aims to identify all agriculture related fatalities and hospitalizations using administrative data and records. Among children under the age of 20 years, CAIR identified 344 agricultural fatalities that occurred in Canada from 1990-2008.<sup>6</sup> The resulting crude annual incidence rates of agricultural fatalities per 100,000 were: 12.6 in 0-4 year olds, 6.8 in 5-9 year olds, 4.1 in 10-14 year olds, and 6.8 in 15-19 year olds.<sup>6</sup>

There is limited information available to describe the prevalence of non-fatal agricultural injuries for the full spectrum of injury severity. Agricultural injuries that do not require admission to hospital or emergency care are more difficult to monitor via existing surveillance mechanisms. However, CAIR identified 2,828 hospitalised agricultural injuries among children from 1990-2000 and this translated to a crude annual incidence rate of 98.3 per 100,000.<sup>1</sup>

#### **2.4.2 Costs**

Agricultural injuries can result in substantial burdens: for the child, their family, their community, and society. These injuries can be fatal or result in long-term disability due to severe injuries such as spinal cord injury, traumatic brain injuries, crush injuries, loss of limbs, and chemical ingestion. Although information on the outcomes of agricultural injuries is limited, estimates of permanent disability in retrospective studies of survivors range from 13-41%.<sup>7</sup> Aside from the obvious immediate medical expenses and the costs of rehabilitation and ongoing treatment, costs attributed to pediatric agricultural injuries also include short-term and long-term child and parental work loss, reduction in household productivity, and impacts on quality of life.<sup>8</sup> There were no studies or reports identified that attempted to quantify the economic losses associated with pediatric injuries in Canada. However, a national study in the United States found an annual loss of 4,322 quality-adjusted life years due to non-fatal injury in children and youth under the age of 19 using surveillance data from 2001-2006.<sup>8</sup>

#### **2.4.3 Common Patterns of Pediatric Agriculture Injuries**

Pediatric agricultural injuries follow predictable and preventable patterns. This section will summarize common patterns identified from descriptive analyses of pediatric agricultural injuries in Canada: by age, sex, and mechanism of injury.

*By Age.* The developmental stage of a child characterizes their physical, cognitive, and social abilities. In general, the occurrence and patterns of pediatric agricultural injuries varies with age which acts as a proxy for developmental stage.<sup>1,8-11</sup> As Table 1 demonstrates, there are substantial differences in rates of injury experienced in different age groups. These were estimated from Canadian national surveillance data from 1990-2000 for hospitalizations and 1990-2008 for fatalities.<sup>1,6</sup> The highest rates of fatalities occurred in children under the age of 5 years (15.8 per 100,000 persons per year). Youth aged 15-19 years had highest rate of hospitalized agricultural injuries. These findings, along with other descriptive analyses indicate

that farm children are most likely to be injured as toddlers and preschool aged children, or as youth of working ages.<sup>1,10,12</sup>

**Table 1. National Fatal and Hospitalized Agricultural Injuries by Age Category**

Age Group	Fatal Agricultural Injuries <sup>a</sup>			Hospitalized Agricultural Injuries <sup>b</sup>			Rate ratio of hospitalized to fatal
	Number	Percent	Crude rate per 100,000/year	Number	Percent	Crude rate per 100,000/year	
1-4	109	31.7	12.6	471	16.7	90.4	7:1
5-9	80	23.3	6.8	675	23.9	95.0	14:1
10-14	59	17.2	4.1	742	26.2	88.3	22:1
15-19	96	27.9	6.8	940	33.2	116.8	17:1

Notes. a. CAIR surveillance data from 1990-2008<sup>6</sup>; b) CAIR surveillance data from 1990-2000<sup>1,13</sup>

*By Sex.* Rates and proportions of agricultural injuries are consistently higher in male children than in female children.<sup>1,6,10,11,2</sup> For example, males accounted for 82.5% of Canadian agricultural fatalities in children under the age of 20 years, with a 4.7:1 overall male to female ratio reported in the 1990-2003 national surveillance data. In addition, rates of pediatric agricultural injury in males are between 2.0 to 3.6 times the rates of injuries reported for females.<sup>11, 14</sup>

*Mechanisms leading to agricultural injury.* Tractors and other farm machinery are the leading cause of serious agricultural injuries in children and youth under the age of 20 in Canada.<sup>1</sup> Different types of farm machinery account for 66% of pediatric agricultural fatalities and 48% of hospitalized agricultural injuries in children under 20 years.<sup>1</sup> Machinery is most frequently associated with injuries via the following mechanisms: tractor runovers (“victim is stationary on the ground or falls off a moving tractor and then is crushed underneath a tractor wheel”) and rollovers (“victim is on the tractor when it tips over”), entanglement, or being pinned or struck by machinery.<sup>1,15-17</sup> After machinery-related injuries, drowning is the most common mechanism of fatal pediatric injury, accounting for 16% of fatalities in children under age 15.<sup>6</sup> Water and other liquid hazards on farms include irrigation ditches, dugouts, sloughs, watering troughs, sewage ponds and manure lagoons.

Animal-related mechanisms and activities are among of the leading causes of non-fatal pediatric agricultural injury in both Canadian and American farm populations.<sup>1,8</sup> Included in these



are horseback riding, livestock operations, herd maintenance, and veterinary activities. These exposures have been identified as the contributing mechanisms of injury in 18% of hospitalized pediatric agricultural injuries.<sup>1</sup> Falling from heights is also a recurrent pattern. There are a variety of scenarios in farm operations that involve working at heights such as grain bin or silo maintenance and riding or working on high machinery. Haylofts, balestacks, and tall farm structures are additional hazards with a risk of falling. Falls account for 15% of hospitalized pediatric agricultural injuries.<sup>1</sup>

All-terrain vehicles (ATVs) are frequently identified as causes of injury in children and youth and are often used on farm sites and for farm work.<sup>12,18</sup> In a study of machine-related fatal and hospitalized farm injuries in children aged 0-17 years, ATVs were the most common cause of injury (N=76, 25%; 1990-1997).<sup>12</sup> ATVs accounted for 4.4% of the fatalities in children and youth under 20 years identified by CAIR from 1990-2003 but were not specifically reported in the hospitalization data.<sup>1</sup>

*Seasonally.* For fatalities from 1990-2003 and hospitalizations from 1990-2000 in Canada, there was a trend of increased pediatric agricultural injuries during the summer and fall months.<sup>1</sup> A study of pediatric agricultural injury in Ontario from 1985-1990 also found the hospitalized and fatal agricultural injuries peaked from July to September.<sup>19</sup>

#### **2.4.4 Comparing Pediatric Agricultural Injuries in Canada to other countries**

How does agricultural injury in children and youth in Canada compare to other countries? A summary of available descriptive research of pediatric agricultural injuries is presented in Table 2. Comparisons between incidence and characteristics of pediatric agricultural injuries across countries are difficult to interpret due to methodological differences. Furthermore, the international research rarely involved calculating rates due to problems with identifying or obtaining appropriate denominator data.

**Table 2. International Descriptive Research on Pediatric Agricultural Injuries Using Surveillance Data**

Author, date, and country	Source and time period of data	Participants	Findings
Mitchell et al, 2001 <sup>20</sup> Australia	Coroners records 1989-1992	117 farm fatalities in children less than 15 years old	<ul style="list-style-type: none"> <li>• Children less than 15 year old account for 20% of all unintentional farm-related fatalities in Australia, with</li> <li>• Children less than 5 years old representing 63% of all child fatalities.</li> <li>• Drowning was the most common mechanism of farm fatality in children 0-4 years (58%)</li> <li>• Vehicles were a leading agent of injury across all age groups, increasing with age group (16% for 0-4 year olds, 47% for 5-9 year olds, and 67% for 10-14 year olds)</li> <li>• 8% occurred while working, 77% occurred while bystanding I the area of agricultural work</li> </ul>
Fragar et al., 2005 <sup>21</sup> Australia	Hospitalization records 1994-1998	2408 hospitalized farm injuries in children less than 15 years of age	<ul style="list-style-type: none"> <li>• Annual rate of 574 per year</li> <li>• Trend of increasing proportions with age group: 20% aged 0-4 years, 28% aged 5-9 years, and 52% aged 10-14 year olds</li> <li>• Leading agents of injury: motorcycles, farm vehicles, horses, and falls</li> </ul>
Trichopoulos et al., 2004 <sup>22</sup> Austria, Denmark, France, Greece, Portugal, Sweden, The Netherlands	European Home and Leisure Accident Surveillance System (EHLASS) Austria: 1996-2001 Denmark: 1998-2002 France: 1996-2000 Greece: 1996-2000 Portugal: 2002 Sweden: 1998-2002	Non-fatal farm injuries in children and youth aged 0-16 years Austria: N=199 Denmark: N=113 France: N=162 Greece: N=277 Portugal: N=82 Sweden: N=638	<ul style="list-style-type: none"> <li>• Male were more frequently injured in all countries but Sweden, ranging from 52%-76% of the injuries. In Sweden, males accounted for 45% of farm injuries</li> <li>• Increased proportion of injuries by age group in Austria, Denmark, France, Sweden and the Netherlands: 0-5 years: 9-21%; 10-14 years: 26-38%; 15-19 years: 44-64%</li> <li>• In Portugal and Greece, 5 to 9 year olds had the highest proportion of farm injuries (43% and 48%, respectively)</li> <li>• Falls were the leading mechanism of injury in all countries</li> <li>• Leading types of injuries were open wounds, contusions/abrasions, fractures, and dislocations</li> </ul>
Cameron et al, 1992 <sup>23</sup> United Kingdom	Health and Safety Executive Registrar 1986-1990	33 farm fatalities in children aged 0-16 years	<ul style="list-style-type: none"> <li>• 45% of fatalities were in 10-14 year olds</li> <li>• Leading mechanisms were tractors and other farm machinery and falling objects</li> </ul>
Sosnowska and Kostka, 2007 <sup>24</sup> Large region in Poland (Wloclawek province)	Farmers' Insurance Fund in Wloclawek, which registered all farm-related Injuries 1994-2003	449 farm injuries in children aged 6 to 15 years	<ul style="list-style-type: none"> <li>• Crude rate of 1.3 per 1,000 rural residents</li> <li>• 71% of children injured were male</li> <li>• Trend of increasing injury with age, although 14 year olds had the highest proportion of injuries</li> <li>• Leading mechanisms of injury were: falls and slips on the same altitude (47.2%), falls from height (22.9%), and machine-related injuries (14.9%)</li> <li>• Leadings types of injury were fractures and dislocations and the majority of injuries were to limbs</li> </ul>

Author, date, and country	Source and time period of data	Participants	Findings
Rivara, 1997 USA	US National Center for Health Statistics Mortality Multiple Cause of Death Data 1991-1993 National Electronic Injury Surveillance System 1990-1993	Children and adolescents 19 years and younger injured on farms	<ul style="list-style-type: none"> <li>• Average 104 deaths per year, resulting in a rate of 8 per 100,000 child farm residents per year</li> <li>• Average 22 288 emergency department treated agricultural injuries per year, resulting in a rate of 1717 per 100,000 child farm residents per year</li> <li>• Males were injured more frequently than females</li> <li>• Highest rate of fatalities was among 15 to 19 year olds (10.2 per 100,000 per year)</li> <li>• Leading mechanisms of fatalities were farm machinery (34%) and drowning (24%)</li> <li>• Leading agents of all farm injuries were tractors (21%), horses (8%), all-terrain vehicles and mini-bikes (8%), and farm wagons (8%)</li> <li>• Leading nature of farm injuries were open wounds (38%), contusions/abrasions (23.3%), and fractures/dislocations (20%)</li> </ul>
Myers and Adekoya, 2001 <sup>25</sup> USA	Vital Statistics Mortality files and from the National Traumatic Occupational Fatalities 1982-1994	770 farm fatalities in 16 to 19 year olds	<ul style="list-style-type: none"> <li>• Rates of non-work related farm fatalities ranged from 6.8-8.4 deaths per 100,000 per year</li> <li>• Rates of work-related farm fatalities ranged from 4.9-12.0 per 100,000</li> <li>• 40% of the farm fatalities were work-related</li> <li>• The leading mechanisms of work-related fatalities were machinery (54%) and electrical current (20%)</li> <li>• The leading mechanisms of non-work-related fatalities were drowning (38.9%) and firearms (28.6%)</li> </ul>
Hendricks et al., 2005 <sup>26</sup>	Childhood Agricultural Injury Survey (CAIS), nationally representative survey 2001	Farm children and youth under the age of 20 years	<ul style="list-style-type: none"> <li>• Estimate of national rates of injury per 1,000 household youth on farms <ul style="list-style-type: none"> <li>- Overall: 15.7</li> <li>- Males: 18.7, Females: 13.1</li> <li>- Less than 10 years old: 14.7, 10-15 years old: 21.1, 16-19 years old: 11.0</li> </ul> </li> <li>• Leading nature of injuries: fractures and open wounds</li> <li>• Leading mechanisms of injury: falls, contact with objects, and transportation incidents</li> <li>• Vehicles and animals among leading mechanisms of injury</li> </ul>
Zaloshna et al, 2012 <sup>27</sup>	CAIS, Mortality Multiple Cause of Death Data 2001-2006	Farm children and youth under the age of 20 years	<ul style="list-style-type: none"> <li>• An estimated average of 26,570 non-fatal injuries occurred per year</li> <li>• Average annual incidence of 84 agricultural fatalities per year</li> <li>• The leading mechanism of fatal injuries was farm machinery</li> <li>• Leading mechanisms of unintentional non-fatal injury were falls and transportation</li> <li>• Most agricultural injuries occurred to older youth (10-14 and 15-19 years old)</li> <li>• Children age 0 to 4 had the largest proportion of fatalities</li> </ul>

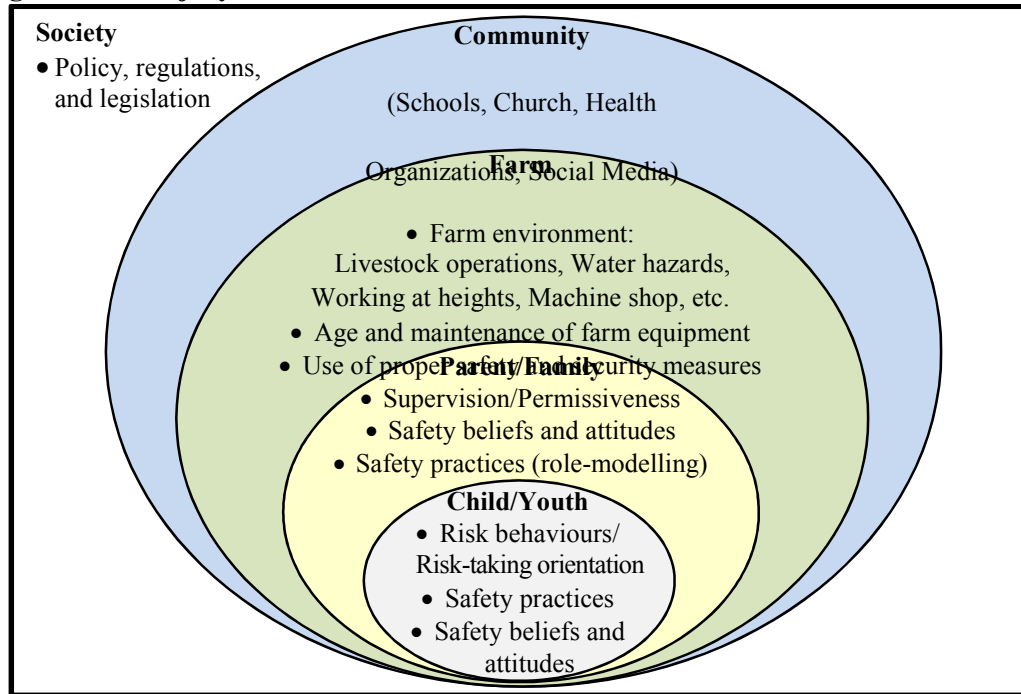
Results presented in Table 2 demonstrate that there are some common injury patterns observed across countries and contexts. The fatality rates observed in surveillance data in the United States (8.0 per 100,000 per year in children under the age of 20 years, and 6.8-8.4 in 16-19 year olds) are comparable to the fatality rates estimated from Canadian surveillance data.<sup>6,14,25</sup> Likewise, children less than 5 years of age accounted for the majority of agricultural fatalities in Australia, and the United States.<sup>20,27</sup> Comparable to the trend of increasing hospitalization rates by age group in Canada, non-fatal agricultural injuries followed a trend of increasing proportions of injuries as age groups increase in Australia, Austria, Denmark, France, Sweden, the Netherlands, and Poland.<sup>21,22,24</sup> Another similarity is that males were consistently injured more frequently in farming contexts than females in all countries with the exception of non-fatal injuries in Sweden.<sup>11,14,20–24,27</sup> Common leading mechanisms of farm injury in the international research were the same as in Canada including drowning, falls, machine-related mechanisms (including tractors and motor vehicles), and animal-related mechanism with horses as a frequent agent of injury.<sup>11,14,21–25,27</sup>

## **2.5 Risk Factors for Pediatric Agricultural Injury**

### **2.5.1 Introduction and Conceptual Model**

Supporting the descriptive body of research presented above, there is also a modest body of analytic research on the risk factors for pediatric agricultural injury. We adapted a socioecological conceptual model (Figure 1) to frame the discussion of risk factors based on Bronfenbrenner's ecological model of human development.<sup>28</sup> This classic model has been used as a basis for many socioecological models, including Gallagher's model of childhood farm injury interventions, which also informed the development of our conceptual model.<sup>29</sup> Proposed levels in the adapted nested and hierarchical model include: child or youth individual factors, parental factors, and farm-related factors, broader community level factors, and societal factors. For each level, we included factors that could affect the risk for pediatric agricultural injury.

**Figure 1. Socioecological Model for a Farm Child or Youth in the Context of Agricultural Injury**



There are complex interactions between the hierarchical levels and factors listed in this socioecological model. To illustrate, consider a child's exposures to potential risk factors for injury such as "high-risk farm tasks". Parents may assign work based on the age and sex of the child, the needs of their farm operations, and their beliefs about whether the task is age-appropriate and safe. Parental beliefs about the farm tasks can in turn be influenced by their own experiences, the beliefs and practices of other members of their social circle, by exposure to safety information and education, and by awareness of any relevant policy or legislation. This is just one example of how farm work exposures result from interplays between individual, parental, community, and societal factors.

A total of 8 analytic studies using 6 data sources were identified that investigated risk factors for pediatric agricultural injuries. A summary of each study's design, key results and limitations is presented in Table 3. Potential risk factors will be discussed at the individual, parent, and farm-levels even though it is extremely difficult to separate the levels at which risk factors are operating due to the unique operational nature of a farm.

**Table 3. Summary of Studies of Risk Factors for Pediatric and Young Adult Agricultural Injury**

Study name and details	Design and Exposure(s) Investigated	Key Findings	Key Limitations
University of California, Davis Youth Agricultural Injury Study <sup>2</sup> <ul style="list-style-type: none"> <li>• 489 public high school students in rural California</li> <li>• 2002-2005</li> </ul>	Cohort study <ul style="list-style-type: none"> <li>• Farm characteristics</li> <li>• Work habits</li> <li>• Sleep</li> <li>• Safety attitudes</li> </ul>	Odds ratios (95% CI) for agricultural injury from adjusted logistic model include <ul style="list-style-type: none"> <li>• Heavy machinery operation: 3.19 (1.21, 8.40)</li> <li>• Applying chemicals: 2.50 (1.20, 5.21)</li> <li>• Current smoker: 4.98 (1.95, 12.7)</li> <li>• Risky farm safety attitude: 2.82 (1.03, 7.75) compared to safe attitude</li> </ul> Number of hazardous tasks performed: associated prospectively with injury in stepwise fashion ( $P_{trend} < 0.05$ )	<ul style="list-style-type: none"> <li>• Recall bias/error – even though it is a cohort study, follow-up was once yearly, so recall of injuries over the past year may be problematic (less likely to recall less severe injuries);</li> <li>• Limited power due to a relatively small number of prospective injuries</li> <li>• Representativeness (low follow-up response rate); generalizability</li> </ul>
Westaby and Lee, 2003 <sup>30</sup> <ul style="list-style-type: none"> <li>• 3,081 American farm youths aged 12-21 years</li> <li>• 1998-2000</li> </ul>	Cohort study <ul style="list-style-type: none"> <li>• Safety consciousness</li> <li>• Dangerous risk taking</li> <li>• Safety knowledge</li> </ul>	<ul style="list-style-type: none"> <li>• Dangerous risk-taking was the strongest predictor of injury in cross-sectional analyses and of future injury in prospective analyses</li> <li>• Safety consciousness negatively related to injury</li> <li>• Counterintuitively, safety knowledge was positively related to injury</li> </ul>	<ul style="list-style-type: none"> <li>• No quantifiable estimates of risk (i.e. relative risk or odds ratios) as results are from path analyses and structural equation modelling</li> <li>• Potential confounding – analyses did not control for age or sex</li> <li>• Quality of measures used</li> </ul>
Shipp et al., 2013 <sup>31</sup> <ul style="list-style-type: none"> <li>• 410 farmworkers aged 13-19 years in Southern Texas</li> <li>• Large proportion of migrant workers</li> <li>• 2003-2004</li> </ul>	Combined cross-section and cohort <ul style="list-style-type: none"> <li>• Demographic characteristics (sex, age, school, main language etc.)</li> <li>• Health Characteristics (sleep, alcohol use, cigarette smoking, health, stress/anxiety)</li> <li>• Work variables (location and type of farm operation, job tasks performed, job hazards, work organizations)</li> </ul>	Significant hazard ratios (95%CI) for agricultural injury based on an adjusted Cox model included <ul style="list-style-type: none"> <li>• Age &lt;15: 5.8 (1.9, 17.8) and age 16: 4.5 (1.6, 12.8) compared to 17 year olds</li> <li>• Sleep &lt;8 hours during the week: 2.1 (1.1, 4.0) compared to ≥8 hours</li> <li>• Sometimes/often feeling tense, stressed or anxious: 2.3 (1.2, 4.1) compared to not often/never</li> <li>• Working around ditches: 2.0 (1.1, 3.7)</li> <li>• Detasseling corn: 2.7 (1.2, 6.3)</li> </ul>	<ul style="list-style-type: none"> <li>• Recall error due to self-report of exposures</li> <li>• Potential power issues – large confidence intervals; 50 injury event in sample of 410</li> <li>• Potential bias – exposures collected prior to establishing cohort therefore, identified determinants of injury may be predictors of injury survival and recovery rather than risk factors for injury</li> </ul>
Gerberich et al., 2001 <sup>9</sup> <ul style="list-style-type: none"> <li>• 4,398 children aged 0-19 years in rural Midwestern USA</li> <li>• 1990</li> </ul>	Cross-sectional study <ul style="list-style-type: none"> <li>• Selected demographics</li> <li>• Number of hours worked on farm</li> <li>• General farm environment:               <ul style="list-style-type: none"> <li>- Presence of animals</li> <li>- Machinery in active use</li> </ul> </li> <li>• Specific exposures involving animals, machinery, and chemicals (i.e. riding on a tractor, working with dairy cattle)</li> </ul>	Significant relative risks (96% CI) were <ul style="list-style-type: none"> <li>• Operating tractors: 1.42 (1.04, 1.94)</li> <li>• Working with dairy cattle: 1.60 (1.19, 2.14)</li> <li>• Being male: 1.63 (1.15, 2.30)</li> </ul> Findings also suggestive of potential increased risk for injury with working with beef cattle, ATV use and operating harvesters	<ul style="list-style-type: none"> <li>• Self-report measures</li> <li>• Data on exposure and outcome recorded at the same time - greater potential for recall bias</li> <li>• Lack of power due to a small number of agricultural injuries</li> <li>• Unable to establish temporality – injury may have proceeded exposure.</li> </ul>

Study name and details	Design and Exposure(s) Investigated	Key Findings	Key Limitations
Stallones, Beseler, & Chen, 2006 <sup>32</sup> <ul style="list-style-type: none"> <li>• 262 Colorado farm youth aged 13-18 years</li> <li>• 2003-2004</li> </ul>	Cross-sectional study <ul style="list-style-type: none"> <li>• Sleep patterns</li> </ul>	<ul style="list-style-type: none"> <li>• Sleeping <math>\leq 8.5</math> hours: 2.23 (1.09, 4.58)</li> <li>• Ever up past 3 am: 2.22 (1.22, 4.02)</li> <li>• Ever overslept and late for class: 2.28 (1.02-5.11)</li> <li>• Ever fallen asleep in afternoon class: 2.30 (1.17-4.52)</li> </ul>	<ul style="list-style-type: none"> <li>• Limited power</li> <li>• Unable to establish temporality – based on average sleeping habits</li> <li>• Self-report</li> <li>• Potential for recall error/bias</li> </ul>
Marlenga et al., 2010 <sup>33</sup> <ul style="list-style-type: none"> <li>• 1, 068 eligible farms in rural Saskatchewan</li> </ul>	Cross-sectional study <ul style="list-style-type: none"> <li>• Adult working habits: long working hours worked by owner-operator and spouse</li> <li>• Outcome: Scores of hazard exposure scale</li> </ul>	<ul style="list-style-type: none"> <li>• Higher farm working hours reported by spouses of farm owner-operators was positively associated with increased scores on hazard exposure scale for young children (<math>\beta=2.06</math>; <math>p&lt;.001</math>)</li> <li>• Increases in longer farm working hours reported by owner-operators was associated with marginal increases hazard exposure scale among youth workers (<math>\beta=0.90</math>; <math>p=.10</math>)</li> </ul>	<ul style="list-style-type: none"> <li>• Outcome was injury risk (exposure to farm hazards), but did not directly investigate injury</li> <li>• Used self-report which is susceptible to measurement error</li> <li>• Did not account for adult hours worked off farm</li> </ul>
Regional Rural Injury Study-II <sup>34–36</sup> <ul style="list-style-type: none"> <li>• Large cohort of rural communities in Midwest USA</li> <li>• 425 cases of agricultural injury in children (aged &lt; 20 years)</li> <li>• 1,886 controls (aged &lt; 20 years) selected using incidence density</li> <li>• 1999, 2001</li> </ul>	Nested case-control study <ul style="list-style-type: none"> <li>• Parental safety beliefs<sup>36</sup></li> </ul>	Significant adjusted odds ratios (95%CI) for agricultural injury include <ul style="list-style-type: none"> <li>• Parental monitoring: 0.60 (0.40,0.90),</li> <li>• Parents believing in the importance of readiness when assigning new tasks: 0.80 (0.60, 0.95) for physical readiness and 0.70 (0.50, 0.90) for cognitive readiness</li> </ul>	<ul style="list-style-type: none"> <li>• Self-report measures</li> <li>• Data on exposure and outcome recorded in the same interview resulting in greater potential for recall bias</li> <li>• Exposure and outcome based on recall – possible misclassification</li> <li>• Generalizability issues due to potential selection bias due to non-response</li> <li>• Unable to establish temporality – injury may have proceeded exposure.</li> </ul>
	Nested case-control study <ul style="list-style-type: none"> <li>• Bystanding near farm hazards:<sup>35</sup> <ul style="list-style-type: none"> <li>- Equipment in use</li> <li>- Stored equipment</li> <li>- Fields or barnyards</li> <li>- Workshops</li> <li>- Bodies of water</li> <li>- Animals</li> </ul> </li> </ul>	Adjusted odds ratios (95%CI) of agricultural injury for bystander near <ul style="list-style-type: none"> <li>• Equipment in use: 1.5 (1.1, 1.9)</li> <li>• Stored equipment : 1.4 (1.1, 1.8)</li> <li>• Fields or barnyards: 1.4 (1.0, 1.9)</li> <li>• Workshops: 1.2 (0.9-1.6)</li> <li>• Bodies of water: 1.2 (0.9-1.7)</li> <li>• Animals: 1.3 (0.9-1.7)</li> </ul>	
	Nested case-control study <ul style="list-style-type: none"> <li>• Work habits:<sup>34</sup> <ul style="list-style-type: none"> <li>- Agricultural work</li> <li>- Performing chores earlier than developmentally appropriate</li> <li>- Hours worked per week</li> <li>- Number of chores performed</li> </ul> </li> </ul>	Adjusted odds ratio (95% CI) for agricultural injury <ul style="list-style-type: none"> <li>• Any agricultural work: 3.9 (2.6, 5.6) compared to none</li> <li>• Performing chores 2-3 years earlier than developmentally appropriate: 2.6 (1.4, 4.5) compared to age-appropriate</li> <li>• Worked 11-30 hours/week: 1.6 (1.2, 2.1) and worked 31-40 hours/week: 2.2 (1.3, 3.7) (using 1-10 hours a week as reference)</li> <li>• 7-10 chores performed per month: 2.2 (1.3, 3.5) compared to one chore</li> </ul>	

### 2.5.2 Risk Factors Related to the Individual

Based on the studies presented in Table 3 and supporting literature, key individual risk factors for agricultural injury have been identified. This section will highlight some of the common risk factors that have been investigated in analytic studies.

*Exposure to farm work.* Children as young as 12 years old participate in farm work.<sup>2</sup> Exposures to farm work and participation in specific high-risk farm tasks have been associated with the occurrence of pediatric agricultural injuries. In a recent prospective cohort study of 489 rural California high school students working on farms from 2002-2005, total hours annually worked on the farm or ranch was directly associated with injuries observed prospectively (OR 5.09, 95% CI 1.61 to 16.1 for 1,501+ compared to 0–300 hr/year).<sup>2</sup> After simultaneous adjustments for hours worked, school grade (as a proxy for age) and sex, the odds of experiencing an injury was associated with operating heavy machinery, (OR 3.19; 95% CI 1.21 to 8.40) and application of chemicals (OR 2.50; 95% CI 1.20 to 5.21). An increasing number of hazardous tasks performed was also associated with increased rates of injury ( $P_{\text{trend}} < 0.05$ ) with a strong odds ratio of 2.60 (95% CI 0.67 to 10.1; for 7+ compared to 0–2 reported tasks).<sup>2</sup> The effect was not statistically significant most likely due to a lack of statistical power. Other farm work exposures were not significantly associated with injury in these multivariate analyses but these findings are not conclusive due to the limited power and possible bias due to a low follow-up response rate.

Further supporting the finding of increased risk for injury associated with operating heavy machinery above, in a cross-sectional study of a sample of 4,398 farm children and youth from five states in the U.S. in 1990, injury rates were significantly higher in those operating tractors (Adjusted Risk Ratio: 1.42; 95% CI: 1.04 to 1.94). Additionally, children and youth that worked with dairy cattle were 1.6 (95% CI: 1.19 to 2.14) times more likely to have experienced injury.<sup>9</sup> There were suggested positive associations of injury with: operating harvesters (Adjusted RR: 1.37; 95% CI: 0.98 to 1.91); all-terrain vehicle use (Adjusted RR: 1.23; 95% CI: 0.96 to



1.59); and working with beef cattle (Adjusted RR: 1.22; 95% CI: 0.94 to 1.59).<sup>9</sup> Lack of statistical significance may be the result of methodological limitations, such as insufficient power due to a low count of injury events. Furthermore, due to the cross-sectional nature of the data, the temporality of farm work exposures preceding the agricultural injury cannot be established, limiting the inference of causality.

*Age.* In addition to the observed patterns of pediatric agricultural injury by age, analytic research has supported that age influences risk for injury. For example, one study of 13-19 year old farm workers in Southern Texas found that teens aged 13 to 15 years and 16 years were injured 5.8 (95%CI 1.9, 17.8) and 4.5 (95%CI: 1.6, 12.8) times more frequently than 17 year olds in time to event analysis.<sup>31</sup> The difference in hazard of injury for 18-19 year olds was not statistically different from 17 year olds.<sup>31</sup> However, as the large confidence intervals demonstrate, there are concerns about the power of this study to detect significant differences due to relatively small sample size of 410 and 50 injury events.<sup>31</sup>

Furthermore, age may confound or modify the relationship between potential risk factors and pediatric agricultural injury, particularly in terms of exposures to farm environments and activities.<sup>37</sup> For young children under the age of 7 years, simply being exposed to the farm worksite is a significant risk, typically when they are brought in to the worksite when adults are simultaneously engaged in farm work.<sup>16</sup> Older children and youth may possess the cognitive abilities to ensure that they can be more safely brought into farm worksites; however, they frequently participate in farm work and chores, some of which may be beyond their cognitive and physical abilities.<sup>37,38</sup> Participation in farm chores that are not “age-appropriate” have been shown to be associated with an increased risk for injury (OR=2.6 for 2-3 years early, 95% CI:1.4, 4.5) in a US-based case-control study.<sup>34</sup> Whether a task was age appropriate or not was based on the voluntary *North America Guidelines for Children’s Agricultural Tasks* (NAGCAT) published in 1999.<sup>37</sup> NAGCAT has updated recommendations in 2014 to reflect novel research findings which

limits the conclusions that can be drawn from this finding about participating in tasks that are not age appropriate.<sup>39</sup>

In addition, a series of investigations of the physical capabilities required for operation of tractors demonstrate that the majority of youth operators lack the reach and strength necessary to operate critical controls and that youth operators have a diminished field of vision.<sup>40–42</sup> As such, the discrepancy between physical developmental abilities of youth and those required for safe operation of tractors may account for increased risks of injuries due to runovers, rollovers, and collisions but requires further research to confirm.

*Gender.* In a cross-sectional study of pediatric agricultural injury in the American Midwest, males under the age of 20 years were 4.44 times more likely to experience an injury (95% CI: 2.31 to 8.51) compared to females, based on unadjusted analysis. This rate ratio was reduced to 1.63 (95% CI: 1.15 to 2.30) when controlling for tractor operation, working with dairy cattle, working with beef cattle, operating a harvester, sheep on the farm, number of different types of equipment, and any all-terrain vehicles.<sup>9</sup> However, age was not included in the model and was not investigated in the model building strategy as a confounder or effect modifier.

In contrast, a California teen farm worker study found that once adjusted for age, school grade, and hours worked, being female was associated with a marginal increase in prospective injury although the finding was not statistically significant (OR=1.61; 95% CI: 0.74 to 3.48).<sup>2</sup> Given the difference in findings from the two studies, it is possible the relationship between sex and agricultural injury is confounded or mediated by age (the American Midwest study did not control for age or grade) or specific work exposures and other potential mediators (the Californian study did not control for specific farm exposures, only hours worked). Alternatively, the Californian study may have simply lacked the statistical power to detect the difference in prospective injury rates between females and males.

Although the findings of these studies are inconsistent, they both demonstrate that controlling for farm work exposures can change the risk of pediatric injury associated with sex. This suggests that much of the observed sex pattern found in descriptive studies and analytic research could be explained by differential farm exposures among males and females.

*Fatigue.* Fatigue and sleep patterns have also been identified as contributing to agricultural injury in children and youth.<sup>32,9,43</sup> A cohort study of 410 adolescent farmworkers aged 13-19 years, found that typically sleeping less than 8 hours per day during the week was associated with increased risk for injury with an odds ratio of 2.10 (95% CI: 1.09 to 4.04).<sup>2</sup> In a cross-sectional study of Colorado farm residents aged 13 to 18 years, sleeping 8.5 hours or less on average was associated with increased risk for injury with an odd ratios of 2.23 (95% CI 1.09-4.58).<sup>32</sup> Measures of fatigue such as falling asleep in afternoon classes and oversleeping in the morning were also associated with increased odds of agricultural injury [Adjusted OR=2.30 (95%CI 1.17-4.52) for falling asleep in class; Adjusted OR=2.28 (95%CI 1.02-5.11) for overslept]. However, based on the cross-sectional data, it cannot be determined if the fatigue and insufficient sleep preceded the injury. As such, it is possible that lasting effects from an agricultural injury such as pain can impact sleep and fatigue which would also account for the observed associations.

*Risk behaviours and risk-taking orientation.* In general, there is an established relationship between engaging in risk taking behaviours and injury. For example, early engagement in risk behaviours such as smoking, drinking and sexual activity is related to injury at age 15 years across countries and cultures. There was a substantial trend of odds of injury increasing with early engagement in one, two, three, or four risk behaviours in a cross-national analysis, with the odds of injury increasing to 1.85 (95% CI: 1.70-2.02) for early engagement in four risk behaviours.<sup>44</sup>

However, research specific to risk-taking and agricultural injuries is much more limited. A longitudinal study of youth aged 12 to 21 years in the United States demonstrated that scores on a dangerous risk-taking scale predicted future agricultural injury in a structural equation model but the analyses did not account for key covariates of age and sex.<sup>30</sup> Additionally, specific risk behaviours have also been demonstrated to be related to injury.<sup>45</sup> In the California teen farm workers study, smoking demonstrated a significant and graded increased odds for injury for smoking with an odds ratio of 4.98 (95% CI 1.95 to 12.7) for current smokers and an odds ratio of 2.19 (95% CI 0.67 to 7.14) for former smokers when compared to never smokers.<sup>2</sup> Although there are no known analytic studies focusing on risk-taking orientation and pediatric agricultural injuries, a study of a wide range of youth workers in the United States found that risk-taking orientation significantly predicted work injury in a structural equation model.<sup>46</sup>

*Safety attitudes.* A risky attitude toward safety predicted future injuries in the California teen farm workers study.<sup>2</sup> Safety attitude was measured by a composite safety attitude risk index consisting of 3 items: (1) “No matter how hard you try to prevent them, serious injuries are going to occur on a farm or ranch;” (2) “Safety precautions are important and necessary, even if they slow the job;” and (3) “I am less likely to be injured doing farm work than other people my age doing the same work.” An odds ratio of 2.82 (95% CI 1.03 to 7.75; adjusted for sex, school grade and hours worked) was observed when comparing those with risky attitudes to those with safe attitude and overall, the index demonstrated a significant trend with injury risk ( $P_{\text{trend}} < 0.05$ ).<sup>2</sup>

### **2.5.3 Risk Factors Related to Parents**

Pediatric agricultural injury has been attributed to parental factors such as inappropriate supervision, the related concept of *permissiveness* (such as allowing young children in the farm worksite), safety beliefs and attitudes, and work habits.<sup>33,36,47</sup> There is little known about the degree to which these factors contribute to pediatric agricultural injuries. A retrospective case study of adult supervision was conducted using 334 cases of fatal or hospitalized pediatric

agricultural injuries from Canada and the United States from 1989-2002. Adequate supervision was defined as being available, proximal, and continuous.<sup>47</sup> With this definition, 34% of injuries occurred in the presence of adequate supervision, implying that supervision alone is not enough to prevent pediatric agricultural injury.<sup>47</sup> However, this was a descriptive study only, and there currently are no analytic studies investigating the contributable risk associated with lack of adequate supervision at the time of injury.

Parental beliefs about farm safety have been demonstrated as being significantly related to risk for injury.<sup>36</sup> In a nested case-control study in the American Midwest, stricter beliefs about the importance of supervision were associated with decreased risks of injury for working children with an odds ratio of 0.60 when comparing “moderate” to “very strict” (95% CI: 0.40 to 0.90).<sup>36</sup> Parents believing in the importance of considering developmental readiness when deciding whether children were ready to perform a new chore was associated with a concomitant decrease in injury rates with an odds ratio of 0.80 for physical readiness (95% CI: 0.60 to 0.95) and of 0.70 for cognitive readiness (95% CI: 0.50 to 0.90).<sup>36</sup> Notably, there was no association between parents’ safety beliefs and chore assignments, indicating that the observed relationships are not mediated or confounded by chore assignments.

Although not specific to the outcome of injury, a cross-sectional study of Saskatchewan farm families investigated the association between adult work habits and both young child and youth exposure to farm hazards. Higher farm working hours reported by spouses of farm owner-operators was positively associated with exposures to hazards for young children ( $\beta=2.06$ ;  $p<.001$ ). Increases in farm working hours reported by owner-operators was associated with marginal increases in exposures to hazards among youth workers ( $\beta=0.90$ ;  $p=.10$ ). These findings suggest the potential association between parent work habits contribute and risk for injury may be mediated by exposure to farm hazards.

#### 2.5.4 Risk Factors Related to the Farm Environment

Certain hazards on farms have been identified as leading causes of pediatric agricultural injuries including *tractors and machinery, water hazards, falls from heights, working with animals, and all-terrain vehicles*.<sup>1,6,16,12</sup> Exposure to these acute risk factors is modifiable and as such they are especially important targets for safety interventions. In a prospective cohort study of adults and children on farms in Saskatchewan, farms with high levels of physical risks are associated with increased rates of injury [OR: 1.48 (95% CI: 1.15 to 1.90)].<sup>48</sup> However, there is little analytic research investigating the degree to which the natures of specific farm work environments, and the degree of hazard imposed by those environments contribute to pediatric farm injury.

Researchers using a case-control study design of farm children in the Midwest of the United States investigated the effects of being a bystander near hazardous farm environments and activities.<sup>35</sup> Bystanding in the vicinity of equipment in use [OR: 1.5 (95% CI: 1.1 to 1.9)] and equipment being stored [OR: 1.4 (95% CI: 1.1 to 1.8)] were both identified as risk factors.<sup>35</sup> Bystanding near fields and barnyards also was significantly associated with injury (OR=1.4; 95% CI: 1.0 to 1.9).<sup>49</sup> Other exposures were positively associated with risk for injury in a marginal manner, but were not statistically significant including bystanding near bodies of water, animals, and workshops.<sup>49</sup> However, these results may have been susceptible to recall error and bias. Bystanding near these hazards was based on self-report of past exposure (if child or youth was 12 years of age or older) or parent report (if child was younger than 12 years) in a structured interview. Given that bystanding near farm hazards is likely commonplace and not particularly memorable, recall of exposures is particularly vulnerable to recall error. Furthermore, information about injury was collected in the same interview which could result in biased recall (i.e., parents who recall greater exposure of their children to hazards may be more likely to recall their child experiencing an injury).

## **2.6 Prevention of Pediatric Agricultural Injury**

This section focused on strategies that are currently used to prevent agricultural injury. Educational interventions have been the standard of practice for prevention in this area and will be summarized and evaluated below. A traditional approach to hazard prevention in occupational health is the hierarchy of controls which recommends from most to least effective: elimination, substitution, isolation, engineering controls, administrative controls, and the use of personal protective equipment.<sup>50</sup> In this discussion of preventive strategies for pediatric agricultural injury, I will focus on two of those elements: administrative controls and engineering controls, which will be discussed in turn.

### **2.6.1 Educational Interventions**

In practice, the majority of interventions aimed specifically at children and youth have been educational in nature: school-based programs, safety days or day camps, tractor training programs, and educational campaigns.<sup>29,51</sup> Although frequently used in the prevention of pediatric agricultural injuries, evaluations of educational interventions are limited. In particular, many evaluations use weak methods and there is a lack of randomized controlled trials.<sup>29,51</sup> Furthermore, based on a systematic review of existing evidence it appears that educational interventions for pediatric agriculture injuries may not be effective on their own, as the support is mixed at best.<sup>29,51</sup> Moreover, a recent systematic evaluation of safety days demonstrated limited and mixed results supporting effectiveness in preventing pediatric agricultural injury.

These findings about educational interventions are supported by evaluations of educational strategies aimed at general and adult populations. Two systematic reviews which included meta-analyses whenever data were available also concluded that educational interventions have limited effectiveness.<sup>52,53</sup> Since these systematic reviews, an assessment of a farm safety program in Saskatchewan that administered 112 mainly educational interventions had

no demonstrated effect on farm safety practices, exposure to farm hazards, and agricultural injuries.<sup>54</sup>

### **2.6.2 Assignment of Developmentally Appropriate Tasks**

The North American Guidelines for Children's Agricultural Tasks (NAGCAT) is a unique preventive strategy that combines an educational and administrative approach. NAGCAT incorporates research findings to give recommendations for developmentally appropriate and safe farm work tasks for children aged 7–16 years.<sup>37,39</sup> NAGCAT is intended to be a resource to assist parents in assigning tasks to their children.<sup>37</sup>

Initially developed in 1999, the NAGCAT has recently been updated in 2014 based upon the latest empirical evidence.<sup>39</sup> While NAGCAT does have the potential as an educational intervention for preventing pediatric agricultural injury, uptake has been sporadic, despite widespread distribution and efforts. Furthermore, NAGCAT does not target children under 7 years, which have been identified as having the greatest risks for injury.<sup>16,20,27</sup> As such, although NAGCAT is a great resource and is demonstrated to be effective when used, it needs to be used in combination with other preventive efforts.

### **2.6.3 Administrative Controls**

Administrative controls for agricultural injury include workplace policy and practices, occupational health and safety regulations, labour laws and other relevant legislation. However, these types of controls are limited in practice as traditionally farmers and farm operations in our country emphasize autonomy and are highly resistant to outside interference.<sup>55</sup> As such, occupational regulations governing the agricultural sector are inconsistent and can be difficult to enforce. For example, in the United States, farms that employ less than 10 employees are exempt from occupational safety and health regulations including mandatory safety training.<sup>56</sup> Similar exemptions exist in most provinces and territories in Canada. In both Canada and the United States, children of farm owner-operators are exempt from child labour regulations.<sup>57</sup>



Although regulatory controls have demonstrated potential for reducing the burden of agricultural injury,<sup>58</sup> farming populations are traditionally resistant to outside interference.<sup>55</sup> For example, Marlenga and colleagues demonstrated that if the family farm exemption from the Hazardous Occupations Orders for agriculture within the US Child Labor Laws was removed and age restriction for performing hazardous agricultural work was raised from 16 to 18 years that, hypothetically, there would be a reduction in the burden of injuries experienced by youth farm workers.<sup>58</sup> Based on this study and other research, in 2012, United States Departmental of Labor proposed to reform child labor laws pertaining to agricultural work. This proposal was strongly opposed by the some portions of the farming community,<sup>59</sup> and ultimately was rejected.

In contrast, there are recent trends of farms using voluntary policy such as using certification systems, safety audits, and safety standards.<sup>60</sup> Based on these trends, a novel approach to the prevention of agricultural injury in youth workers was the development a new voluntary “best practice” model policy for youth employment in agriculture.<sup>60</sup> The researchers also produced a template that can be easily customized and adapted for immediate use in farm operation. Given the novelty of this approach (published in June 2014), currently there is no information about the uptake and effectiveness of this intervention.

#### **2.6.4 Engineering controls**

Ergonomic and physical engineering controls involve altering the physical nature of farm work and the farm work environment in order to prevent injuries. Examples of physical engineering controls include roll-over protection structures for tractors, guards for power take off shafts, guard rails to prevent falls, better handling facilities for animals and closed transfer systems for pesticides.<sup>61</sup> More socially oriented injury prevention strategies aim to keep children out of the farm work space and include designated outdoor play areas away from farm work and improved access to daycare options during fieldwork seasons in rural areas.<sup>16</sup> Although studies have demonstrated that advances in engineering controls have made farm work safer, there is

very little research that investigates if engineering controls reduce the burden of injury at the population level.<sup>51,61</sup> One study found that legislative mandates expanding the use of roll-over protective structures on tractors were not associated with a reduction of injuries, although this study did not control for adherence to the legislation.<sup>52</sup>

## **2.7 Agricultural Injury in Young Adults**

It is hypothesized that young adults on farms have similar experiences to youth working on farms. It is in the teenage years and young adulthood where farm work begins to be conducted independently with minimal supervision. It has also been demonstrated that young adults are at substantial risk for injury. In CAIR surveillance data, from 1990-2008, young adults aged 20 to 29 years accounted for 145 agricultural fatalities.<sup>6</sup> The resulting crude agricultural injury rate was 10.2 per 100,000 per year. This rate is comparable to the highest pediatric fatality rate which was for 0-4 year olds (12.8 per 100,000 per year).<sup>6</sup> For hospitalizations, from 1990-2000 there was a crude annual incidence rate of 193.3 per 100,000 for 20 to 29 year olds, based on the occurrence of 1,561 hospitalized agricultural injuries.<sup>13</sup> This hospitalization rate is higher than rates for pediatric agricultural injury.

Unlike pediatric agricultural injuries, which have comparatively received more attention in research, there is very limited research about agricultural injuries in young adults, even at a descriptive level. Usually, this age group is grouped together either with youth or with adults under the age of 60.<sup>6,13,62,63</sup> As such, there is little known about common patterns or risk factors of injury in this specific population.

## **2.8 Summary**

Common causes of more serious pediatric agricultural injuries include: tractors and machinery, water and other liquid hazard, animal-related mechanisms, falls from heights, and ATV use. Risk factors supported by analytic research include: specific age groups, sex, hours

worked on farm, times of year associated with intensive field work, operating machinery, participation in developmentally inappropriate chores, bystander in the vicinity of hazards, working with certain types of livestock, fatigue, risk behaviours, and safety attitudes. Prevention strategies for pediatric agricultural injuries largely have focused on educational interventions and these may be limited in effectiveness. Interventions should focus more on administrative and engineering controls.

The following research gaps were identified. The surveillance data used in the most recent comprehensive report on pediatric agricultural injury is over a decade old. As such, the information about the rates and characteristics of pediatric agricultural injuries and fatalities in Canada needs to be updated using more recent national surveillance data in order to identify contemporary patterns. Analytic research specific to pediatric agricultural injuries is limited and may not be generalizable to Canadian farming populations as studies almost exclusively used samples from American farm populations. Majority of analytic research has investigated the presence or absence of farm exposures which does not provide information about how the amount of exposure impacts rates of injury. These gaps will be addressed in the following two manuscripts.

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## **Chapter 3**

# **Fatal and Hospitalized Pediatric Agricultural Injuries in Ontario and Saskatchewan, Canada, 1990-2011**

## **Abstract**

**Objective:** This study aimed to provide updated information on the epidemiology of agricultural injury in Canadian children and youth.

**Methods:** We described the incidence and patterns of pediatric agricultural fatalities and hospitalizations in the provinces of Ontario and Saskatchewan. The primary data source was the Canadian Agriculture Injury Reporting system. Age-adjusted rates were calculated using Poisson regression. Available descriptors included demographic factors, temporal factors (years and month), anatomical sites and nature of injuries, and mechanisms of injury.

**Results:** The overall age-adjusted annual rates of agricultural injuries per 100,000 persons were: 7.8 (95%CI: 6.2-10.0) for Saskatchewan fatalities, 6.9 (95%CI: 5.6-8.5) for Ontario fatalities, 80.2 (95%CI: 73.9-87.1) for Saskatchewan hospitalizations, and 74.5 (95%CI: 69.9-79.4) for Ontario hospitalizations. Males accounted for majorities of both fatalities and hospitalizations in both provinces. Temporally, the only substantial trends were that Ontario fatality rates and Ontario hospitalization rates from 2000-2009 decreased slightly over time. Agricultural hospitalization and fatality rates peaked during summer months. Leading mechanisms of injury in both provinces were: falls from heights, animal-related mechanisms, machine entanglements, machine runovers and rollovers, and drowning.

**Conclusion:** There continues to be a substantial burden of agricultural injuries in Canadian children and youth. Recurrent patterns of injury provide evidence in support of preventive recommendations.

### **3.1 Introduction**

Children who live on farms experience higher rates of premature death, injury-related morbidity, disability due to injury, and associated healthcare costs when compared with children from the general population.<sup>1,2</sup> Agricultural injuries can result in substantial burdens to the children involved, their families, their communities, and society. These injuries can be fatal or result in long-term disability due to severe injuries such as spinal cord injury, traumatic brain injuries, crush injuries, loss of limbs, and chemical ingestion.<sup>3</sup>

Aside from the obvious medical expenses, costs attributed to pediatric agricultural injuries also include short-term and long-term child and parental work loss, reduction in household productivity, and impacts on quality of life.<sup>4</sup> Given that pediatric agricultural injuries occur early in life, the resulting burdens in terms of person-years of lost life or quality-adjusted life years lost are high. For example, a national study in the United States found an annual loss of 4,322 quality-adjusted life years due to non-fatal agricultural injury in children and youth under the age of 19.<sup>4</sup>

Contemporary epidemiological data that describe the occurrence and patterns of pediatric farm injuries in Canada are lacking in the biomedical literature. The most recent information published by the Canadian Agricultural Injury Reporting system (CAIR) about hospitalized agricultural injuries in children and youth contains surveillance information from 1990 to 2003.<sup>5</sup> More current analyses are warranted. Furthermore, there are very few comparisons of pediatric agricultural injury between agricultural or geographic regions. We therefore used provincial surveillance data covering two decades, from 1990-2011, to: 1) describe fatal and hospitalized agricultural injuries in children and youth in the provinces of Ontario and Saskatchewan; and 2) identify common patterns and potential causes of preventable agricultural injuries.

### **3.2 Methods**

Cases of agricultural injury (hospitalized injuries and fatalities) were abstracted from the Ontario and Saskatchewan provincial registries of the CAIR program. CAIR, formerly known as Canadian Agricultural Injury Surveillance Program, is an ongoing national initiative established to monitor agricultural injuries.<sup>6</sup> Since the founding of this system in 1995, standard protocols have been established for the identification and description of agricultural injuries and fatalities in Canada<sup>6</sup> which are described below.

We focused on a single comparison of geographic regions in Canada. Ontario and Saskatchewan were chosen for this comparison because these provinces: 1) represent two of the largest proportions of the national farming population, 26.1% and 16.3% respectively; and 2) have very different farming characteristics such as acreage, scope and type of farm operations, and contributions to the national economy.<sup>7</sup> Surveillance data were available for 1990-2011 for fatalities in both provinces. For hospitalizations, the surveillance period was 1990-2008 for Ontario and 1990-2006 for Saskatchewan.

#### **3.2.1 Definition and identification of fatalities and hospitalizations**

CAIR defines an agricultural fatality as: “1) Any unintentional injury resulting in death that occurs during activities related to the operation of a farm or ranch in Canada and/or 2) any unintentional injury resulting in death that involves any hazard of a farm or ranch environment in Canada (excluding fatal non work-related injuries that take place in the farm residence).”<sup>5</sup> Included in this definition are deaths that occurred off farm but involved farm work (e.g., driving tractor on a public road) and deaths where victims are killed because a third party is engaged in agricultural work.<sup>5</sup>

For the agricultural fatalities, data were collected on-site at provincial Chief Coroners’ or medical examiners’ offices using standardized abstraction methods.<sup>6</sup> For hospitalizations, basic hospital data were obtained through agreements with the Ministry of Health for each province.<sup>8</sup>

Cases were identified by systematic searches of hospital discharge (or separation) databases. Cases were considered for inclusion if the International Classification of Diseases (ICD) code for place of occurrence identified that the injury took place on a farm or ranch (ICD 9 CM code = E849.1; ICD 9 CA 5th digit sub-classification "place of occurrence" code =1; ICD 10 CA code= U98.7) and/or the external cause of injury codes indicate involvement of agricultural machinery (ICD 9 code=E919.0; ICD 10 codes=W30 or V84X).<sup>9</sup> The majority of hospitalized agricultural injury cases were identified using ICD 9 codes, with the exception of most Ontario cases filed after March 1999 which were identified using ICD 10 codes. Only cases where a patient has been admitted to hospital for at least one day are included.

Enhanced hospitalization data were obtained by chart data requests to the institutions where cases were admitted. Medical records personnel abstract specific information from the individual patient charts using a standardized data abstraction form that has been mailed to the institution.<sup>8</sup> These forms were mailed back to CAIR collaborators where the information obtained from the mail survey abstraction form was combined with the computerized hospital record to create the enhanced data sets.<sup>8</sup>

Human subject requirements used in this study and by CAIR were approved by Research Ethics Boards at a variety of institutions including the Biomedical Research Ethics Board at the University of Saskatchewan and the Health Sciences and Affiliated Teaching Hospital Research Ethics Board at Queen's University.

### **3.2.2 Analysis strategy**

SAS 9.3 (SAS Institute Inc., Cary, NC) was used to conduct all analyses. Patterns of injury were described by the key data elements of interest: 1) age and sex of person injured; 2) year and month of injury; 3) mechanisms of injury; 4) natures and anatomical sites of injury. Analyses were descriptive in nature: using simple counts, frequencies, and cross-tabulations. Rates, rate ratios, and 95% confidence intervals were estimated using Poisson regression,

controlling for age where cell sizes permitted. Age-specific rates were calculated for any mechanism that accounted for more than 10% of hospitalizations because there was insufficient cell counts when considering all mechanisms by age group.

Denominator data used for rate calculations was comprised of data from the 1996 through 2006 Canada Census of Agriculture<sup>10</sup> combined with data from the seasonal agriculture workers program from Citizenship & Immigration Canada.<sup>11,12</sup> Data were extrapolated for the years in which the census did not occur. Chi-square tests were used to identify differences in injury rates by age group and sex.

### **3.3 Results**

Saskatchewan had a higher age-adjusted rate of hospitalizations at 80.2 per 100,000 per year (95%CI: 73.9-87.1) compared to Ontario at 74.5 per 100,000 per year (95%CI: 69.9-79.4;  $p=0.06$ ). The age-adjusted rates of fatalities were 7.8 (95%CI: 6.2-10.0) per 100,000 per year and 6.9 (95%CI: 5.6-8.5) per 100,000 per year in Saskatchewan and Ontario, respectively ( $p=0.28$ ). In both provinces, the leading anatomical sites and natures of hospitalized injuries were fractures of the upper and lower limbs, open wounds on limbs, and intracranial injuries excluding skull fractures (Table 1).



**Table 1. Description of Primary Injuries**

	Saskatchewan		Ontario	
	n	(%)	n	(%)
Total Injuries	705	(100.0)	1066	(100.0)
Fatalities	71	(10.1)	103	(9.7)
Hospitalized Injuries <sup>a</sup>				
Fracture: upper/lower limb	208	(29.5)	339	(31.8)
Open wound: limb	66	(9.4)	131	(12.3)
Fracture: skull, spine/trunk	48	(6.8)	111	(10.4)
Intracranial injury, excluding those with skull fractures	63	(8.9)	104	(9.8)
Internal injury of chest, pelvis, and abdomen	17	(2.4)	58	(5.4)
Open wound: head, neck, and trunk	30	(4.3)	39	(3.7)
Contusion with intact skin surface	33	(4.7)	19	(1.8)
Burns	29	(4.1)	10	(0.9)
Certain traumatic complications	26	(3.7)	22	(2.1)
Cellulitis	22	(3.1)	14	(1.3)
Crushing injury	14	(2.0)	29	(2.7)
Superficial injury	17	(2.4)	8	(0.8)
Exposure to toxic substance	17	(2.4)	4	(0.4)
Sprains/strains of joints and adjacent muscles	14	(2.0)	7	(0.7)
Dislocation	10	(1.4)	5	(0.5)
Injury to nerves and spinal cord	2	(0.3)	3	(0.3)
Foreign body (eye)	2	(0.3)	1	(0.1)
Injury to blood vessels	0	(0)	2	(0.2)
Other	16	(2.3)	45	(4.2)
Missing	0	(0)	12	(1.1)

a. Nature of injury categorization determined from ICD-9 and ICD-10 codes for nature of injury

### 3.3.1 Age and Sex

As shown in Table 2, younger age groups experienced a significant reduction in risk when compared to 15-19 year olds in Saskatchewan [RR=0.77 (95%CI: 0.60-0.97) for 0-4 year olds; RR=0.78 (95%CI: 0.63-0.97) for 5-9 year olds; and RR=0.75 (95%CI: 0.61-0.91) for 10-14 year olds]. In contrast, in Ontario, only 10-14 year olds had a risk reduction compared to 15-19 year olds [RR=0.78 (95%CI: 0.66-0.92)]. The rate observed for 10-14 year olds was also significant lower than the rates for children under 5 ( $\chi^2=12.37$ ;  $p=0.004$ ) and aged 5 to 9 years ( $\chi^2=12.37$ ;  $p=0.002$ ). In Saskatchewan, males had substantially higher age-adjusted rates of injury [RR=3.5 (95% CI: 2.9-4.2)] with the annual rates of 60.4 per 100,000 (95% CI: 55.0-66.2) for males and 17.7 per 100,000 (95% CI: 15.6-20.2) for females. Similarly, in Ontario, the annual age-adjusted rates were 54.3 per 100,000 (95% CI: 50.5-58.5) for males and 17.7 per 100,000 (95% CI: 15.6-20.2) for females [RR=3.1 (95% CI: 2.6-3.4)].

**Table 2. Fatal and Hospitalized Pediatric Agricultural Injuries by Province, Age and Sex: Counts and Rates per 100,000**

	Saskatchewan			Ontario		
	Fatal <sup>a</sup>	Hospitalized <sup>b</sup>	Combined <sup>b</sup>	Fatal <sup>a</sup>	Hospitalized <sup>c</sup>	Combined <sup>c</sup>
<b>Age 0-4 Years</b>						
Males	15	65	78	32	141	170
Females	4	29	33	11	53	62
Total Count	19	94	111	43	194	232
Total Rate	12.8	75.0	88.6	17.7	84.5	101.0
(95%CI)	(8.2-20.0)	(61.3-91.8)	(73.5-106.7)	(13.1-23.8)	(73.4-97.3)	(88.8-114.9)
<b>Age 5-9 Years</b>						
Males	9	97	103	14	172	186
Females	2	39	41	2	71	73
Total Count	11	136	142	16	243	259
Total Rate	5.3	76.8	81.3	5.0	79.5	84.7
(95%CI)	(3.0-9.6)	(64.9-90.9)	(69.1-95.8)	(3.0-8.1)	(70.1-90.1)	(75.0-95.7)
<b>Age 10-14 Years</b>						
Males	18	135	151	15	169	184
Females	1	35	36	1	59	60
Total Count	19	170	187	16	228	244
Total Rate	7.1	73.3	80.6	3.9	59.9	64.1
(95%CI)	(4.5-11.2)	(63.1-85.2)	(69.9-93.1)	(2.4-6.4)	(52.6-68.2)	(56.6-72.7)
<b>Age 15-19 Years</b>						
Males	21	196	214	24	244	267
Females	1	38	38	4	54	58
Total Count	22	234	252	28	298	325
Total Rate	7.8	98.0	105.5	6.6	76.6	83.6
(95%CI)	(5.1-11.8)	(86.2-111.4)	(93.3-119.4)	(4.6-9.6)	(68.4-85.8)	(75.0-93.2)
<b>Overall: Age 0-19 Years<sup>d</sup></b>						
Males	63	493	546	85	726	807
Females	8	141	148	18	237	253
Total Count	71	634	694	103	963	1060
Total Rate <sup>d</sup>	7.8	80.2	88.4	6.9	74.5	82.3
(95%CI)	(6.2-10.0)	(73.9-87.1)	(81.9-95.7)	(5.6-8.5)	(69.9-79.4)	(77.4-87.4)

a. 1990-2011 surveillance period; b. 1990-2006 surveillance period due to availability of hospitalization data from Saskatchewan; c. 1990-2009 surveillance period due to availability of hospitalization data from Ontario; d. Age-adjusted rates

Children in older age groups were 38-59% less likely to be involved in an agricultural fatality than children aged 0-4 years in Saskatchewan [Rate Ratio=0.41 (95%CI: 0.20-0.87) for 5-9 year olds; RR=0.55 (95%CI: 0.30-1.0) for 10-14 year olds; RR=0.61 (95%CI: 0.33-1.1) for 15-19 year olds]. Similarly, in Ontario, compared to children under 5 years, older age groups were 62-78% less likely to be involved in an agricultural fatality [RR=0.28 (95%CI: 0.16-0.50) for 5-9 year olds; RR=0.22 (95%CI: 0.13-0.40) for 10-14 year olds; RR=0.38 (95%CI: 0.23-0.61) for 15-19 year olds]. Age-adjusted fatality rates were 7.9 times higher (95%CI: 3.7-16.4) for males than

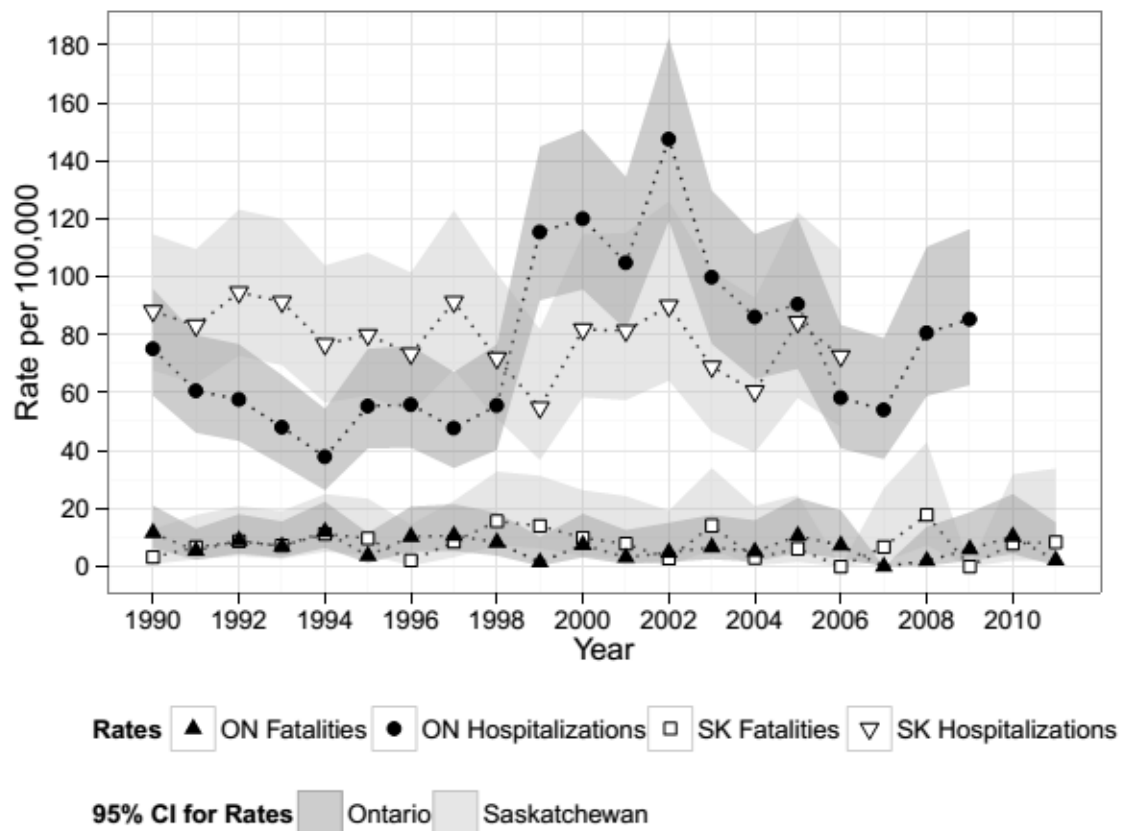
females in Saskatchewan with annual rates of 7.4 per 100,000 (95%CI: 5.8-9.6) and 0.9 (95%CI: 0.5-1.9) respectively. In Ontario, males had age-adjusted annual fatality rate of 5.9 (95%CI: 4.7-7.4) which was 4.7 times (95%CI: 2.8-7.9) the annual age-adjusted rate of 1.3 (95% CI: 0.8-2.0) observed in females.

In comparing hospitalizations across provinces, Saskatchewan had significantly higher rates for 10-14 year olds [RR=1.22 (95%CI: 1.01-1.50)] and 15 to 19 year olds [RR=1.28 (95%CI: 1.05-1.56)]. For fatalities, there were no differences in age-specific rates [RRs ranging between 0.72-1.8].

### **3.3.2 Temporal Factors**

Comparing the two provinces, in three out of the 9 years when Ontario and Saskatchewan used the same method of identifying hospitalized agricultural injuries (1990-1998), Saskatchewan had significantly higher rates (Figure 1). After 1999, when Ontario began using ICD 10 codes to identify hospitalizations, rates were consistently similar between provinces. There were no statistically significant differences between Ontario and Saskatchewan in fatality rates regardless of year (Figure 1).

**Figure 1. Age-adjusted Injury Rates by Year**

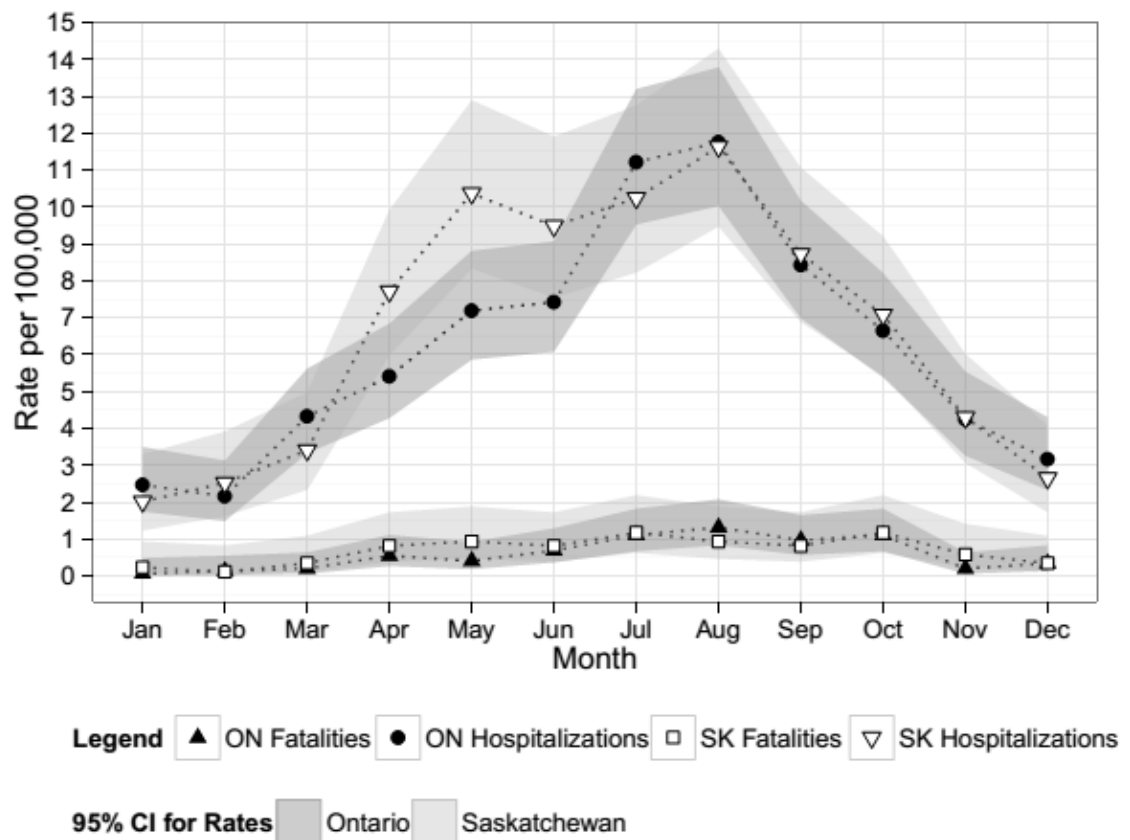


Saskatchewan hospitalization rates were fairly stable over time, decreasing at a rate 0.01 per 100,000 per year ( $\chi^2=2.35$ ,  $p=0.12$ ). As seen in Figure 1, Ontario hospitalizations did not follow a linear trend. From 1990-1998, when Ontario hospitalizations were identified using ICD 9 codes, annual rates had a decreasing linear pattern at a rate of 0.05 per 100,000 each year ( $\chi^2=3.69$ ,  $p=0.06$ ). From 2000-2009, when CAIR used ICD-10 codes to identify hospitalizations, rates of hospitalization decreased by 0.07 per 100,000 each year ( $\chi^2=19.5$ ,  $p<0.001$ ). In 1999, both ICD 9 and ICD 10 codes to identify hospitalizations, so data from that year was not included in stratified analyses. Saskatchewan fatalities remained consistent in occurrence over time, with no statistically significant increase or decrease in rates ( $\chi^2<0.005$ ,  $p=0.95$ ). In comparison,

Ontario fatalities demonstrated a decreasing linear pattern at a rate of 0.03 per 100,000 per year ( $\chi^2=4.33$ ,  $p=0.04$ ).

Monthly hospitalization and fatality rates for Ontario and Saskatchewan are presented in Figure 2. Hospitalization rates were lowest during the late fall and winter, and peaked in the summer months. Monthly patterns were stable by year with no statistically significant interactions between year and month of injury. Fatalities followed a similar trend, albeit less dramatically. There were no statistically significant differences between provinces in terms of monthly injury rates.

**Figure 2. Aggregated Monthly Age-adjusted Injury Rates\***



Note. \* For fatalities, the 1990-2011 surveillance period was used. For hospitalizations, 1990-2006 surveillance period was used for Saskatchewan and 1990-2009 surveillance period for Ontario based on availability of data.

### 3.3.3 Mechanisms of Hospitalized Agricultural Injuries

The top mechanisms of injury were: machine-related entanglements, falls from heights animal-related injuries, and struck by or against object (Table 3). Each of these mechanisms will be discussed in turn, followed by a discussion of the relationships between top mechanisms and age group.

**Table 3. Mechanism of Hospitalized Pediatric Agricultural Injuries in Saskatchewan and Ontario**

	Saskatchewan			Ontario		
	n	Rate	(95%CI)	n	Rate	(95%CI)
Total all-cause hospitalizations	634	82.0	(75.9-88.6)	963	73.8	(69.3-78.6)
Total non-machine related	381	49.3	(44.6-54.5)	457	35.0	(32.0-38.4)
Fall from height	79	10.2	(8.2-12.7)	170	13.0	(11.2-15.1)
Animal-related injury	151	19.5	(16.7-22.9)	134	10.2	(8.7-12.2)
Struck by or against object	55	7.1	(5.5-9.3)	76	5.8	(4.7-7.3)
Exposure to fire/explosions	24	3.1	(2.1-4.6)	5	0.4	(0.2-0.9)
Fall on the same level	13	1.7	(1.0-2.9)	22	1.7	(1.1-2.6)
Contact with toxic substances or environments	21	2.7	(1.8-4.2)	14	1.1	(0.6-1.8)
Caught in-under or between objects	6	0.8	(0.3-1.7)	14	1.1	(0.6-1.8)
Jumped to lower level	10	1.3	(0.7-2.4)	5	0.4	(0.2-0.9)
Firearms	8	1.0	(0.5-2.1)	1	0.1	(0.01-0.5)
Contact with temperature extremes	5	0.6	(0.3-1.5)	2	0.2	(0.04-0.6)
Drowning	0	0	(0-0)	5	0.4	(0.2-0.9)
Contact with electric current	4	0.5	(0.2-1.3)	4	0.3	(0.1-0.8)
Other/unknown	5	0.6	(0.3-1.6)	5	0.4	(0.2-0.9)
Total machine related	250	32.3	(28.6-36.6)	502	38.5	(35.3-42.0)
Entanglement	86	11.1	(9.0-13.7)	175	13.4	(11.6-15.6)
Runover, pinned, struck by moving machine	18	2.3	(1.5-3.7)	71	5.4	(4.3-6.9)
Fell from machine then runover/pinned/struck	15	1.9	(1.2-3.2)	67	5.1	(4.0-6.5)
Fall from machine but not runover/pinned/struck	26	3.4	(2.3-4.9)	45	3.4	(2.6-4.6)
Pinned or struck by machine component	38	4.9	(3.6-6.8)	43	3.3	(2.4-4.4)
Struck by object propelled/slid/fell from machine	10	1.3	(0.7-2.4)	19	1.5	(0.9-2.3)
Fall from machine unspecified	18	2.3	(1.5-3.7)	19	1.5	(0.9-2.3)
Rollovers	12	1.6	(0.9-2.7)	13	1.0	(0.6-1.7)
Struck against machine or machine component	13	1.7	(1.0-2.9)	11	0.8	(0.5-1.5)
Fall from stationary machine	5	0.6	(0.3-1.6)	11	0.8	(0.5-1.5)
Other/unknown	9	1.2	(0.6-2.2)	28	2.1	(1.5-3.1)
Missing mechanism of injury	3			34		

Notes. Rates presented in this table are not age-adjusted.. a. 1990-2006 surveillance period due to availability of hospitalization data from Saskatchewan; b. 1990-2009 surveillance period due to availability of hospitalization data from Ontario

*Machine-related* mechanisms accounted for 39.4% of hospitalized agricultural injuries in Saskatchewan and 52.1% in Ontario. Entanglements were the most frequently cited mechanism of machine-related injuries. Correspondingly, 28.4% and 27.7% of machine-related injuries in Saskatchewan and Ontario involved tractors. In Ontario, after tractors, farm wagons account for the most machine-related injuries at 13.9% compared to 4.8% in Saskatchewan. In Saskatchewan, the second most frequent machinery is augers at 13.2% compared to 9.0% in Ontario.

*Falls from heights.* Falls from heights was one of the most common non-machine related mechanisms of hospitalized agricultural injury in both provinces. In Ontario, 57.1% of falls from a height involved barn interiors such as from the hayloft, upper floor, or rafters. In Saskatchewan, 25.3% reported falls from height occurred in barn interiors, while 30.4% involved hay bales or stacks. Comparatively, hay bales or stacks accounted for only 8.2% of falls from heights in Ontario.

*Animal-related.* The majority of animal-related hospitalizations involved being crushed or struck by an animal: 57.0% in Saskatchewan and 61.9% in Ontario. Next, falls from animals account for 23.8% and 19.4% of animal-related hospitalizations in Saskatchewan and Ontario, respectively. Horses and cattle were the most common types of animals involved in hospitalizations, accounting for 61.6% and 31.1% of animal-related hospitalizations in Saskatchewan and 69.4% and 20.1% in Ontario, respectively.

*Struck by or against object.* This mechanism was a leading cause of non-machine hospitalizations. In both provinces, the objects involved in non-machine injuries were primarily heavy objects such as bales, trees, gates, and doors (43.6% in Saskatchewan; 51.3% in Ontario). In Saskatchewan, 23.6% involved tools or parts of tools (compared to 1.3% in Ontario), while in Ontario 18.4% involved contact with high-pressured liquids (compared to 0% in Saskatchewan).

*Mechanisms of hospitalized injuries and age.* There were significant interactive effects between age and mechanism of injury when restricting analyses to the top mechanisms of injury

(F=5.84; p<0.0001, Saskatchewan; F= 6.90 P<0.0001, Ontario). Consequently, stratified rates for the leading mechanisms of hospitalized agricultural injuries varied by age group (Table 4).

**Table 4. Rates of Top Mechanisms of Hospitalized Injury by Age Group**

	Fall from height			Animal-related injury			Entanglement		
	n	Rate (95%CI)		n	Rate(95%CI)		n	Rate(95%CI)	
Saskatchewan									
0-4 years	10	14.8	(8.0-27.5)	32	33.0	(23.4-46.7)	12	18.4	(10.5-32.4)
5-9 year	36	22.3	(16.1-30.9)	30	19.7	(13.7-28.1)	10	9.2	(5.0-17.1)
10-14 years	20	14.5	(9.4-22.6)	64	16.9	(12.1-23.6)	20	12.1	(7.8-18.8)
15-19 years	13	9.7	(5.6-16.7)	55	25.0	(19.2-32.5)	44	19.3	(14.3-25.9)
Total	79	14.7	(11.5-18.8)	151	22.9	(19.4-26.9)	86	14.1	(11.0-18.1)
Ontario									
0-4 years	40	21.5	(15.8-29.4)	29	34.7	(24.1-49.9)	35	18.9	(13.6-26.3)
5-9 year	75	30.4	(24.2-38.1)	28	20.1	(13.9-29.2)	32	11.9	(8.4-16.9)
10-14 years	32	11.9	(8.4-16.8)	36	13.4	(9.6-18.5)	46	15.8	(11.8-21.1)
15-19 years	23	10.2	(6.8-15.4)	41	14.4	(10.6-19.6)	62	17.6	(13.7-22.5)
Total	170	16.8	(14.2-19.8)	134	19.1	(16.1-22.7)	175	15.8	(13.6-18.4)

### 3.3.4 Mechanisms Leading to Agricultural Fatalities

The majority of fatalities were machine related, accounting for 71.8% in Saskatchewan and 67.0% in Ontario (Table 5). Tractors accounted for 28.1% and 33.9% of all fatalities in Saskatchewan and Ontario respectively. In Saskatchewan, after tractors, the top farm machinery involved in fatalities were motor vehicles (18.3%) and off-road vehicles (15.5%). Farm wagons (6.8%) and motor vehicles (5.8%) were the second and third leading type of machinery in Ontario.



**Table 5. Mechanism of Fatal Pediatric Agricultural Injuries in Saskatchewan and Ontario from 1990-2011**

	Saskatchewan		Ontario	
	n	Rate (95%CI)	n	Rate (95%CI)
Total all-cause fatalities	71	8.4 (6.6, 10.6)	103	7.7 (6.3, 9.3)
Total non-machine related	20	4.5 (2.9, 6.9)	33	3.1 (2.2, 4.4)
Drowning	7	1.6 (0.7, 3.3)	14	1.0 (0.6, 1.8)
Animal-related injury	5	1.1 (0.5, 2.7)	3	0.2 (0.1, 0.7)
Struck by or against object	1	0.2 (0.03, 1.6)	5	0.4 (0.2, 0.9)
Caught in, under or between objects	3	0.6 (0.2, 1.9)	3	0.2 (0.1, 0.7)
Asphyxiation	0	0 (0, 0)	3	0.2 (0.1, 0.7)
Contact with toxic substances or environments	2	0.4 (0.1, 1.8)	2	0.1 (0.04, 0.6)
Fall from height	0	0 (0, 0)	2	0.1 (0.04, 0.6)
Exposure to fire/explosions	1	0.2 (0.03, 1.6)	1	0.1 (0.01, 0.5)
Firearms	1	0.2 (0.03, 1.6)	0	0 (0, 0)
Total machine related	51	6.5 (4.9, 8.5)	69	5.6 (4.4, 7.1)
Rollovers	21	2.7 (1.7, 4.1)	15	1.1 (0.7, 1.9)
Runover, pinned, struck by moving machine	8	1.0 (0.5, 2.0)	21	1.6 (1.0, 2.4)
Fell from machine then runover/pinned/struck	9	1.1 (0.6, 2.2)	17	1.3 (0.8, 2.0)
Entanglement	1	0.1 (0.02, 0.9)	7	0.5 (0.2, 1.1)
Machine or motor collision	5	0.6 (0.3, 1.5)	3	0.2 (0.1, 0.7)
Pinned or struck by machine component	2	0.3 (0.1, 1.0)	5	0.4 (0.2, 0.9)
Fall from machine but not runover/pinned/struck	2	0.3 (0.1, 1.0)	1	0.1 (0.01, 0.5)
Struck by object propelled/slid/fell from machine	2	0.3 (0.1, 1.0)	0	0 (0, 0)
Other/unknown machine-related injury	1	0.1 (0.02, 0.9)	0	0 (0, 0)
Missing mechanism of injury	0		1	

### 3.4 Discussion

This study demonstrates that there continues to be a substantial burden of agricultural injury in children and youth in Ontario and Saskatchewan. Results described and identified key patterns, trends, and differences in the experiences of pediatric agricultural injury. Leading mechanisms of hospitalizations in both provinces were falls from heights, animal-related mechanisms and machine entanglements. The majority of fatalities were machine-related and the leading mechanisms of injury were machine rollovers, machine runovers, and drowning. Strong peaks in injury occurrence were observed during warm weather months. These findings, along with the CAIR national reports and other descriptive provincial studies suggest that working and playing at heights (i.e. hay lofts, beams and upper floors in barns, hay bale and stacks), exposure to horses, cattle, farm machinery, and water hazards likely increase the risk of injury.<sup>5,6,13,14</sup>

Supporting the descriptive research, in a sample of farm children in the United States, bystanding in the vicinity of the following hazards were identified as risk factors for injury: fields and barnyards, [Adjusted OR=1.4 (95% CI: 1.0-1.9)], farm machinery in use [Adjusted OR: 1.5 (95% CI: 1.1 to 1.9)] and being stored [Adjusted OR: 1.4 (95% CI: 1.1 to 1.8)], water hazards [Adjusted OR: 1.2 (95%CI: 0.9-1.70], and animals [Adjusted OR: 1.3 (95%CI: 0.9-1.70)].<sup>15</sup> Research in American farm populations has also found that operating heavy machinery [Adjusted OR: 3.19 (95%CI 1.21 to 8.40)]<sup>16</sup>, operating tractors [Adjusted Risk Ratio: 1.42 (95%CI: 1.04-1.94)]<sup>17</sup>, and working with dairy cattle [Adjusted RR: 1.60 (95%CI: 1.19-2.14)]<sup>17</sup> increase the risk of agricultural injury among children and youth.

This study also demonstrated that different age groups have different injury risks. Our study found that children under the age of 5 years are at the greatest risk of fatalities in Saskatchewan and Ontario. This finding is consistent with past observations from the CAIR system and reports of national surveillance data from the United States and Australia.<sup>5,6,18,19</sup> For preschoolers and other young children, simply being exposed to the farm worksite, most often during warm weather months and times of busy field work, has been demonstrated to be a significant risk for injury.<sup>13</sup> As such, this age group should be a top priority for the targeting of interventions.

A previous CAIR national report demonstrated increasing risks for agricultural hospitalizations by increased age.<sup>5</sup> Similarly, analyses of non-fatal pediatric agricultural injuries from Australia and several European countries found that as age increased, the proportion of injuries accounted for by that age group increased.<sup>20-22</sup> In contrast, the patterns found in the current study were less straight-forward. The patterns of agricultural injury by age group were not consistent between Ontario and Saskatchewan. In Saskatchewan, 15 to 19 year olds were found to be at a significantly increased risk of hospitalized injury. Conversely, in Ontario, children aged 10-14 were found to be at substantially less risk than other age groups. A lack of consistent

relationship between age and non-fatal agricultural injury in children and youth was also demonstrated in research from Greece, Portugal, and the United States.<sup>21,23</sup> Moreover, this study found interaction effects between age group and mechanisms of injury. Consequently, certain age groups are at higher risk of injuries by certain mechanisms. These findings underscore the importance of considering age when investigating pediatric agricultural injuries.

In addition, there were demonstrated differences in farm injury rates by age group and mechanisms observed between Ontario and Saskatchewan, likely attributable to variations in commodities produced and the heterogeneous natures of the methods of agricultural practiced between geographic regions.<sup>10</sup> This finding is supported by regional differences also observed in farm injury experiences in past farm injury surveillance work conducted in Ontario and the United States.<sup>23,24</sup> Differences observed between the provinces are also revealing. For example, in Saskatchewan 30.4% of falls from heights involved hay bales or stacks compared to only 8.2% of falls from heights in Ontario. Due to the larger scope of crop operations in Saskatchewan, hay bales are generally much larger than those used in Ontario. However, it is possible that the differences in experiences of pediatric agricultural injury across the provinces may be partly related to the methodological differences. Prior to 1999, both provinces used ICD 9 codes to identify hospitalized agricultural injuries.<sup>5</sup> In 1999, CAIR began to use ICD 10 codes when it was demonstrated that ICD 10 codes were better at identifying hospitalized agricultural injuries than ICD 9 codes, particularly for non-machine related injuries.<sup>9</sup> Since Saskatchewan continued to use ICD 9 codes to identify hospitalizations, results from 1999 and beyond may not be comparable across provinces.

Although this study provides a valuable update on the epidemiology of pediatric agricultural injury, it is not without limitations. The major limitations are as follows: 1) the data source relies on the amount and completeness of data available within the medical records and the vigilance and expertise of technicians who are abstracting the data; 2) comparisons of

hospitalized agricultural injuries between the two provinces is limited by the change in method of identifying hospitalizations in Ontario; and 3) limitations of denominator data such as changes in the farm population during the course of the year due to the seasonal nature of migrant workers. While the data cleaning process attempts to improve the accuracy of the data, it is constrained by the amount of information recorded in the open-ended descriptions of injury circumstances. Additionally, the denominator data used is the best source available.

The strengths of this study are that findings: 1) provide updated epidemiological information about pediatric agricultural injuries; 2) provide comparisons agricultural injuries in Saskatchewan and Ontario, two provinces with varying farm characteristics; and 3) cross-tabulates rates of leading mechanisms of injury by age group.

Based on the findings presented above, and the supporting literature, we recommend that interventions to prevent pediatric agricultural injuries should be targeted to a combination of specific age groups and high-risk farm hazards within a particular agricultural or geographic region.

In practice, the majority of interventions aimed specifically at children and youth have been educational in nature: school-based programs, safety day camps, tractor training programs, and educational campaigns.<sup>25</sup> Since efficacy of educational interventions in the prevention of agricultural injuries is questionable, these interventions need to be used in combination with other preventative efforts that focus on controlling the farm work environment.<sup>25,26</sup> Another strategy in use is The North American Guidelines for Children's Agricultural Tasks (NAGCAT).<sup>27</sup> NAGCAT incorporates research findings to give recommendations for developmentally appropriate and safe farm work tasks for children aged 7-16 years.<sup>27,28</sup> NAGCAT is intended to be a resource to assist parents in assigning tasks to their children; however, uptake has been sporadic, despite widespread distribution and efforts.<sup>27</sup>

Other recommended injury prevention strategies involve improving working conditions on farms, through ergonomic, engineering, and regulatory controls. Ergonomic and physical engineering controls involve altering the physical nature of the farm work and the farm environment in order to prevent injuries. Examples of engineering controls that are currently used are: physical barriers and rails to prevent falls and contact with animals, rollover protection on tractors, and improved shields and guards on farm machinery to prevent entanglements. However, there are still new innovations that can improve safety such as incorporating the use of cameras and viewing screens for blind spots that cannot be seen from the cockpit of the farm machinery to improve situational awareness, similar to those used in cars for reversal. More social-oriented injury prevention strategies aim to keep children out of the farm work space and include designated outdoor play areas away from farm work and improved access to daycare options during fieldwork seasons in rural areas.<sup>13</sup>

Recommended regulatory controls are enforced rules and regulations targeted at specific farm injury patterns. For example, although considerable efforts have been made over the years to improve the safety of tractors from an engineering standpoint, there are limited regulations that dictate the age of farm machinery used. As such, it is not uncommon for farms to be using tractors without modern safety features; therefore, regulations which involve restricting the age of farm machinery used could prevent injuries.

In summary, this study provided an epidemiological update of agricultural injuries in Ontario and Saskatchewan and described hospitalizations and fatalities annually, monthly, by age and sex, by mechanism of injury, and by nature of injury. Age-group and province had an impact on rates and experiences of agricultural injury. The leading mechanisms of fatal and hospitalized pediatric agricultural injuries were: falls from heights, animal-related mechanism, machine entanglements, rollovers, and runovers. Based on the identified recurrent pattern of injury, we

recommend that interventions for pediatric agricultural injury should target to a combination of specific age groups, farm hazards, times of year, and farming regions.

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## **Chapter 4**

### **Associations between Exposure to High-Risk Farm Activities and Agricultural Injuries in Youth and Young Adult Workers**

## **Abstract**

**Objectives:** To investigate relations between high-risk farm activities and the occurrence of agricultural injuries in youth and young adults on farms.

**Methods:** A cross-sectional analysis of written questionnaire data from 1135 youth and young adults from the Saskatchewan Farm Injury Cohort, an on-going study of active farm populations.

**Results:** The prevalence of farm injury was estimated at 4.9% (95%CI 3.7, 6.2). After adjustment for important covariates relative to baseline (<10 hours/week), duration of farm work was strongly associated with the occurrence of injury [RR 8.0 (95%CI 1.7, 36.7) for 10-34 hours/week; RR 10.3 (95%CI 2.2, 47.5) for those working 35+ hours/week]. Tractor maintenance, tractor operation, chores with large animals, herd maintenance activities, and veterinary activities were identified as risk factors for agricultural injury.

**Conclusions:** There is a considerable burden of agricultural injury among youth and young adults on farms that directly relates to the amounts and types farm work exposures that young people engage in.

**KEYWORDS:** Agriculture, epidemiology, farming, occupational injury, trauma (wounds and injuries)

## 4.1 Introduction

The agricultural industry has unique characteristics that contribute to an increased burden of occupational injury in youth and young adults. Farms and ranches are not only work environments, but are often residential areas that increase exposure to potential injury hazards. In addition, occupational regulations governing this sector are inconsistent and can be difficult to enforce. In the United States, farms that employ less than 10 employees are exempt from occupational safety and health regulations including mandatory safety training.<sup>1</sup> Similar exemptions exist in most provinces and territories in Canada. In both Canada and the United States, children of farm owner-operators are exempt from child labor regulations.<sup>2</sup> As a result, children as young as 12 years old are engaging in paid and unpaid farm labor.<sup>3</sup> Youth and young adults working in agriculture and living on farms consequently suffer from a heavy burden of agriculture injury.<sup>4,5</sup>

In Canada, from 1990-2008, 300 youth and young adults aged 10-29 years old died of agricultural injuries, resulting in an annual incidence rate of approximately 7 per 100,000 persons in the same age range.<sup>6</sup> From 1990-2000, there were 3274 hospitalized agricultural injuries in this age group, which accounted for 21.3% of all hospitalized agricultural injuries.<sup>5</sup> In Saskatchewan, from 1990-2011, there were 71 agriculture-related fatalities in children in youth under the age of 20 and resulting rate was 7.8 per 100,000 per year (Chapter 3: Manuscript 1). In the same age group, there 634 agriculture-related hospitalizations from 1990-2006 resulting in an annual rate of 80.2 per 100,000 (Chapter 3: Manuscript 1).

Specific mechanisms and activities on farms contribute to the occurrence of agricultural injuries in young people. Most notable are tractors and machinery operation, water hazards, falls from heights, working with animals, and all-terrain vehicle use.<sup>6-9</sup> Exposure to these acute risk factors is modifiable and as such they are important targets for safety interventions. Analytic studies have identified more underlying risk factors for farm injury in youths, including: total

hours annually worked on the farm or ranch (OR 5.09 for 1,501+ compared to 0–300 hr/year), operating heavy machinery (OR 3.19), application of chemicals (OR 2.50), operating tractors (Adjusted Risk Ratio 1.42), working with dairy cattle (Adjusted RR 1.60), and bystanding in the vicinity of equipment in use (OR 1.5) and equipment being stored (OR 1.4).<sup>3,10,11</sup> However, these analytic studies have a number of limitations.

The existing body of analytic research specific to agricultural injuries in youth and young adults is limited in scope and is based almost exclusively upon experiences in American farm populations. Furthermore, analytic research in this field has mainly employed very simple (e.g., dichotomous) categorizations of farm work exposures.<sup>3,10,11</sup> As a result, little is known about how the amount of exposure to hazards relates to injury. The dose-dependency of this relationship has not been established; therefore the direction and type (i.e. linear, exponential) of a potential dose-response effect are unknown. To address gaps in the research, we had the opportunity to examine a sample of Canadian farm dwellers to: (1) describe the characteristics of injuries that occurred in youth and young adult farm workers aged 12 to 29 years; (2) describe exposures to specific farm work tasks in this sample using multiple categories; and (3) investigate the association between exposures to high-risk farm environments and activities, and the occurrence of agriculture injuries. It was hypothesized that increased engagement in specific high-risk work tasks would result in a concomitant increase in injuries in youth.

## **4.2 Materials and Methods**

### **4.2.1 Study Population and Procedures**

We used data from Phases 1 and 2 of the Saskatchewan Farm Injury Cohort (SFIC). The SFIC is a Canadian study, with both cross-sectional and longitudinal components, developed to evaluate potential causes of injury among farmers and their family members using mailed questionnaires.<sup>12</sup> Phase I of the study followed a baseline sample of 5,492 farm people in

Saskatchewan from 2007 to 2009.<sup>12-14</sup> Phase 2 is an ongoing extension of the original project.

The baseline data were collected from 2,849 individuals from January to July of 2013.

Study procedures were approved by the Biomedical Research Ethics Board at the University of Saskatchewan. The sampling frame for the SFIC study included active farms in the province of Saskatchewan as of January 1, 2007 for Phase 1 data, and January 1, 2013 for Phase 2. The study used a stratified cluster sampling method with farms nested inside randomly selected rural municipalities.<sup>12</sup> Stratification was based on three strata of soil types and membership (yes or no) in an agricultural health and safety network.<sup>12,13</sup> For Phase 1, 50 municipalities were recruited for participation through in-person meetings with each rural municipal council. An additional 24 municipalities were recruited for Phase 2 of the study. For recruitment in Phase 2, a small number of municipalities were excluded due to their participation in other ongoing studies. In the event that a council declined to participate, a nearby municipality in the same strata was recruited in its place. Each participating municipal council provided a complete list of active farms and addresses in the municipality.

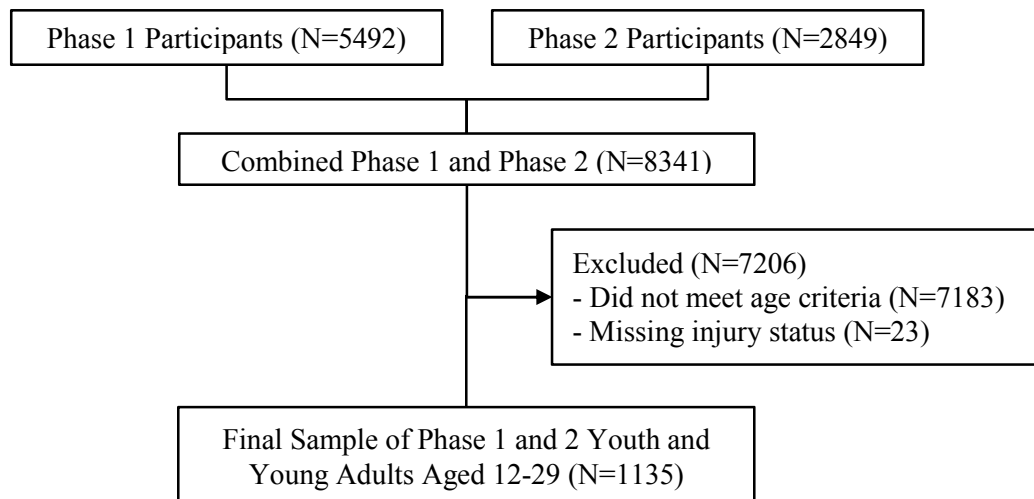
Farms were recruited by mail using a modified version of the Dillman Total Design Method for Mail and Telephone Surveys in order to maximize response rates.<sup>15</sup> To maximize study response participants were sent: a short letter one week prior to the arrival of the questionnaire, a personalized, participant-friendly questionnaire package with a detailed cover letter, a reminder postcard, two replacement questionnaires sent out one month apart, and a final thank you letter. A key adult informant from each farm responded to questions about the farm operation, work and health experiences of farm dwellers and workers, and farm health and safety practices.

The response rate was 33% (2,390/7,246) of all eligible farms contacted.<sup>12</sup> Phase 2 was comprised of a sample of 588 farms from Phase 1 that wished to continue their participation and 628 farms from 24 newly enrolled municipalities leading to the inclusion of new participants that

resulted in a total of 1218 farms and 2,849 individuals. The response rate in Phase 2 was similar to Phase 1 with 31% (1211/3930) of eligible contacted farms participating. The aim of the SFIC was to create a large sample of farms with a heterogeneous degree of exposure rather than a representative sample in order to examine associations between various risk factors and injury outcomes.

Three specific inclusion criteria were employed for the present analysis: (1) participation in the Phase 1 or Phase 2 SFIC study baseline survey; (2) reported age of 12 to 29 years at the time of survey completion; and (3) valid responses to core study items about age and injury status required for the analysis (Figure 1) There were 800 participants from Phase 1 and 358 participants from Phase 2 that met the initial inclusion criterion, with a final sample of 1,135 following exclusions.

**Figure 1. Participant Selection Flow Chart.**



#### **4.2.2 Measures**

In both phases, standard sets of questions were asked for each person living on the farm as well as a set of questions that asked about farm-level characteristics. Since we combined the baseline data from both phases of the study, we were limited to questionnaire items that appeared

in both the Phase 1 and Phase 2 questionnaires. Core items were developed specifically for the Phase 1 questionnaire by the research team with feedback from knowledgeable members of the farm community. Items from existing research were selected or modified for use wherever possible.<sup>16–18</sup> The questionnaire and recruitment method underwent extensive pilot testing for face validity and were revised and refined based on feedback received from various sources including participants.<sup>12,13,19</sup>

The outcome was defined as any reported farm injury in the year prior to the completion of the questionnaire. Farm injuries were defined in the questionnaire as: “all injuries that occurred in a farm environment whether you were working or not. This includes injuries that occurred off farm but involved farm work (e.g., driving tractor on public road). This also includes being poisoned or burned.” This definition is consistent with definitions used in other contexts.<sup>20</sup> Farm work exposures were assessed via a number of questions. Specifically, participants were asked to report for each member of the farm the average weekly hours of farm work for each season. Summer hours were used in this analysis in order to better represent farm work hours, given that the sample population consisted of youth and young adult workers many of whom attend school. These hours were categorized into three groups: 0-9 hours, 10-29 hours per week, and 30+ hours a week (due to a very low number of respondents indicating zero hours and concerns for small cell sizes and power, the zero hours category was collapsed in to the lowest exposure group). Thirty hours was used as a standard cut-off value to distinguish between part-time and full-time work commitments.<sup>21</sup>

Additional questions asked participants about engagement in specific farm work tasks during 2012: *operation of tractors, maintenance of tractors, operation of all-terrain vehicles, routine chores with large animals, herd maintenance activities* (e.g., branding, vaccinating, and transporting), and *veterinary activities* (e.g., medications, breeding, and birthing). Tractor operation and maintenance were reported in hours per year and the remaining items were reported



in days per year. These specific farm work exposures were chosen prior to the analysis due to their hypothesized relationship with farm injury outcomes. In the analyses, these exposures were categorized in to three categories: no exposure, low exposure, and high exposure. The low and high exposure groups were created using the median of non-zero responses as a cut point.

We were also interested in a variety of demographic and farm characteristics that may confound hypothesized relationships between agricultural injuries and farm work exposures. These included: *sex*,<sup>3,10,22</sup> *age in years*,<sup>7,22</sup> *relationship to the farm owner-operator* (“primary owner-operator”, “child”, “other relative”),<sup>20</sup> and *comorbidity status* (no comorbid conditions, at least one comorbid condition of sleep apnea, arthritis, high blood pressure, heart disease, stomach or intestinal problems, and asthma or other lung conditions),<sup>23</sup> *typical hours of sleep* (<6 , >7 hours),<sup>10,24</sup> *alcohol consumption* (yes, no).<sup>3,25</sup> At the farm-level, the *farm size* in acres (0-1500, 1501-2500, and more than 2500) and the *farm commodities* produced (grain crops, beef cattle, and other livestock) were hypothesized to be possible confounders based on their strong and known associations relations with injury.<sup>26–28</sup>

#### 4.2.3 Analysis

SAS 9.3 (SAS Institute Inc., Cary, NC) was used to conduct all analyses. We described the prevalence rates of injury and the nature, anatomical site and mechanism of the injuries. We also characterized patterns of injury according to both individual and farm-level characteristics of the sample. Rao-Scott Chi-Square tests which account for clustering at the farm level were used in group comparisons.<sup>29</sup> Tests for linear trend in prevalence estimates were conducted using the Cochran-Armitage test.<sup>30</sup> Farm work exposures were cross-tabulated by age and sex. Due to the non-parametric distributions of the exposure variables, Wilcoxon Rank Sum tests were used to test for statistically significant differences in farm work exposure between males and females and Spearman’s correlations were used to test for association between age and farm work exposures.<sup>31</sup>

Relations between farm work exposures and injury were explored using multiple logistic regression analyses. The intra-class correlation for farms was 0.13, indicating a substantial amount of clustering at the farm level due to the nested nature of the data (individuals nested within farms). As such, a model was built for each farm work exposure separately using PROC GENMOD with random effects statements that accounted for clustering at the farm level and the fact that the data were collected at two different time points. Model building used the change in estimate approach and considered all potential covariates with a cut-point of a 10% change in estimate for retention.<sup>32</sup> Final models and calculations of relative risk accounted for age, sex, farm size, comorbidity status, and typical hours of sleep. A sensitivity analysis of the final models was conducted using a data set with all participants who were in both Phase 1 and Phase 2 removed in order to test for any possible influence of these 49 individuals.

### **4.3 Results**

In the final sample of 1,135 participants, 56 participants had at least one farm-related injury in the past year, resulting in crude injury prevalence of 4.9% (95%CI 3.7, 6.2). Leading natures of injury were open wounds and fractures, each accounting for 14.3% of injuries (Table 1). Falls or jumps were the leading mechanism of injury at 17.9% of injuries, followed by animal-related mechanisms (e.g., falls from animals, crushed or struck by animals) at 16.1%. Overall, the top locations of injuries were hands (16.1%) and lower back (14.3%). Anatomical sites of injury were cross-tabulated with natures of injury. The top location for open wounds was the hands and these accounted for 50% of open wounds. There were no other strong trends regarding the location of remaining injuries by nature of injury. Overall, 41.1% of injuries were machine-related. Among these machine-related injuries, 30.4% involved off-road vehicles (n=7), 26.0% involved tractors (n=6), and 17.4% involved combines (n=4).

**Table 1. Characteristics of Agricultural Injuries Reported by 56 Youth and Young Adult Saskatchewan Farm Residents**

	<b>n</b>	<b>% of Injuries</b>
<b>Nature of Injury</b>		
Open wound	8	14.3
Fracture	8	14.3
Sprain or strain	6	10.7
Injury to muscle or tendon	5	8.9
Dislocation (including ruptured disc, cartilage, ligament)	3	5.3
Superficial (including bruises)	3	5.3
Burn or corrosion	3	5.3
Intracranial injury (including concussion)	3	5.3
Crushing injury	1	1.8
Traumatic amputation	1	1.8
Injury to internal organ	1	1.8
Foreign body in eye	1	1.8
Other specified nature of injury	1	1.8
Injury of unspecified nature	12	21.4
<b>Mechanisms of Injury</b>		
Fall or jump	10	17.9
Animal-related <sup>a</sup>	9	16.1
Pinned or struck by or against machine or machine component	7	12.5
Overexertion	5	8.9
Struck by or against non-machine object	3	5.3
Machine rollover	3	5.3
Caught inside, under, or between non-machine objects	3	5.3
Fires, explosions and burns	3	5.3
Contact with toxic substances	1	1.8
Off-road machine collision	1	1.8
Bystander runover	1	1.8
Other specified mechanism	3	5.3
Unknown or missing	7	12.5

a. Animal related mechanisms include: fall from animal, crushed or struck by animal

Males experienced a significantly higher injury rate of 6.0% per year (95%CI 4.3, 7.7) compared to females with a rate of 3.1% (95%CI 1.4, 4.7; Table 2). Approximately 41.2% of the population was between the ages of 12 to 17 years, 28.8% between 18 and 23 years, and 30.0% between the ages of 24 to 29 years. A Cochran-Armitage test for linear trend demonstrated that as the age groups increased, the rates of injury also rose significantly ( $Z=5.6$ ,  $p<0.0001$ ). All remaining individual characteristics considered (typical sleep, alcohol consumption, relationship to owner-operator, and comorbidities) were related to increased observed rates of injury in a statistically significant manner (Table 2,  $p<0.05$ ). At the farm level, farms with beef cattle, and

farms with other animals both experienced higher rates of injuries than farm that did not have these livestock (Table 2).

**Table 2. Select Individual and Farm Characteristics among 1135 Youth and Young Adult Saskatchewan Farm Residents**

	<b>N</b>	<b>n Injured</b>	<b>% Injured (95% CI)</b>	<b>P-value</b>
<b>Individual Characteristics</b>	1135	56	4.9 (3.7-6.2)	
Gender				
Male	714	43	6.0 (4.3-7.7)	0.03
Female	421	13	3.1 (1.4-4.7)	
Age group				
12-17 years	468	6	1.3 (0.3-2.3)	<0.0001
18-23 years	327	14	4.3 (2.1-6.5)	
24-29 years	340	36	10.6 (7.3-13.9)	
Sleep				
7 hours or more	798	24	3.0 (1.8-4.2)	0.0002
6 hours or less	328	31	9.5 (6.3-12.6)	
Missing	9	1		
Alcohol Consumption				
No	447	8	1.8 (0.6-3.0)	<0.0001
Yes	669	47	7.0 (5.1-9.0)	
Missing	19	1		
Relationship to Owner-Operator				
Owner-operator	103	17	16.5 (9.3-23.7)	0.0005
Child	907	29	3.2 (2.1-4.3)	
Other	119	8	6.7 (2.2-11.2)	
Missing	6	2		
Comorbidity Index				
None	865	39	4.5 (3.1-5.9)	0.09
1 or more	137	12	8.8 (4.0-13.5)	
Missing	133	5		
<b>Farm Characteristics <sup>a</sup></b>	697	53	7.6 (5.6-9.6)	
Farm Acreage				
0-1500	261	19	7.3 (4.1-10.4)	0.91
1501-2500	162	13	8.0 (3.8-12.2)	
More than 2500	234	16	6.8 (3.6-10.1)	
Missing	40	5		
Grain Crops				
No	88	9	10.2 (3.9-16.6)	0.38
Yes	607	44	7.3 (5.2-9.3)	
Beef Cattle				
No	304	15	4.9 (2.5-7.4)	0.01
Yes	391	38	9.7 (6.8-12.7)	
Other Animals				
No	586	39	6.7 (4.6-8.7)	0.07
Yes	109	14	12.8 (6.6-19.1)	

<sup>a</sup> Farm characteristics are reported per farm, rather than per individual

There were reported differences in exposure to farm work and specific farm tasks by age group and sex (Table 3). An increase in age was associated with a concomitant increase in: hours worked on the farm (Spearman's  $r=0.30$ ,  $p<0.0001$ ); hours spent operating tractors (Spearman's  $r=0.43$ ,  $p<0.0001$ ), maintaining tractors (Spearman's  $r=0.41$ ,  $p<0.0001$ ); and days spent working with large animals (Spearman's  $r=0.17$ ,  $p<0.0001$ ), performing herd maintenance (Spearman's  $r=0.18$ ,  $p<0.0001$ ), and veterinary activities (Spearman's  $r=0.22$ ,  $p<0.0001$ ). However, age was not related to days per year of ATV operation (Spearman's  $r=-0.03$ ,  $p=0.28$ ). Results of the Wilcoxon rank-sum tests indicated that there were some statistically significant differences in farm work exposure between males and females. Males worked more hours on the farm than females ( $Z=-12.5$ ,  $p<0.0001$ ). Females had less exposure to mechanized tasks: operation of tractors ( $Z=-19.0$ ,  $p<0.0001$ ), tractor maintenance ( $Z=-18.2$ ,  $p<0.0001$ ), and all-terrain vehicle use ( $Z=-4.92$ ,  $p<0.0001$ ). Similarly, females overall had significantly less days of exposure to herd maintenance activities ( $Z=-2.53$ ,  $p=0.01$ ). However, with working with large animals and veterinary activities, the amounts of exposure were not significantly different between males and females ( $Z=-1.87$ ,  $p=0.06$ ; and  $Z=-1.16$ ,  $p=0.25$  respectively).

**Table 3. Selected Farm Work Exposures among 1135 Youth and Young Adult Saskatchewan Farm Residents by Age and Gender**

	Males				Females			
	12-17	18-23	24-29	Total	12-17	18-23	24-29	Total
	n=248	n=232	n=251	n=731	n=226	n=105	n=96	n=427
Hours of Farm Work								
0-9 hours/week	31.6	21.2	18.1	23.8	61.0	56.4	40.5	55.3
10-29 hours/week	41.9	30.9	17.7	30.3	32.9	28.7	36.0	32.5
30+ hours/week	26.5	47.9	64.2	46.0	6.1	14.9	23.6	12.2
Operation of Tractors								
0 hours/year	18.5	7.7	4.3	10.3	64.6	45.5	44.1	55.3
1-69 hours/year	6.3	34.2	16.0	35.7	34.9	37.6	40.9	36.9
70+ hours/year	25.2	58.1	79.7	54.0	0.5	16.8	15.1	7.8
Tractor Maintenance								
0 hours/year	52.6	25.8	11.6	30.1	89.7	82.5	86.5	87.3
1-10 hours/year	38.5	32.3	27.5	32.8	10.3	14.4	10.1	11.3
11+ hours/year	9.0	41.9	60.9	37.1	0	3.1	3.4	1.5
ATV Use								
0 days/year	27.8	33.2	33.0	31.3	32.6	45.4	42.9	38.0
1-29 days/year	26.1	33.2	29.5	29.5	45.6	36.1	27.5	39.2
30+ days/year	46.2	33.7	37.4	39.3	21.9	18.6	29.7	22.8
Working with Large Animals								
0 days/year	47.5	44.3	43.6	45.2	54.0	41.8	32.2	46.1
1-49 days/year	26.0	26.1	15.6	22.5	26.1	32.7	25.6	27.6
50+ days/year	26.5	29.6	40.8	32.3	19.9	25.5	42.2	26.3
Herd Maintenance								
0 days/year	48.9	48.0	44.2	47.1	57.8	46.9	35.2	50.0
1-14 days/year	25.3	19.8	20.8	22.1	27.7	35.4	33.0	30.8
15+ days/year	25.8	32.2	34.8	30.9	14.6	17.7	31.9	19.3
Veterinary Activities								
0 days/year	57.7	56.9	45.4	53.2	60.3	51.0	36.7	52.8
1-9 days/year	16.4	10.2	13.8	13.5	18.7	27.1	15.6	20.0
10+ days/year	25.9	33.0	40.8	33.2	21.0	21.9	47.8	27.3

Relationships between farm injury status and amount of exposure to farm work and specific farm tasks are shown in Table 4. Of the exposures assessed, the amount of hours worked on the farm was associated with the greatest increase in risk of injury. Participants that worked full-time, 30 or more hours a week were 10.3 (95%CI 2.2, 47.5) times more likely to have experienced an injury in the past year than those that worked <10 hours a week after controlling for a variety of demographic characteristics. Tractor maintenance was the only other exposure that was significantly related to injury at both the low and high exposure levels: participants working 1-10 hours a year and more than 11 hours per year were 3.7 (95%CI 1.2, 11.2) and 6.7

(95%CI 2.0, 22.4) times more likely to have experienced an injury than those that did not maintain tractors.

**Table 4. Unadjusted (Univariate) and Adjusted (Multivariate) Logistic Regression Relative Risk Estimates of Agricultural Injury for Select Farm Work Exposures**

	% Injured	<i>Unadjusted</i>		<i>Adjusted*</i>	
		RR (95%CI)	P value	RR (95%CI)	P-value
Hours of Farm Work					
0-9 hours/week	0.8	ref		ref	
10-29 hours/week	4.5	5.9 (1.7-20.6)	0.006	8.0 (1.7-36.7)	0.008
30+ hours/week	9.0	12.2 (3.7-40.7)	<0.0001	10.3 (2.2-47.5)	0.003
Operation of Tractors					
0 hours/year	1.4	ref		ref	
1-69 hours/year	3.6	2.7 (0.8-8.3)	0.09	2.7 (0.7-10.4)	0.13
70+ hours/year	8.8	6.9 (2.4-19.9)	0.0004	4.3 (1.0-17.9)	0.04
Tractor Maintenance					
0 hours/year	1.8	ref		ref	
1-10 hours/year	5.6	3.2 (1.4-7.4)	0.005	3.7 (1.2-11.2)	0.02
11+ hours/year	10.2	6.1 (2.9-12.9)	<0.0001	6.7 (2.0-22.4)	0.002
ATV Use					
0 days/year	4.5	ref		ref	
1-29 days/year	3.7	0.8 (0.4-1.8)	0.28	1.1 (0.4-2.7)	0.30
30+ days/year	6.3	1.5 (0.7-2.9)	0.63	1.5 (0.7-3.4)	0.87
Working with Large Animals					
0 days/year	1.7	ref		ref	
1-49 days/year	2.0	1.2 (0.4-3.6)	0.80	1.0 (0.3-3.5)	0.99
50+ days/year	11.6	7.6 (3.4-16.9)	<0.0001	5.2 (2.1-12.6)	0.0004
Herd Maintenance					
0 days/year	2.0	ref		ref	
1-14 days/year	3.8	1.9 (0.8-4.7)	0.17	1.2 (0.5-3.4)	0.66
15+ days/year	11.1	6.0 (2.8-12.8)	<0.0001	3.2 (1.4-7.3)	0.005
Veterinary Activities					
0 days/year	2.2	ref		ref	
1-9 days/year	1.8	0.8 (0.2-3.1)	0.77	0.7 (0.1-3.2)	0.60
10+ days/year	11.1	5.5 (2.8-11.0)	<0.0001	3.7 (1.7-8.2)	0.002

\* Adjusted models controlled for age, sex, typical sleep, farm size, and comorbidity status

With the exception of all-terrain vehicle use, all other farm exposures were significantly associated with injury at their high level of exposure only. Although the lower exposure category was not statistically significant, there was a demonstrated trend of increased risk of injury with increased exposure. Removing the individuals who participated in both Phase 1 and Phase 2 of the SFIC and repeating the analysis did not affect the significance of findings and resulted in minor changes to relative risk estimates.

#### 4.4 Discussion

This study presents analyses of data from youth and young adults who participated in baseline data collection for the Saskatchewan Farm Injury Project, an ongoing prospective cohort study of farmers in rural Saskatchewan. Results demonstrated a dose-effect trend of increased risk of injury with increased exposure to farm work tasks. Specifically, tractor maintenance was significantly related to agricultural injury at both the low and high exposure levels (OR 3.7, 95% CI 1.2, 11.2 and OR 6.7, 95% CI 2.0, 22.4). Similarly, tractor operation, routine chores with large animals, herd maintenance activities, and veterinary activities were significantly associated with increased rates of agricultural injury at high levels of exposure. Although existing analytic research has found relationships between injury and similar dichotomous exposures of operating heavy machinery, operating tractors, and working with dairy cattle,<sup>3,10</sup> the novelty of our study lies in our extension of this work to examine gradients in risk for injury by amounts of exposure to farm work tasks. Furthermore, this study expands on the existing analytic research that has focused on American populations by using a sample of Canadian farmers.

Additionally, the results from both the crude and adjusted analyses indicated a positive relationship between the number of hours worked on the farm per week and risk of injury. This finding is consistent with results from a recent prospective cohort study of 489 rural California high school students. The latter found that total hours annually worked on the farm or ranch was directly associated with the occurrence of injury (OR 5.09, 95% CI 1.61, 16.1 for 1,501+ compared to 0–300 hr/year).<sup>3</sup>

Adjusted models controlled for a standard set of covariates: age, sex, farm size, comorbidity status, and typical hours of sleep. It was expected that sex would be a confounder in the relationship between farm work exposure and farm injury in all models since there is a well-established difference in agricultural injury experiences between males and females.<sup>3,6,11</sup> Gender changed the effect estimate for the risk of farm injury associated with tractor maintenance by



more than 10% but had to be forced into the remaining farm exposure models as it did not affect the estimates noticeably. In the farm maintenance model, females were found to be at a greater risk of injury than males [RR=1.7 (95%CI: 0.6, 4.3)]. To contrast, in unadjusted analysis, females were at a significantly decreased risk of injury [RR: 0.5 (95%CI: 0.3, 0.9)]. These findings may indicate that the relationship between sex and farm injury is explained by other factors, such as types and amounts of farm work in which males and females engage.

The overall rate of agricultural injury observed was 4.9% per year. This is lower than published estimates from California which found (8.2% to 10.3%).<sup>3</sup> The difference in rates is likely due to differences in methodologies: 1) the California study was restricted to youth farm workers, while the SFIC sample consisted of youth and young adult farm dwellers; and 2) the California study used self-report whereas in the SFIC questionnaire was often filled out by a third-party. Third party knowledge and recall of farm injuries and exposures may be less accurate than self-report.

Characteristics of the farm injuries in this study are fairly consistent with past reports. For example, the leading mechanisms of injury in this study were falls or jumps followed by animal-related mechanisms. This is similar to surveillance data of hospitalized agricultural injuries in Canada where animal related mechanisms and falls from height were leading causes of injury respectively in children and youth under 20 years.<sup>7</sup> In contrast with this surveillance data, open wounds were the leading nature of injury in the 56 farm injuries in our study. Although the sample size limits interpretation, this discrepancy in top mechanisms could be because open wounds are often less serious and do not require hospitalization.

Few studies have described the amount of time youth and young adults spend engaged in farm work and specific farm tasks. Our analysis suggested that age was related to hours worked on the farm, and amount of time spent operating tractors, maintaining tractors, working with large animals, performing herd maintenance, and performing veterinary activities. Gender was related

to farm work with males reporting more hours worked on the farm, more days of exposure to herd maintenance activities, and more exposure to mechanized tasks: operating and maintaining tractors, and all-terrain vehicle use.

Limitations of this study warrant comment. One weakness was our reliance on third-party reports of injuries and exposures. While our analysis controlled for a variety of confounders which have been found to be important confounders in previous research,<sup>3</sup> there may be some uncontrolled confounding present as there are additional theoretical covariates such as parental supervision that are not available in the SFIC Phase 1 and Phase 2 data set. In addition, the response rates were rather low (33% and 31% for Phase 1 and Phase 2 respectively); therefore rates of injury and exposure to farm work tasks may not be representative of the overall youth and young adult worker population in Saskatchewan. However, the aim was to create a large sample of farms with a heterogeneous degree of exposure, as opposed to be “representative”, hence these modest response rates are of less concern. Furthermore, the lack of representativeness should not have biased the relationships observed between increased exposure to specific farm tasks and the occurrence of injury. Additional weaknesses of the study include: inability to establish temporality of the exposure preceding the outcome due to the cross-sectional nature of the data; our modest level of statistical power and precision of risk estimates due to the modest number of injury events.

One of the main strengths of this study is that it is one of few investigations of agricultural injury in youth and young adults that is etiological in nature. Furthermore, it investigates the dose-effect gradient associated with specific farm work exposure by using three categories of exposure which is a novel contribution to the body of research about pediatric agricultural injury as the majority of analytic research utilizes a dichotomous exposures. Lastly, data were compiled using modern survey methods which aimed to maximize response rates and improve quality of data.

Consequently, future research should aim to replicate and further explore these findings using additional youth farm worker populations. This future research should use data that would yield improved statistical power and should also consider potential mediating effects of safety practices and attitudes. In an effort to further understand the burden of agricultural injury in this population, future research should investigate if youth and young adults perceive hazards, assess risks, and engage in risk-taking differently than other adults and if these differences are related to risk of agricultural injury.

Preventing agricultural injuries in youth and young adults is particularly important. With injuries and fatalities that occur early in life, the associated burden is greater: more disability-adjusted life years, more costs in terms of medical expenses and economically in lost labor. Interventions for the prevention of agricultural injuries in youth workers primarily consist of school-based programs, safety day camps, tractor training programs, and community- and farm-based interventions and educational campaigns.<sup>33</sup> Although considered standard practice, educational interventions such as those listed above may not be effective on their own. An assessment of a farm safety program in Saskatchewan that administered 112 mainly educational interventions aimed at the prevention of farm injury had no demonstrated effect on farm safety practices, exposure to farm hazards, and agricultural injuries.<sup>34</sup> As such, different approaches to agricultural injury prevention such as engineering controls and regulation should be considered.

This study provides evidence that can be used as justification for targeting of future interventions towards high-risk activities such as tractor operation and maintenance. In addition to the targeting of educational campaigns towards these high-risk exposures, future research could also investigate engineering solutions to make these tasks safer. Although considerable efforts have been made over the years to improve the safety of tractors from an engineering standpoint, there may still be room for improvement. Furthermore, there are limited regulations that dictate the age of farm machinery used and it is not uncommon for farms to be using tractors

without modern safety features. Future research investigating the risk of injury attributable to aging farm machinery could be used in combination with evidence from this study to support regulations in this area.

In general, the results can help improve the impact of inventions by providing easily understood estimates of risk associated with farm work exposures. In addition, findings of this research provide evidence to policy-makers and planners which can be used to support and identify priorities for occupational health and safety regulation reform for this vulnerable population.

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## **Chapter 5**

### **Discussion**

#### **5.1 Key Findings**

The goal of this thesis was to provide novel information about the occurrence and etiology of pediatric agricultural injury in Canada. My thesis focused on farm work and high-risk farm work activities high risk farm environments and activities as potential determinants of injury. Towards this goal, the first manuscript was a descriptive study and provided an epidemiological update for agricultural injuries in children under 20 years in the provinces of Ontario and Saskatchewan based upon surveillance data. Manuscript 2 built upon the descriptive analyses by investigating specific risks for agricultural injury associated with high risk farm work exposures in young people from Saskatchewan.

Manuscript 1 used over two decades of surveillance data from Canadian Agricultural Injury Reporting (CAIR) to describe hospitalizations and fatalities in Ontario and Saskatchewan annually, monthly, by age and sex, by time, by mechanism of injury, and by nature of injury. Common patterns of agricultural injuries were identified. There were differences in the farm injury experiences in Ontario and Saskatchewan, particularly in terms of farm hazards involved in injuries and age-specific rates. Overall, children under 5 years of age were at increased risk of fatalities and 10-14 year-olds experienced lower rates of hospitalization. Leading mechanisms of injury identified in our study were: falls from heights, animal-related mechanisms, machine entanglements, rollovers, and runovers. Notable seasonal peaks in injury occurrence were also observed.

To address existing gaps in analytic research, the second manuscript used a sample of 12-29 year olds from the Saskatchewan Farm Injury Cohort (SFIC) study. The prevalence of injury in the sample was 4.9% and the most common type of injury was fractures and open wounds.



There were age and sex differences in farm work exposures. In general, results were consistent with our hypothesis that increased engagement in specific high-risk work tasks is related to an increased risk of injury. Specifically, after adjustment for important covariates, both the duration of farm work and tractor maintenance demonstrated a significant dose-response trend with increased risk at both low and high exposure levels compared to no exposure. Tractor operation, chores with large animals, herd maintenance activities, and veterinary activities demonstrated a trend of increasing risk, but were only significantly related to injury when comparing high exposure to no exposure. Operation of all-terrain vehicle demonstrated a minor trend of increased risk of injury with increased exposure but these effects were not statistically significant.

Together, these manuscripts demonstrate that there is a considerable burden of agricultural injury among children, youth, and young adults on farms. Furthermore, findings support that experiences of injury are related to the amounts and type of exposure to farm work and other farm hazards. The remainder of this discussion will focus on the internal and external validity of the research, other strengths and limitations of the studies, future research directions, and implications for public health.

## **5.2 Internal Validity**

Internal validity is the degree to which results are accurate in the target population.<sup>1</sup> Internal validity is threatened by sources of nonrandom error, also known as systematic error, that can artificially inflate or reduce measures of effects.<sup>1</sup> Common sources of systematic error include: selection bias, information bias, confounding, and chance. These four threats to internal validity will be discussed in the context of the two studies in this thesis.

### **5.2.1 Manuscript 1 (Chapter 3)**

*Selection bias* is a result of systematic differences between people who are excluded or included in a study that can influence observed measures of effect.<sup>1</sup> For descriptive analyses, selection bias is often considered in light of the representativeness of study findings, and when

defined in this manner influences the degree to which results are accurate for the target populations. Manuscript 1 is based on CAIR surveillance databases which only capture agricultural injuries that: a) were admitted to hospital; or b) result in a fatality.<sup>2</sup> Therefore, the CAIR databases do not capture agricultural injuries where the injured person did not seek medical attention. Furthermore, some injuries of similar severity may be treated in emergency rooms while others are hospitalized. The decision to hospitalize may differ based on physician judgment, hospital policies, and availability.<sup>3</sup> Consequently, there could be systematic differences between the characteristics of agricultural injuries that lead to hospitalization and those that do not. Therefore, using admission to hospital as a proxy for severity of injury is problematic as these systematic differences would result in underestimating injuries of this severity.

*Information bias.* CAIR uses International Classification of Disease (ICD) codes to identify agricultural related hospitalizations, which in turn depends on complete hospital records and correct use of ICD codes (see Appendix A for more information).<sup>2</sup> A CAIR report for Ontario justified switching from the traditional use of ICD-9 codes to using ICD-10 codes because the ICD-10 codes identified more agricultural hospitalizations and were more accurate.<sup>4</sup> Although the ICD 9 coding system is very effective in identifying injuries involving farm machinery such as tractors and harvesters, it is less effectual at identifying in motor vehicles, off-road vehicle, and non-machine agricultural injuries.<sup>4</sup> Conversely, the use of ICD 10 codes provides a coding structure that identifies non-machine agricultural injuries more effectively.<sup>4</sup> The employment of the ICD 10 coding system in Ontario resulted in a substantial increase in the identification of non-machine agricultural hospitalizations, specifically animal-related, fall-related, struck by object, caught under object, and overexertion injuries. Due to the limitations of the use of ICD 9 codes, the CAIR data from Saskatchewan and from Ontario prior to 1999 likely underestimates non-machine related hospitalizations and consequently overestimates the frequency of machine-

related hospitalizations. Overall, rates of hospitalizations are likely underestimated due to the lack of complete capture of all agricultural-related injuries from the hospital discharge records.

*Confounding.* The differences between Ontario and Saskatchewan in the ICD codes used to identify hospitalizations after 1999 confounds provincial comparisons of rates and characteristics of hospitalized pediatric agricultural injuries. Since ICD codes are more effective at identifying non-machine related injuries, observed differences in frequency of mechanisms of hospitalization between the two provinces could be accounted for by this methodological difference. To facilitate comparisons between provinces, we controlled for the underlying age-distribution of each province by calculating age-adjusted rates. However, because this data set is based on surveillance data, the information we have about demographics and farm characteristics are limited so we were not able to investigate any other possible covariates other than sex. As a result, it is possible that there are uncontrolled confounders that could partially or fully account for geographic differences in farm injury experiences observed in our study.

*Statistical Power and Chance.* We calculated confidence intervals for the rates and rate ratios observed in our study. These confidence intervals give some indication of the accuracy of rates observed and the odds that observed rate ratios were a result of chance. For hospitalizations, the larger sample sizes resulted in improved statistical power, and as a result, confidence intervals were generally fairly narrow. Fatalities were much lower in number, and consequently, confidence intervals were comparatively wider.

### **5.2.2 Manuscript 2 (Chapter 4)**

*Selection bias.* More classically, selection bias can be defined as the distortion of an effect estimate in an analytical study due to selection in to or out of a study. With respect to this definition, it is not likely that selection bias affected the results from the cross-sectional analyses of data from the SFIC study presented in Manuscript 2. The SFIC used a strong sampling technique with stratification and random selection at the municipality level. Modern survey methods that aim to

maximize participation were also used (see Appendix D and Chapter 4 for more information). Yet, the response rates were rather low (33% and 31% for Phase 1 and Phase 2 respectively). Low response rates can be indicative of possible selection bias in the event that there are systematic differences in demographic or farm characteristics between those who decide to participate and those that decline to participate. However, there is no evidence or intuitive reason that participation was nonrandom by exposure status. Therefore we do not believe the relationships observed between increased exposure to specific farm tasks and the occurrence of injury were biased based on selection.

*Information bias.* The measures used in the SFIC study to access information about farm work exposures and the outcome of agricultural injury have precedent in existing literature and have demonstrated face and content validity through pilot testing.<sup>5-7</sup> However, little is known about the true “test validity” of these measures (how accurately they capture the truth). For example, tractor operation and tractor maintenance are measured in hours per year, which may be difficult for a participant to accurately estimate, particularly for other members of their household. As such, these estimates of exposure may not be highly accurate or reliable. Measurement error arising from this lack of accuracy could result in misclassification in terms of exposure groups (no exposure, low exposure, and high) and the outcome (injury in past year, no injury). However, this misclassification should most likely be non-differential as a lack of test validity would affect all participants equally. As such, any resulting bias would be towards the null.

Furthermore, the SFIC uses self-report and third-party report since one person fills out the questionnaire for all farm dwellers. The farm exposures are estimated for the past year, which may be difficult for participants to accurately recall for self-report.<sup>8,9</sup> Although the outcome of agricultural injury in the past year might be more memorable and therefore easier to recall, minor injuries may not be remembered.<sup>10</sup> Compounding the issues with self-report there are also third

party or proxy reports in the data which are susceptible to both issues in recall and are dependent on accurate knowledge. For example, the respondent may not be aware of injuries resulting from children and youth not reporting injuries to their parents.<sup>10</sup>

A potential difference between self-report and third party report is supported by the data. There were higher rates of injuries among the 24-29 year old group and owner-operators had much higher rates of injury than other family members. Although this trend could be explained by differences in exposure to farm work tasks, owner-operators and young adult participants were also more likely to have filled out the questionnaire themselves. Although this recall error may be random, it is possible that injured participants overestimate their farm work exposures because they believe there is a causal association between their agricultural injury and farm work exposure, in which case, effects would be biased away from null. However, the questions about farm work exposures precede and are on a separate page from the injury questions in order to minimize the possibility of recall bias.

*Confounding.* Potential covariates were identified based on descriptive literature and covariates included in other research investigating the risk factors for agricultural injuries. Although we were able to incorporate age, sex, and eight other potential covariates into the model building process, there are other potential confounders that were not available from the SFIC data and hence there may be uncontrolled confounding. The intra-class correlation for clustering within farms was 0.13, indicating a substantial amount of the variance observed is accounted for by differences between farms. The majority of potential farm-level covariates were not available in the data used such as: age of farm equipment, availability of safety features of on equipment and structures, and the training and safety procedures used in the farm. As such, findings may be susceptible to uncontrolled confounding which may bias effect estimates towards or away from the null.

*Type II error and Statistical Power.* Some null findings may have resulted from Type II error, which is the failure to detect true relationships due to an inadequate sample size. Low statistical power is the primary reason for Type II error. Although a-priori power calculations demonstrated sufficient power for the analyses (80% power to detect RR of 2.2), the injury rate and hence number of persons in specific cells for analyses was much lower than originally predicted. Furthermore, the exposure data were very highly skewed and thus not appropriate for a continuous representation meaning that in order to investigate the dose-response relationship between farm work exposures and injury, the exposure variables needed to be categorized. Categorizing exposures into three categories representing no, low, and high exposures potentially further reduce the power for the analyses.

Consequently, post-hoc power calculations were necessary (Appendix G). Post-hoc power was estimated using PROC POWER procedure for logistic regression. The procedure supports the inclusion of multiple covariates in power calculations and is based on the best known methods for estimating power for logistic regression<sup>11,12</sup> However, PROC POWER does not have any options for multi-level models. In order to compensate for the clustered nature of data, the effective sample size was reduced for the design effect associated with farms. This is a commonly used method for power calculations involving multilevel models.<sup>13</sup> The design effect estimates how the standard error of parameter estimates is affected by the clustered data.<sup>13</sup> For manuscript 2, the design effect for clustering at the farm level was calculated as 1.08, resulting in an effective sample size was 1051.

In post-hoc analysis, power to detect the relative risks observed in for each of the seven adjusted farm exposure models was calculated, as well as the minimum RR that could be detected at 80% power (Appendix G). The minimum detectible relative risk was between 1.5 and 1.6 for each farm exposure. For veterinary activities, which had a protective relative risk for one exposure level ( $RR < 1$ ), the minimum protective RR was 0.6. As such, the analyses lack sufficient

power to detect the significance of the relative risks observed for ATV operation and for comparing the low exposure groups to no exposure groups of the other specific farm work exposures as these relative risks were below 1.5. However, the majority of effect estimates in Manuscript 2 were high enough that there was over 99% power.

### **5.3 External Validity**

External validity, also known as generalizability, is the degree to which the findings of the study are representative of the target population and can be generalized beyond the scope of the study into other populations.<sup>1</sup> A discussion of the external validity of the two studies in this thesis will be presented below.

#### **5.3.1 Manuscript 1 (Chapter 3)**

Manuscript 1 used CAIR surveillance databases, which identify agricultural injuries from provincial hospitalization and death records (for more information on CAIR methods, see Appendix A and Chapter 3). Given that the CAIR database aims to identify all hospitalized and fatal injuries, rates and other findings should be representative of the target farm populations in Ontario and Saskatchewan for these outcomes. However, one threat to the representation of Manuscript 1 findings is the migrant farm worker population, which may not accurately be accounted for in the denominator data. Although denominator data includes numbers from with data from the seasonal agriculture workers program from Citizenship & Immigration Canada,<sup>14,15</sup> the seasonal nature of migrant workers mean that they are not necessarily at risk for the entire year. In addition, there are many migrant farm workers that are not accounted for in the seasonal agricultural workers program. The seasonal variance in the farm population at risk due to the ebb and flow of migrant and other occasional workers particularly limits the interpretations of monthly rates and trends observed: increased monthly rates may in part be a function of increased population at risk.

The rates and characteristics of agricultural injury observed in Manuscript 1 may not be generalizable to other farm populations outside of Ontario and Saskatchewan. The observed differences between Ontario and Saskatchewan demonstrate that geographic or potentially farming region plays a role in the experiences of agricultural injuries. Yet, the leading mechanisms of injury was consistent between provinces, and with other studies including national reports on farm injuries in Canada and the United States.<sup>16,17</sup> Therefore, results of this study should be generalized with caution.

### **5.3.2 Manuscript 2 (Chapter 4)**

As previously mentioned, the response rates for the SFIC study are low, which is common with mailed survey methods.<sup>18</sup> As a result, the injury rates, demographics, and farm exposures may not be representative of the Saskatchewan farming population. However, the SFIC was not designed to be representative in terms of rates of injury and some associated patterns. It was designed to capture a wide and heterogeneous range of exposures and experiences. For example, sampling was stratified by soil type and thus farm regions resulting in potential over-representation of some farming regions in the cohort. Due to the lack of representation, descriptive results about should not be generalized to the Saskatchewan farm population or should be done with caution.

However, we believe that the relationships found between farm work exposures and agricultural injury are generalizable to the Saskatchewan farm population, and other farming regions. The relationships do appear to follow a dose-response pattern as there was a concomitant increase in risk for agricultural injury with increasing time involved in various types of farm work. In other words, the relationship between farm work and agricultural injuries should be the same, at least qualitatively, regardless of the representativeness of exposure prevalence and injury rates are of the target population. However, generalizing findings from this study beyond the age group of 12 to 29 year olds used in this study, particularly to younger children, would not be



recommended as the risk associated with farm work exposures may not be the same for children at earlier developmental stages.

#### **5.4 Other Limitations and Strengths**

A strength common to both studies is that results provide novel foundational information to the existing body of literature on pediatric agricultural injuries that can be used to inform the design, priorities, and targeting of health and safety efforts to prevent agricultural injuries. Manuscript 1 provides updated epidemiological information about agricultural injury and characteristics in a Canadian context, as the majority of existing reports are based on data that is more than a decade old. Furthermore, the analyses presented a comparison of two farming regions to compare regional effects, which is rare in the descriptive literature. Lastly, manuscript 1 presented cross-tabulated results comparing age group and mechanism of injury which demonstrated that age affects the rate of injury associated with specific mechanisms.

Manuscript 2 adds to the limited body of analytic literature about pediatric agricultural injuries by investigating specific farm work exposure and their relationship with injury in a Canadian context. To date, the analytic research in this area has been restricted to American farming populations. The analyses also investigated a dose-response relationship between different farm work exposures and agricultural injury, which is novel as the majority of prior investigations have used dichotomous farm work exposure variables.

Both studies presented in Manuscript 1 and 2 have limitations that can be drawn about causality. Manuscript 1 is a descriptive analysis of case-only agricultural injury surveillance data. Even though leading mechanisms of injury were identified, assessment of causation is not possible as there is no comparison group free of injury and limited information about the exposures and circumstances leading to injury. In manuscript 2, due to the cross-sectional design we lacked an ability to establish temporality, which definitively limits interpretations about causation. We cannot determine that farm work exposures preceded agricultural injury because

the exposures and outcomes were measured for the same time period. There is also some concern about reverse causality as a prior farm injury could reduce the amount of time engaged in farm work and specific farm tasks. However, if this was the case, it would reduce the dose-response relationship found and bias results toward the null.

## **5.5 Future Research Directions**

Future research should aim to replicate and further explore these findings about pediatric agricultural injuries. For descriptive analyses, it would be beneficial to further investigate the geographic differences in agricultural injury. To further understand why there are differences in agricultural injury experiences across regions, regional farming characteristics should be compared in future studies with sufficient numbers to permit such comparisons with accuracy. Furthermore, stratification and cross-tabulations by age group should be incorporated into future descriptive analyses as Manuscript 1 demonstrated that age can have a substantial effect on the characteristics of agricultural injury.

Analytic studies need to confirm and further explore the dose-response relationship between farm work exposures. Future studies should use data with sufficient injury events to yield improved statistical power and therefore could allow for the comparison of more exposure categories. Studies should also use validated measures to measure farm work exposures or conduct validation studies to investigate the test validity of measures. Moreover, future investigation should use exposure information to predict prospective agricultural injury such as from a cohort study in order to improve interpretations of the temporal aspects of causality. Additionally, as previously discussed, the results from Manuscript 2 demonstrate a substantial effect of farm-level factors and there may be uncontrolled confounding. Therefore, future research should investigate additional potential covariates such as: age of farm equipment, farm safety and training practices and policies, parent level factors such as permissiveness, supervision, and attitudes and beliefs about farm safety. Lastly, future analytic research needs to

continue to investigate the effects of sex in order to better understand what risk, if any, is associated with sex and to investigate potential mediation in the relationship between sex and agricultural injury by farm work exposures.

## **5.6 Recommendations for Public Health, Prevention, and Policy**

Implications and recommendations have been discussed in depth in Manuscript 1 and 2 (see Chapters 3 and 4). In summary, we recommend that future preventive efforts are specifically targeted to: 1) farming regions; 2) specific age groups; and 3) specific farm exposures, including the timing of those exposures. These recommendations are based on the existing body of literature and findings from this research. Specifically, Manuscript 1 demonstrated that there are differences between the geographic regions of Ontario and Saskatchewan which have differences in farm size, type of operations, and economic contributions. Both manuscripts found that age distributions have a substantial impact on farm injury and provided evidence supporting targeting interventions to specific farm work exposures. For example, Manuscript 2 identified tractor maintenance as a high risk farm activity that should be a priority for intervention.

Based on the limited effectiveness of educational interventions demonstrated in the literature,<sup>19–24</sup> we also recommend future intervention expand beyond educational interventions to incorporate ergonomic, engineering, and regulatory controls. Research has demonstrated that legislative changes, such as removing the family farm exemption for agriculture in the US Child Labor Law’s Hazardous Occupations Orders and raising the age restriction for performing hazardous agricultural from 16 to 18 years would hypothetically be able to help prevent agricultural injury.<sup>25</sup> However, the farming community is traditionally opposed to outside interference and control, as demonstrated when the recent attempts to reform the US Child Labor Laws as they apply to the agricultural sector which were rejected, in part, due to strong opposition from the agricultural sector.<sup>26,27</sup> For that reason, future regulatory efforts should encourage uptake of voluntary policies such as The North American Guidelines for Children’s Agricultural Tasks

and the best practice model policy for youth employment in agriculture proposed by Miller and colleagues.<sup>28</sup>

## **5.7 Summary**

This thesis demonstrates that there is a substantial burden of agricultural injuries in children and youth in Ontario and Saskatchewan. Furthermore, findings suggest that this burden can be explained in part by farm work exposures in youth and young adults. The relationships between farm work exposures and agricultural injury followed a dose-response trend. Future research should: 1) investigate the farming characteristics of geographic regions and rates of pediatric injury to better understand regional effects; 2) use cohort data to determine how farm work exposures contribute to prospective injuries; 3) use additional categories of exposure to further investigate the dose-response relationships of farm work exposures with injury; and 4) should consider more farm and parent-level factors in future investigations. Pediatric agricultural injury should be a priority for public health of rural and agricultural populations. Future preventive efforts should focus on specific farming regions, age groups, and high risk farm exposures and should incorporate a variety of strategies such as engineering controls and uptake of voluntary farm policy about farm safety, training, and the assignment of developmentally appropriate farm work.

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## **Appendix A**

### **Canadian Agricultural Injury Reporting (CAIR) Methods**

This appendix will summarize the methods used by CAIR that are explained in data in Agricultural Injuries in Canada for 1990-2000; Agricultural Fatalities in Canada for 1990-2008; and Agricultural Fatalities and Hospitalizations in Ontario 1990-2004.<sup>1-3</sup>

#### **Methods for identifying fatalities**

Although the process used in the identification of agricultural fatalities varies by province, the general procedure is as follows:

1. Potential sources of agricultural fatality data are identified using a variety of agencies depending on the province. Both Ontario and Saskatchewan use records from the offices of the Chief Coroner for Ontario along with data from occupational health and safety organizations. The CAIR program in Ontario supplements these sources with records from the Registrar General.
2. Within each province, a comprehensive list of all potential agriculture-related fatalities is assembled using each available source of fatality data. Detailed case reports are sought for identified cases from coroners' investigation reports; occupational safety and health agency investigation reports; and RCMP/provincial police reports.
3. Data abstraction and entry are completed on each eligible fatality. This is done in a consistent manner using a standard data abstraction form (Appendix B). Data abstraction is completed onsite at provincial chief coroners' or medical examiners' offices.
4. The resulting data are sent to the national site for verification, cleaning, coding and analysis by a subcommittee of CAIR researchers called the Data Cleaning Committee. The data cleaning process follows procedures outlined in the Fatality Coding manual that was written and continues to be updated by the Data Cleaning committee. Key database



elements are reviewed for each case in the fatality database. At least two members of the committee review each case for eligibility and if deemed eligible, code or recode the cause and other characteristics of the fatality. Cases with poor agreement are reviewed for consensus by the Data Cleaning committee.

5. The cleaned and coded data are maintained in an electronic database. This database is managed centrally by the national coordinator under the supervision of the program director. The provincial collaborators retain the complete data set for their own provinces.

However, this data collection process is not without limitations. It is difficult to standardizing the process across province due to the different types of agencies available across provinces. Furthermore, there are discrepancies in terms of the organization and computerization of case files within provincial mortality databases. As a result, there are likely differences in efficiency of case definition across provinces. Every effort is made to identify every possible agricultural fatality case and to standardize data collection efforts; however, some variation does exist between provinces.

### **Methods for identifying hospitalizations**

Hospital separation or discharge data are obtained by CAIR collaborators using Hospital separation data are obtained by CAISP collaborators through agreements with the Ministry of Health in each province. The identification of hospitalized agricultural injuries follows a different method based on whether the injuries are machine-related or not. Hospitalized agricultural injuries are identified using a systematic computer search of the hospital separation database. Cases are considered for inclusion if they meet the criteria listed in Table 1. Ontario began using ICD 10 codes in March of 1999; therefore, the inclusion criteria are listed for both ICD 9 and ICD 10 codes.

**Table 1. Inclusion criteria for CAIR hospitalization data<sup>3</sup>**

		Inclusion criteria
Machine-related	ICD 9	<ul style="list-style-type: none"> <li>- External cause of injury code on the hospital discharge record was E919.0, 'Injuries caused by agricultural machinery'.</li> <li>- Cases with the location of injury 'farm' (ICD 9 CM place of occurrence code = E849.1 or ICD 9 CA 5th digit sub-classification "place of occurrence" code =1) were also included if the incident involved a machine or a motorized vehicle.</li> </ul>
	ICD 10	<ul style="list-style-type: none"> <li>- ICD 10 CA external cause of injury on the hospital discharge record was W30 'Contact with agricultural machinery' or V84X 'Transport accident – special vehicle'</li> <li>- Cases coded with the location of injury 'farm' using ICD 10 CA place of occurrence code U98.7 are also included if the incident involved a machine or a motorized vehicle</li> </ul>
Non-machine related	ICD 9	<ul style="list-style-type: none"> <li>- Injury occurred on a farm: ICD 9 CM place of occurrence code = E849.1 or ICD 9 CA 5th digit sub-classification "place of occurrence" code =1, excluding injuries that involved a machine or vehicle.</li> </ul>
	ICD 10	<ul style="list-style-type: none"> <li>- Cases coded with the location of injury 'farm' using ICD 10 CA place of occurrence code U98.7, excluding incidents involving a machine or a motorized vehicle</li> </ul>

Whenever possible, hospitalization data is enhanced by chart data. The patient identifier and institution code in the basic hospital separation or discharge data set are used to identify the institutions to which individual cases were admitted. To request chart data from the medical records department, the Chief Executive Officer (or equivalent) approached for permission. Information is requested using a mail survey format once permission is granted to access chart data. Medical records personnel use the standardized data abstraction form (Appendix B) received in the mail to abstract specific information from the individual patient charts. Regular mail and telephone follow-ups are conducted following the initial mailing in order to ensure a high response rate. The resulting enhanced data set includes variables in addition to those in the basic data set that can be used to better describe injury patterns. Data is cleaned, verified, and coded by the Data Cleaning committee using the hospitalization coding manual using the same process as the fatality data.

The CAIR hospitalization data is limited by the amount and completeness of data available in the medical record, and the diligence and accuracy of the abstraction by medical records technician which to some degree is dependent on the technicians' knowledge of agricultural operations. Based on these limitations, there likely variations in the quantity and the accuracy of the information that is returned on the data abstraction forms. The data cleaning process aims to improve the quality and accuracy of resultant data.

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## Appendix B

### CAIR Data Abstraction Forms



#### FARM INJURIES – DATA ABSTRACTION FORM

Coroner's File #: \_\_\_\_\_ - \_\_\_\_\_

CAIR ID: \_\_\_\_\_ - \_\_\_\_\_

\_\_\_\_\_ year no.  
no.

prov. year

**An Agricultural Fatality is:** 1) Any unintentional injury resulting in death that occurred during activities related to the operation of a farm or ranch and/or 2) Any unintentional injury resulting in death that involved any hazard of a farm or ranch environment in Canada (excluding fatal non work-related injuries that took place in the farm residence). This includes deaths that occurred away from agricultural work locations if agricultural work was being done; e.g., transporting livestock, supplies, workers or harvested crops on public highways. Deaths where victims were killed because a third party was engaged in agricultural work are also included.

Age: \_\_\_\_\_

Birth Date: \_\_\_\_ / \_\_\_\_ / \_\_\_\_  
mm dd yyyy

Birth date missing (circle)? Yes No

Gender (circle): M F

Province: \_\_\_\_\_

County/Regional Municipality: \_\_\_\_\_

Region: \_\_\_\_\_ Date of Injury: \_\_\_\_ / \_\_\_\_ / \_\_\_\_ Weekday of Injury (circle): S M T W T F S  
mm dd yyyy

Time of Injury \_\_\_\_\_ (24:00)

Date of Death: \_\_\_\_ / \_\_\_\_ / \_\_\_\_  
mm dd yyyy

Source of data for case identification (circle all that apply):

1 Coroner

2 Medical Examiner

3 Media

4 RCMP / police

5 Registrar General

6 Other

#### **A. DESCRIPTION OF INJURY EVENT**

Please include as many details as possible about the decedent's activity, task and location at the time of the incident. For falls and drownings, please describe exact location. For struck or pinned by object injuries, please specify object or machine component. For entanglements, please state whether clothing was involved. For tractor rollovers, please indicate whether the tractor had ROPS. For machine injuries, please describe the machine in as much detail as possible.

If the injury was not machinery or vehicle related, complete Section B and then proceed to Section E.

If the injury was machinery or vehicle related, begin with Section C and continue.

<p><b>B. CAUSE OF INJURY NOT MACHINERY OR VEHICLE RELATED</b></p> <p>1 crushed or struck by animal. Specify animal: _____</p> <p>2 other type of animal injury. Specify animal: _____</p> <p>3 fall from animal. Specify animal: _____</p> <p>4 struck by non-machine object</p> <p>5 struck against non-machine object</p> <p>6 caught inside, under or between non-machine objects</p> <p>If 4 or 6, specify object: _____</p> <p>7 fall from height. Give specific fall location: _____</p> <p>8 fall on same level</p> <p>9 jumped to lower level</p> <p>10 overexertion</p> <p>11 drowning</p> <p>12 exposure to fire/explosion</p> <p>13 contact with temperature extremes</p> <p>14 contact with electric current</p> <p>16 contact with radiation, caustic, toxic or noxious substance by (circle): inhalation ingestion absorption injection</p> <p>Specify agent: _____</p> <p>18 asphyxiation by grain or soil. Specify: _____</p> <p>19 firearm</p> <p>77 other non machine related. Specify: _____</p> <p>88 unknown non machine related</p> <p>99 not applicable</p>	<p><b>C. CAUSE OF INJURY MACHINERY OR VEHICLE RELATED</b></p> <p>1 sideways rollover</p> <p>2 backwards rollover</p> <p>3 unspecified rollover</p> <p>4 entangled/caught in machinery</p> <p>5 pinned or struck by machine component or collapsing machine (specify) _____</p> <p>6 traffic collision on road or highway</p> <p>7 operator fell from moving machine, not runover, pinned, or struck by it</p> <p>8 operator fell from moving machine, then runover, pinned, or struck by it</p> <p>9 passenger fell from moving machine, not runover, pinned, or struck by it</p> <p>10 passenger fell from moving machine, then runover, pinned, or struck by it</p> <p>11 alighted operator/other person runover, pinned, or struck by unmanned machine</p> <p>12 alighted passenger runover, pinned, or struck by moving machine</p> <p>13 bystander runover, pinned, or struck by moving machine</p> <p>14 machine-related contact with electrical current</p> <p>15 machine related fire, explosion or burn</p> <p>16 machine collision off-road</p> <p>17 machine-related drowning</p> <p>18 struck by object falling or propelled from machine (specify) _____</p> <p>20 runover, pinned, or struck by moving machine - unspecified</p> <p>77 other machine related. Specify: _____</p> <p>88 unknown machine related</p> <p>99 not applicable</p> <p>If 5 or 18, specify object/component: _____</p>	<p><b>D. TYPE OF MACHINERY</b></p> <p>(Circle appropriate number if the injury event was machinery or vehicle related)</p> <p>1 tractor</p> <p>2 auger. Specify whether freestanding, attached to machine, or unknown (circle)</p> <p>3 mower</p> <p>4 power take off, specify machine PTO attached to: _____</p> <p>5 baler</p> <p>6 farm wagon/trailer</p> <p>7 combine</p> <p>8 power tool (not chainsaw)</p> <p>9 chainsaw</p> <p>10 welder</p> <p>11 harvester</p> <p>12 plough/disk</p> <p>13 hay elevator</p> <p>14 manure spreader</p> <p>15 bulldozer, bob cat, skid steer</p> <p>16 motor vehicle. Specify: _____</p> <p>17 off-road vehicle. Specify: _____</p> <p>19 fencing equipment</p> <p>20 spraying equipment</p> <p>22 garden equipment</p> <p>24 planting equipment</p> <p>25 swather</p> <p>26 rock picker</p> <p>27 snow blower</p> <p>28 airplane</p> <p>77 other farm implement/machine. Specify: _____</p> <p>88 unknown</p> <p>99 not applicable</p>
<p><b>E. IMMEDIATE LOCATION OF INJURY</b></p> <p>1 Field (includes dry ditches next to field)</p> <p>2 Barn</p> <p>3 Silo/grain bin, (circle)</p> <p>4 Shed</p> <p>5 Farmyard</p> <p>6 Road/highway (includes dry ditches)</p> <p>7 Driveway (includes dry ditches)</p> <p>8 Farm house</p> <p>9 Farm road (includes dry ditches)</p> <p>10 Woods, orchard</p> <p>11 Water source; includes water-filled ditch, dugout, manure lagoon, sewage pit, etc. Specify: _____</p> <p>12 Corral/outdoor animal enclosure</p> <p>13..Other unspecified ditch/embankment/dyke</p> <p>14 Trench</p> <p>77 Other location. Specify: _____</p> <p>88 Unknown</p> <p><b>F. LOCATION OF DEATH</b></p> <p>1 Found dead</p> <p>2 Died en route</p> <p>3 Died in hospital</p> <p>77 Other location of death. Specify: _____</p> <p>88 Unknown</p>	<p><b>G. RELATIONSHIP OF INJURED PERSON TO FARM OWNER/OPERATOR</b></p> <p>1 Operator</p> <p>2 Spouse of farm operator</p> <p>3 Child of farm operator</p> <p>4 Other relative of farm operator. Specify: _____</p> <p>5 Hired worker</p> <p>6 Spouse of hired worker</p> <p>7 Child of hired worker</p> <p>8 Other relative of hired worker. Specify: _____</p> <p>9 Other non-visiting child</p> <p>10 Other non-visiting adult</p> <p>11 Adult visitor or contractor</p> <p>12 Child visitor</p> <p>77 Other relationship. Specify: _____</p> <p>88 Unknown</p>	<p><b>H. METHOD OF DISCOVERY</b></p> <p>Who found the deceased? (i.e. relationship to deceased) _____</p> <p>Was the injury event witnessed? (circle) Y N (Indicate if the information is not available)</p> <p><b>I. NATURE OF INJURY BY BODY PART</b> e.g., N11 crush injury, BP1 chest. (List from most to least serious injury, where the most serious injury was the cause of death.)</p> <p><b>Nature of injury 1:</b> _____</p> <p><b>Body part 1:</b> _____</p> <p><b>Nature of injury 2:</b> _____</p> <p><b>Body part 2:</b> _____</p> <p><b>Nature of injury 3:</b> _____</p> <p><b>Body part 3:</b> _____</p>

**J. REVIEW FOR CONSENSUS?** (Circle) Yes No If yes, please explain the points needing consensus of opinion.



## CAISP HOSPITALIZED FARM INJURIES – DATA ABSTRACTION FORM

ID: XX-XX-XXXX

Prov yr number

### Instructions:

The <respective provincial agency> has provided us with the hospital separation record for the following patient treated in your hospital for an agricultural injury. Please confirm the information below and provide us with the additional information requested on the back of this form. Thank you for your help.

### Hospital Information

Chart number:

Year:

Institution code:

### Patient Information

Date of birth:

Sex:

### Services

Date of admission:

Date of discharge:

Length of stay:

Admission category:

Ambulance required:

### Injury Information

Main diagnostic code:

Other diagnostic codes:

External cause of injury code:

Is the above information correct? (circle number)

1 YES

2 NO Please comment on any corrections:

Was this patient transferred from another hospital? (circle number)

1 YES Please tell us which hospital: \_\_\_\_\_

2 NO

Was this a readmission for a previous injury? (circle number)

1 YES If yes, date of original admission: \_\_\_\_/\_\_\_\_/\_\_\_\_ (dd/mm/yyyy)

2 NO

If this was not a farm-related injury, please describe with as much detail as possible what type of injury this was:

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---

1. Please describe in detail the circumstances of the injury event and what the injured person was doing at the time of the injury:

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---

---

2. Did the injury event involve a machine or vehicle?

No complete section 1.

Yes complete section 2, parts A and B.

SECTION 1 – NON-MACHINE	SECTION 2 – MACHINE/VEHICLE RELATED	
<b>Cause of injury</b>	<b>Part A Cause of injury</b>	<b>Part B Machine type</b>
<b>Animal-related</b> Specify animal: _____ 1 crushed or struck by animal 2 other type of animal injury 3 fall from animal  <b>Struck/caught by non-machine object(s)</b> Specify object: _____  4 struck by object 5 struck against object 6 caught inside/under/between objects  <b>Fall/Jump</b> Specify fall from where: _____  7 fall from height 8 fall on same level 9 jumped to lower level  10 <b>Overexertion</b>  11 <b>Near drowning</b> Specify where: _____  12 <b>Exposure to fire</b>  <b>Contact with:</b> 13 temperature extremes 14 electric current 16 toxic substances/allergens Specify substance: _____  <b>Contact by: (circle)</b> inhalation ingestion absorption injection 19 firearms 77 other non-machine cause, Specify: _____  88 Unknown, not machine related 99 Does not apply (machine-related)	<b>Machine/vehicle rollover</b> 1 sideways rollover 2 backwards rollover 3 unspecified rollover  4 <b>Entangled in machine</b>  <b>Struck by, against or pinned by</b> Specify: _____  5 pinned or struck by machine component or collapsing machine 18 struck by object propelled or falling from machine 23 struck against machine/machine component  6 <b>Traffic collision (farm road or highway)</b>  <b>Fall from moving machine, not run over, pinned, or struck</b> 7 operator 9 passenger 15 person unspecified over age 10  <b>Fall from moving machine, then run over, pinned, or struck</b> 8 operator 10 passenger 16 person unspecified over age 10  <b>Run over, pinned, or struck by moving machine (no fall involved)</b> 11 alighted operator 12 alighted passenger 13 bystander 17 person unspecified  21 <b>Machine-related overexertion</b> 22 <b>Jumped from machine</b>  77 <b>Other cause, specify:</b> _____  88 Unknown machine-related 99 Does not apply (no machine)	1 Tractor 2 Auger Specify whether freestanding, attached to machine or unknown 3 Mower 4 Power take off. Specify machine PTO attached to: _____  5 Baler 6 Farm wagon/trailer 7 Combine 8 Power tool (except chainsaw) 9 Chainsaw 10 Welder 11 Harvester 12 Plough/disk 13 Hay elevators/conveyors 14 Manure spreader 15 Bulldozer, bobcat, skid steer, FEL 16 Motor vehicle, Specify type: _____  17 Off-road vehicle, Specify type: _____  19 Fencing equipment 20 Spraying equipment 21 Lawn mower 22 Garden equipment 24 Planting equipment 25 Swather 77 Other type, specify: _____  88 Unknown machine 99 Does not apply (no machine)

**Location**

1 Field (includes dry ditches)	8 Farm house
2 Barn	9 Farm road (includes dry ditches)
3 Silo/grain bin	10 Woodlot, orchard
4 Shed	11 Water source (any kind), manure lagoon, sewage pit etc. (specify)
5 Farm yard	12 Corral/outdoor animal enclosure
6 Road/highway (includes dry ditches)	77 Other (specify)
7 Driveway (includes dry ditches)	88 Unknown

**REVIEW FOR CONSENSUS?** (circle) Yes No If yes, please explain points needing consensus of opinion.

March 2006

## Appendix C

### Denominator Data Table for Manuscript 1

	Saskatchewan					Ontario				
	0-4	5-9	10-14	15-19	0-19	0-4	5-9	10-14	15-19	0-19
1990	10230	14802	18562	18654	62248	16593	21601	25680	23323	87197
1991	9850	14225	17945	18060	60080	16010	20920	24930	22845	84705
1992	9470	13648	17328	17466	57912	15427	20239	24180	22367	82213
1993	9090	13071	16711	16872	55744	14844	19558	23430	21889	79721
1994	8710	12494	16094	16278	53576	14261	18877	22680	21411	77229
1995	8330	11917	15477	15684	51408	13678	18196	21930	20933	74737
1996	7950	11340	14860	15090	49240	13095	17515	21180	20455	72245
1997	7570	10763	14243	14496	47072	12512	16834	20430	19977	69753
1998	7190	10186	13626	13902	44904	11929	16153	19680	19499	67261
1999	6810	9609	13009	13308	42736	11346	15472	18930	19021	64769
2000	6430	9032	12392	12714	40568	10763	14791	18180	18543	62277
2001	6050	8455	11775	12120	38400	10180	14110	17430	18065	59785
2002	5876	8135	11176	11693	36880	9834	13516	16941	17955	58246
2003	5702	7815	10577	11266	35360	9488	12922	16452	17845	56707
2004	5528	7495	9978	10839	33840	9142	12328	15963	17735	55168
2005	5354	7175	9379	10412	32320	8796	11734	15474	17625	53629
2006	5180	6855	8780	9985	30800	8450	11140	14985	17515	52090
2007	5006	6535	8181	9558	29280	8104	10546	14496	17405	50551
2008	4832	6215	7582	9131	27760	7758	9952	14007	17295	49012
2009	4658	5895	6983	8704	26240	7412	9358	13518	17185	47473
2010	4484	5575	6384	8277	24720	7066	8764	13029	17075	45934
2011	4310	5255	5785	7850	23200	6720	8170	12540	16965	44395

Used as numerator for Hospitalizations



## **Appendix D**

### **Saskatchewan Farm Injury Cohort Methods**

#### **Development of study materials**

The Phase 1 baseline questionnaire was developed by a panel consisting of the primary research team with advisement from three active members of the farming community. Items that had been used in existing research were selected or modified for use wherever possible.<sup>1-3</sup> The questionnaire and other study materials were tested using a sample of 50 farm people who were not enrolled in the main cohort. Materials were revised based on feedback about question clarity, comprehension, time of completion, acceptability, and overall impressions.

The Phase 2 baseline questionnaire was based on the Phase 1 questionnaire. The research panel modified or removed items based on experiences with the Phase 1 research and feedback from participants. New items were added based on contemporary research interests and findings from related body of literature. The Phase 2 baseline questionnaire underwent similar pilot test to Phase 1 and was revised further based on the feedback received. This pilot testing has demonstrated that the SFIC questionnaires have good content and face validity.<sup>4-6</sup> However, little else is known about the reliability and validity of farm work exposures and farm injury items used in the study presented in Manuscript 2.

#### **Sampling methods and data collection**

The SFIC used a stratified cluster sampling approach. Municipalities were stratified based on: 1) soil type and hence type of agriculture (3 strata); and, (2) membership or not in the *Agricultural Health and Safety Network* (2 strata). For Phase 1, based on this stratification, 50 municipalities were randomly selected participate. Consent for participation at the municipal level was requested through in-person meetings with each rural municipal council. For Phase 2 of the study, an additional 24 municipalities were recruited using this same method. However, a small

number of municipalities were excluded from participation in Phase 2 due to their participation in other ongoing studies. A total of three municipal councils declined to participate resulting in a nearby municipality in the same strata was recruited in its place. Updated lists of active farms were requested from participating municipal councils. All farms listed as active were invited to participate in the study.

Farms were recruited by mail using a modified version of the Dillman Total Design Method for Mail and Telephone Surveys in order to maximize response rates <sup>7</sup>. The general premise of the Dillman method involves maximizing study response rates by: 1) maintaining ongoing communication with participants; 2) use of consistent and non-intrusive methods of follow-up; 3) using personalized study materials to encourage interest; 4) using participant-friendly materials; and, 5) expressing appreciation for the contributions of participants. Figure 1 demonstrates how recommendations from the Dillman method were applied to Phase 2 data collection, including the timing of follow-up efforts. Phase 1 used a nearly identical process.

**Figure 1. Schedule of mailings**

<b>Week</b>	<b>Module- Description</b>	<b>Date of Mailing</b>
1	Pre-notice Letter	February 1, 2013
2	Survey package #1	February 12, 2013
4	Reminder Card	February 26, 2013
7	Survey Package #2	March 19, 2013
12	Survey Package #3	April 22, 2013
15	Thank-you Letter	
<b>Total</b>		

Survey packages including cover letters, instructions, written paper questionnaires, and return envelopes with postage were sent to all active farms in the municipalities selected for participation. Questionnaires were filled out by a key adult informant on each farm. The questionnaire includes questions about the farm operation, work and health experiences of farm

dwellers and workers, and farm health and safety practices. The cohort was designed to be large and heterogeneous in terms of work-related exposures but not necessarily representative.

## References

1. Statistics Canada. *Canadian Community Health Survey - Annual Component (CCHS)*.; 2013.
2. Currie C, Samdal O, Boyce W, Smith R. *Health Behaviour in School-Aged Children: A WHO Cross-National Study (HBSC), Research Protocol for the 2001/2002 Survey*. Edinburgh, Scotland: University of Edinburgh, Child and Adolescent Health Research Unit; 2001:39-212.
3. Statistics Canada. 2001 Census of Agriculture. 2001.
4. Pickett W, Day L, Hagel L. The Saskatchewan farm injury cohort: Rationale and methodology. *Public Health Rep*. 2008;123(5):567-575.
5. Pickett W, Hagel LM, Day AG, et al. Determinants of agricultural injury: A novel application of population health theory. *Inj Prev*. 2010;16(6):376-82.
6. Marlenga B, Pahwa P. Impact of long farm working hours on child safety practices in agricultural settings. *J Rural Heal*. 2010;26:366-372.
7. Dillman DA. *Mail and Internet Surveys: The Tailored Design Method*. 2nd ed. New York: John Wiley and Sons, Inc.; 2000.

## **Appendix E**

### **Saskatchewan Farm Injury Cohort Questionnaire**

Below are the sections of the SFIC Phase 2 Questionnaire relevant to manuscript 2. Part B of the questionnaire is repeated and filled in for each person on the farm.

## SASKATCHEWAN FARM INJURY PROJECT

### Phase 2

### Household Survey



#### TO FARMERS AND THEIR FAMILIES:

The University of Saskatchewan is conducting this project to learn more about the health of farm families and the occurrence of farm injuries. Farm families from across Saskatchewan are participating. For some of you this will be a continuation of the study and for others this will be your first contact.

We ask that one responsible person complete the questionnaire on behalf of everyone on the farm. Please try to answer all of the questions, but remember you don't have to answer any questions if you choose not to. When you have finished please place the questionnaire in the business reply envelope and mail it back to us at the university.

We will contact you four times over the next two years to see if anyone has been injured. This contact will be made by mail and the questions will take approximately 5 minutes to respond to on each occasion. We wish to respect your time and privacy and make it easy to participate in this study.

#### Instructions

1. In Section B of this questionnaire we have asked questions about each member of your farm family. We have included enough space in this booklet for 2 persons. **If you have more than 2 persons in your farm family PLEASE COMPLETE THE ADDITIONAL PAGES IN THE GREEN BOOKLET called "Additional Pages for Section B".**
2. Please read each question carefully.
3. Answer each question by placing a check mark in the box provided. For some questions you will write in the space provided. Please be sure to complete the contact information on the last page.
4. **Thank you for taking part in this important study.**

The University of Saskatchewan

Sponsored by the Canadian Institutes of Health Research

## PART A YOUR FARM OR RANCH

A-1 From the list below, please check each commodity that is produced for sale on your farm or ranch. (Check all that apply)

1. Grain crops ☐ <sup>1</sup>
- (e.g., cereal, pulse, oil seeds, forage crops)
2. Cattle (beef) ☐ <sup>2</sup>
3. Cattle (dairy) ☐ <sup>3</sup>
4. Pigs ☐ <sup>4</sup>
5. Poultry ☐ <sup>5</sup>
6. Vegetables/Fruit ☐ <sup>6</sup>
7. Other animals ☐ <sup>7</sup>

A-2 What is the total area of land in your farming or ranching operation? (Exclude land rented to others)

Total Acres: \_\_\_\_\_

A-3 How many of these types of livestock are typically raised on your farm or ranch?

1. No Livestock ☐ <sup>1</sup>
2. Cattle (beef) \_\_\_\_\_ (number)
3. Cattle (dairy) \_\_\_\_\_ (number)
4. Swine \_\_\_\_\_ (number)
5. Poultry \_\_\_\_\_ (number)
6. Horses \_\_\_\_\_ (number)
7. Other \_\_\_\_\_ (number)

A-4 What is the operating arrangement of your farm?

- Individual family farm ☐ <sup>1</sup>
- Partnership (with or without a written agreement) ☐ <sup>2</sup>
- Family corporation ☐ <sup>3</sup>
- Other type ☐ <sup>4</sup>

A-5 Did you have any custom workers on your farm during 2012? (Check all that apply)

- No Custom Workers ☐ <sup>1</sup>
- Seeding ☐ <sup>2</sup>
- Combining ☐ <sup>3</sup>
- Spraying ☐ <sup>4</sup>
- Trucking ☐ <sup>5</sup>
- Other ☐ <sup>6</sup>

Please specify: \_\_\_\_\_

A-6 Did you have any hired workers on your farm during 2012? (Exclude custom workers)

Yes ☐ <sup>1</sup> No ☐ <sup>2</sup>

If yes, how many \_\_\_\_\_

A-7 Is the farm your family's main place of residence?

Yes, all family members on the farm ☐ <sup>1</sup>

Yes, some family members on the farm ☐ <sup>2</sup>

No family members live on the farm ☐ <sup>3</sup>

A-8 In the table below please identify all the family members who usually live or work on your farm?

- Include family members who live on your farm.
- Include family members who work on the farm but do not live on the farm.
- Do not include family members that primarily work on their own farm.

Person	Initials	Age	Sex
Example	<u>W M S</u>	40	M <input checked="" type="checkbox"/> <sup>1</sup> F <input type="checkbox"/> <sup>2</sup>
You	_____		M <input type="checkbox"/> <sup>1</sup> F <input type="checkbox"/> <sup>2</sup>
Person 2	_____		M <input type="checkbox"/> <sup>1</sup> F <input type="checkbox"/> <sup>2</sup>
Person 3	_____		M <input type="checkbox"/> <sup>1</sup> F <input type="checkbox"/> <sup>2</sup>
Person 4	_____		M <input type="checkbox"/> <sup>1</sup> F <input type="checkbox"/> <sup>2</sup>
Person 5	_____		M <input type="checkbox"/> <sup>1</sup> F <input type="checkbox"/> <sup>2</sup>
Person 6	_____		M <input type="checkbox"/> <sup>1</sup> F <input type="checkbox"/> <sup>2</sup>

Complete PART B for each person listed in A-8 of your farm family.

This booklet has space for 2 persons. The green booklet has space for 4 more people. If you have more than 6 people listed in A-8, fill in the pages for 6 people and check the box below.

☐ <sup>1</sup>

## PART B PEOPLE ON YOUR FARM

PLEASE COMPLETE THE NEXT 4 PAGES  
FOR THE FIRST PERSON LISTED IN A-8

### Person 1 – Page 1

This is the person completing this questionnaire.

Name: \_\_\_\_\_  
(Please print initials, including middle initial)

B-1 Date of Birth: Month \_\_\_\_\_ Day \_\_\_\_\_ Year \_\_\_\_\_

B-2 Sex: Male <sup>1</sup>☐ Female <sup>2</sup>☐

B-3 Height: Inches \_\_\_\_\_ OR cm \_\_\_\_\_

B-4 Weight: Pounds \_\_\_\_\_ OR kg \_\_\_\_\_

B-5 Highest level of education:

Less than High School <sup>1</sup>☐  
Completed High School <sup>2</sup>☐  
Completed University <sup>3</sup>☐  
Technical/Community College <sup>4</sup>☐

B-6 Have you completed any educational or training  
courses specific to agriculture?

Yes <sup>1</sup>☐ No <sup>2</sup>☐

B-7 Relationship to the farm owner-operator:  
(Choose the one category that best applies)

Primary Farm Owner-operator <sup>1</sup>☐  
Spouse (Husband or Wife) <sup>2</sup>☐  
Parent <sup>3</sup>☐  
Child <sup>4</sup>☐  
Other Relative <sup>5</sup>☐

B-8 What is your main occupation?  
(Choose the one category that best applies)

Farmer/Farm Worker <sup>1</sup>☐  
Student/Pre-school <sup>2</sup>☐  
Retired <sup>3</sup>☐  
Other <sup>4</sup>☐

Please specify: \_\_\_\_\_

B-9 Do you have an off-farm job?

Yes <sup>1</sup>☐ No <sup>2</sup>☐

If YES, please specify the number of hours per week  
that you typically work at your off-farm job?

Hours \_\_\_\_\_

Job Industry (e.g., healthcare) \_\_\_\_\_

Job Type (e.g., nurse) \_\_\_\_\_

B-10 Has a doctor diagnosed you with?  
(Check all that apply)

a. Sleep Apnea..... ☐  
b. Rheumatoid Arthritis..... ☐  
c. Osteoarthritis (wear & tear)..... ☐  
d. High Blood Pressure..... ☐  
e. Heart Disease..... ☐  
f. Diabetes..... ☐  
g. Stomach or Intestinal Problems..... ☐  
h. Asthma or other Lung Conditions..... ☐  
i. Dementia..... ☐  
j. Hearing loss..... ☐  
k. Depression..... ☐  
l. Chronic or Constant Pain..... ☐  
m. Incontinence/Urinary Problem..... ☐  
n. None of the above..... ☐

B-11 Do you regularly take?  
(Check all that apply)

a. Stomach remedies or laxatives..... ☐  
b. Tranquilizers..... ☐  
c. Sleeping Pills..... ☐  
d. Pain Medications..... ☐  
e. Heart or Blood Pressure Pills..... ☐  
f. Anti-depressants..... ☐  
g. Anti-inflammatories (Advil®, Naproxen)..... ☐  
h. Other medications..... ☐  
i. No medication..... ☐

B-12 In general would you say your physical health is:

Excellent <sup>1</sup>☐  
Very good <sup>2</sup>☐  
Good <sup>3</sup>☐  
Fair <sup>4</sup>☐  
Poor <sup>5</sup>☐

B-13 Your eyesight using both eyes (with glasses or contact  
lenses, if used) is:

Good <sup>1</sup>☐ Fair <sup>2</sup>☐ Poor <sup>3</sup>☐

## Person 1 – Page 2

B-14 How often in the past 12 months have you had 5 or more drinks on one occasion?

- Never ☐ <sup>1</sup>  
 At most once a month ☐ <sup>2</sup>  
 At most once a week ☐ <sup>3</sup>  
 More than once a week ☐ <sup>4</sup>

B-15 Do you now smoke cigarettes?

- Yes ☐ <sup>1</sup> No ☐ <sup>2</sup>

B-16a For each season during the past year, on average, how many hours per week did you spend doing farm work? (If not applicable write "0")

- Spring \_\_\_\_\_ Hrs/wk  
 Summer \_\_\_\_\_ Hrs/wk  
 Fall \_\_\_\_\_ Hrs/wk  
 Winter \_\_\_\_\_ Hrs/wk

B-16b Is this person a child? (Less than 18 years old)

- Yes ☐ <sup>1</sup> No ☐ <sup>2</sup> → If **NO**, skip to B-17

If YES, for each season during the past year, on average, how many hours per week did this child spend present in the farm worksite?

(Do not include time spent in home)

(If not applicable write "0")

- Spring \_\_\_\_\_ Hrs/wk  
 Summer \_\_\_\_\_ Hrs/wk  
 Fall \_\_\_\_\_ Hrs/wk  
 Winter \_\_\_\_\_ Hrs/wk

**During 2012, how many hours per year did you:**  
 (If not applicable write "0")

- B-17 Operate tractors? \_\_\_\_\_  
 B-18 Do routine maintenance on **tractors**? \_\_\_\_\_  
 B-19 Operate combines? \_\_\_\_\_  
 B-20 Do routine maintenance on **combines**? \_\_\_\_\_

**During 2012, how many days per year did you:**  
 (If not applicable write "0")

- B-21 Operate all-terrain vehicles? \_\_\_\_\_  
 B-22 Do routine chores with **large animals**? (e.g., cattle or pigs) \_\_\_\_\_  
 B-23 Do routine chores with **small animals**? (e.g., chickens) \_\_\_\_\_  
 B-24 Do **herd maintenance activities**? (e.g., branding, vaccinating) \_\_\_\_\_  
 B-25 Do **veterinary activities**? (e.g., medications, breeding, birthing) \_\_\_\_\_  
 B-26 Lift, lower, or carry **heavy objects** (over 20lbs) more than 1 hour over the day? \_\_\_\_\_  
 B-27 Use a **shovel or pitchfork** more than 1 hour over the day? \_\_\_\_\_  
 B-28 Work with **hands over shoulder height** for more than 1 hour over the day? \_\_\_\_\_  
 B-29 Operate **power tools** with the hands more than 1 hour over the day? \_\_\_\_\_  
 B-30 How many hours of sleep do you typically get at night?  
 More than 7 hours ☐ <sup>1</sup>  
 6 to 7 hours ☐ <sup>2</sup>  
 4 to 5 hours ☐ <sup>3</sup>  
 Less than 4 hours ☐ <sup>4</sup>  
 B-31a Do you snore?  
 Yes ☐ <sup>1</sup>  
 No → If NO, skip to B-32 ☐ <sup>2</sup>  
 Don't know ☐ <sup>3</sup>  
 B-31b If **YES**, is your snoring:  
 Louder than talking ☐ <sup>1</sup>  
 Very loud- can be heard in adjacent rooms ☐ <sup>2</sup>  
 Softer than talking ☐ <sup>3</sup>  
 Don't know ☐ <sup>4</sup>  
 B-32 Has anyone noticed that you stop breathing in your sleep?  
 Yes ☐ <sup>1</sup>  
 No ☐ <sup>2</sup>  
 Don't know ☐ <sup>3</sup>

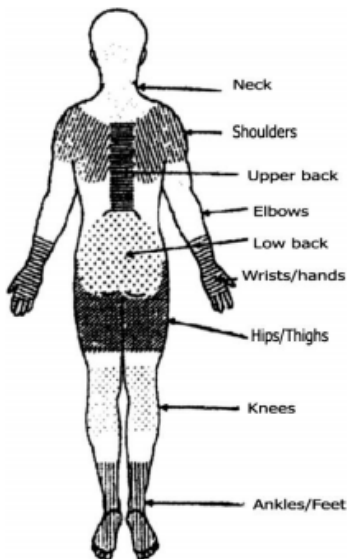


# Person 1 – Page 3

- B-33 How likely are you to doze off or fall asleep in the situations described below, in contrast to just feeling tired? This refers to your usual way of life in recent times. Even if you haven't done some of these things recently, try to work out how they would have affected you. **Please check one response for each situation.**

SITUATION	RESPONSE CHOICES			
	0 Would never doze	1 Slight chance of dozing	2 Moderate chance of dozing	3 High chance of dozing
Sitting and reading	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Watching TV	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Sitting, inactive in a public place (e.g., a theatre, a meeting)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
As a passenger in a car for an hour without a break	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Lying down to rest in the afternoon when circumstances permit	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Sitting and talking to someone	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Sitting quietly after lunch without alcohol	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
In a car, while stopped for a few minutes in the traffic	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

B-34



Have you at any time in the last 12 months had trouble (ache, pain, discomfort) in:		Have you at any time in the last 12 months been prevented from doing your normal work (at home or away from home) because of the trouble?
Neck	Yes <input type="checkbox"/> No <input type="checkbox"/>	Yes <input type="checkbox"/> No <input type="checkbox"/>
One or both shoulders	Yes <input type="checkbox"/> No <input type="checkbox"/>	Yes <input type="checkbox"/> No <input type="checkbox"/>
One or both elbows	Yes <input type="checkbox"/> No <input type="checkbox"/>	Yes <input type="checkbox"/> No <input type="checkbox"/>
One or both Hands	Yes <input type="checkbox"/> No <input type="checkbox"/>	Yes <input type="checkbox"/> No <input type="checkbox"/>
Upper Back	Yes <input type="checkbox"/> No <input type="checkbox"/>	Yes <input type="checkbox"/> No <input type="checkbox"/>
Lower Back	Yes <input type="checkbox"/> No <input type="checkbox"/>	Yes <input type="checkbox"/> No <input type="checkbox"/>
One or both hips/thighs	Yes <input type="checkbox"/> No <input type="checkbox"/>	Yes <input type="checkbox"/> No <input type="checkbox"/>
One or both knees	Yes <input type="checkbox"/> No <input type="checkbox"/>	Yes <input type="checkbox"/> No <input type="checkbox"/>
One or both ankles	Yes <input type="checkbox"/> No <input type="checkbox"/>	Yes <input type="checkbox"/> No <input type="checkbox"/>

Person 1 – Page 4

The questions on this page ask about **farm injuries**. We are interested in all injuries that occurred in a farm environment whether you were working or not. This includes injuries that occurred off farm but involved farm work (e.g., driving tractor on public road). This also includes being poisoned or burned. If you had more than one farm injury, think about the one most serious injury that you had during 2012.

B-35 Did you have a farm injury during 2012?

Yes <sup>1</sup>☐ No <sup>2</sup>☐

If **YES**, how many injuries? \_\_\_\_\_

**If you did not have a farm injury during 2012, please skip to the box on the bottom right.**

B-36 In what month did the one most serious farm injury happen?

<sup>1</sup>☐ <sup>2</sup>☐ <sup>3</sup>☐ <sup>4</sup>☐ <sup>5</sup>☐ <sup>6</sup>☐ <sup>7</sup>☐ <sup>8</sup>☐ <sup>9</sup>☐ <sup>10</sup>☐ <sup>11</sup>☐ <sup>12</sup>☐  
Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec

B-37 Were you working at the time of the injury?

Yes <sup>1</sup>☐ No <sup>2</sup>☐

B-38 In the space below, please provide details about **how** the injury occurred. Please describe **what** you were doing, **where** it happened, and **what went wrong**. Please tell us the type of injury and body part injured.

What were you doing?

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Where did it happen?

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---

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How did it happen?

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---

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What went wrong?

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---

Type of injury & body part injured; (e.g., broken arm, cut leg)

---

---

---

---

B-39 Where was this one most serious farm injury treated? (Check all that apply)

Self-treated <sup>1</sup>☐  
Doctor's office/health clinic <sup>2</sup>☐  
Emergency Room at hospital <sup>3</sup>☐  
Hospital admission overnight/longer <sup>4</sup>☐  
Other <sup>5</sup>☐

Please specify: \_\_\_\_\_

**If you have another person listed in A-8 who works or lives on the farm, continue on the next page. Otherwise go to Part C (yellow).**

## Appendix F

### Additional Tables for Manuscript 2

#### Covariate Regression Table

**Table 2. Unadjusted (Univariate) and Adjusted (Multivariate) Logistic Regression Relative Risk Estimates of Agricultural Injury for Covariates**

	<i>Unadjusted</i>		<i>Adjusted*</i>	
	RR (95%CI)	P value	RR (95%CI)	P-value
Age	1.2 (1.1-1.2)	<0.0001	1.1 (1.0-1.2)	0.003
Gender				
Female	ref		ref	
Male	2.0 (1.1-3.8)	0.03	1.6 (0.7-3.5)	0.17
Typical sleep				
≥7 hours	ref		ref	
≤ 6 hours	3.4 (1.9-5.8)	<0.0001	2.6 (1.3-5.1)	0.007
Comorbidities				
0	ref		ref	
1 or more	2.0 (1.0-4.1)	0.04	2.0 (0.9-4.2)	0.07
Farm Acres				
0-1500	1.1 (0.6-2.2)	0.70	1.1 (0.5-2.2)	0.83
1501-2500	1.1 (0.5-2.2)	0.88	1.0 (0.5-2.4)	0.91
>2500	ref		ref	

\*Holding other listed covariates constant

#### Sensitivity Analysis

There were 48 individuals that participated in both Phase 1 and Phase 2 of the study. We decided to include these 48 individuals to maximize sample size because baseline data for the two phases of the study were collected 6 years apart (2007 and 2013), and participants were likely to have been different development stages, have different exposures, and different outcomes at the two time points. Furthermore, the random effect model controlled for clustering due to farm at year of study participation, which would minimize any potential effects of these repeat participants. A sensitivity analysis with Phase 2 data from the 48 repeat participants removed from the data set. Results are presented in Table 2 below..

**Table 3. Unadjusted (Univariate) and Adjusted (Multivariate) Logistic Regression Relative Risk Estimates of Agricultural Injury for Select Farm Work Exposures from Sensitivity Analysis**

	<i>Unadjusted</i>		<i>Adjusted*</i>	
	RR (95%CI)	P value	RR (95%CI)	P-value
<b>Hours of Farm Work</b>				
0-9 hours/week	ref		ref	
10-29 hours/week	5.5 (1.5-19.5)	0.009	7.1 (1.5-32.9)	0.005
30+ hours/week	11.2 (3.6-37.6)	<0.0001	9.5 (2.0-44.0)	0.01
<b>Operation of Tractors</b>				
0 hours/year	ref		ref	
1-69 hours/year	2.5 (0.8-7.8)	0.12	2.5 (0.6-9.0)	0.17
70+ hours/year	6.5 (2.3-18.9)	0.0006	4.2 (1.0-16.8)	0.05
<b>Tractor Maintenance</b>				
0 hours/year	ref		ref	
1-10 hours/year	3.7 (1.6-8.7)	0.003	4.2 (1.4-13.2)	0.01
11+ hours/year	6.2 (2.8-13.6)	<0.0001	7.2 (2.1-25.1)	0.002
<b>ATV Use</b>				
0 days/year	ref		ref	
1-29 days/year	0.9 (0.4-2.1)	0.23	1.2 (0.5-3.0)	0.30
30+ days/year	1.5 (0.8-3.2)	0.89	1.6 (0.7-3.6)	0.87
<b>Working with Large Animals</b>				
0 days/year	ref		ref	
1-49 days/year	1.2 (0.4-3.7)	0.80	1.0 (0.3-3.5)	0.96
50+ days/year	6.7 (3.0-15.0)	<0.0001	4.9 (2.0-12.0)	0.0007
<b>Herd Maintenance</b>				
0 days/year	ref		ref	
1-14 days/year	1.7 (0.7-4.3)	0.21	1.1 (0.5-3.4)	0.83
15+ days/year	5.3 (2.5-11.4)	<0.0001	3.1 (1.4-7.3)	0.008
<b>Veterinary Activities</b>				
0 days/year	ref		ref	
1-9 days/year	0.8 (0.2-3.1)	0.77	0.7 (0.1-3.4)	0.64
10+ days/year	4.8 (2.4-9.7)	<0.0001	3.5 (1.6-7.6)	0.003

\* Adjusted models controlled for age, gender, typical sleep, farm size, and comorbidity status

## Appendix G

### Post-Hoc Power Calculations

	Exposure Frequency	<i>Adjusted*</i>		Power	Min detectable RR at 80% power
		RR (95%CI)	P-value		
Hours of Farm Work					
0-9 hours/week	0.35	ref			
10-29 hours/week	0.31	8.0 (1.7-36.7)	0.008	>99%	1.6
30+ hours/week	0.34	10.3 (2.2-47.5)	0.003	>99%	1.6
Operation of Tractors					
0 hours/year	0.27	ref			
1-69 hours/year	0.36	2.7 (0.7-10.38)	0.13	>99%	1.6
70+ hours/year	0.37	4.3 (1.0-17.9)	0.04	>99%	1.6
Tractor Maintenance					
0 hours/year	0.51	ref			
1-10 hours/year	0.25	3.7 (1.2-11.2)	0.02	>99%	1.6
11+ hours/year	0.24	6.7 (2.0-22.4)	0.002	>99%	1.6
ATV Use					
0 days/year	0.34	ref			
1-29 days/year	0.33	1.1 (0.4-2.7)	0.30	9%	1.6
30+ days/year	0.33	1.5 (0.7-3.4)	0.87	72%	1.6
Working with Large Animals					
0 days/year	0.45	ref			
1-49 days/year	0.25	1.0 (0.3-3.5)	0.99	5%	1.6
50+ days/year	0.30	5.2 (2.1-12.6)	0.0004	>99%	1.6
Herd Maintenance					
0 days/year	0.48	ref			
1-14 days/year	0.26	1.2 (0.5-3.4)	0.66	21%	1.6
15+ days/year	0.26	3.2 (1.4-7.3)	0.005	>99%	1.6
Veterinary Activities					
0 days/year	0.53	ref			
1-9 days/year	0.16	0.7 (0.1-3.2)	0.60	64%	0.6
10+ days/year	0.31	3.7 (1.7-8.2)	0.002	>99%	1.5

\*Adjusted for age, gender, farm size, typical sleep, and comorbidity status

## **Appendix H**

### **Research Ethics Board Approvals**

Since the research was completed at both Queen's University and the University of Saskatchewan, ethics approval was sought from both institutions. The University of Saskatchewan required two applications, one for each study. Ethics approval certificates are attached in the following pages.



**QUEEN'S UNIVERSITY HEALTH SCIENCES & AFFILIATED TEACHING  
HOSPITALS RESEARCH ETHICS BOARD-DELEGATED REVIEW**

July 19, 2013

Ms. Yvonne DeWit  
Department of Public Health Sciences  
Queen's University

Dear Ms. DeWit

**Study Title: EPID-436-13 High-Risk Environments and Agricultural Injury in Children and Youth  
File # 6010522**

**Co-Investigators: Dr. J. Lawson and Dr. W. Pickett**

I am writing to acknowledge receipt of your recent ethics submission. We have examined the protocol and data collection form for your project (as stated above) and consider it to be ethically acceptable. This approval is valid for one year from the date of the Chair's signature below. This approval will be reported to the Research Ethics Board. Please attend carefully to the following listing of ethics requirements you must fulfill over the course of your study:

**Reporting of Amendments:** If there are any changes to your study (e.g. consent, protocol, study procedures, etc.), you must submit an amendment to the Research Ethics Board for approval. Please use event form: HSREB Multi-Use Amendment/Full Board Renewal Form associated with your post review file # **6010522** in your Researcher Portal ([https://eservices.queensu.ca/romeo\\_researcher/](https://eservices.queensu.ca/romeo_researcher/))

**Reporting of Serious Adverse Events:** Any unexpected serious adverse event occurring locally must be reported within 2 working days or earlier if required by the study sponsor. All other serious adverse events must be reported within 15 days after becoming aware of the information. Serious Adverse Event forms are located with your post-review file **6010522** in your Researcher Portal ([https://eservices.queensu.ca/romeo\\_researcher/](https://eservices.queensu.ca/romeo_researcher/))

**Reporting of Complaints:** Any complaints made by participants or persons acting on behalf of participants must be reported to the Research Ethics Board within 7 days of becoming aware of the complaint. Note: All documents supplied to participants must have the contact information for the Research Ethics Board.

**Annual Renewal:** Prior to the expiration of your approval (which is one year from the date of the Chair's signature below), you will be reminded to submit your renewal form along with any new changes or amendments you wish to make to your study. If there have been no major changes to your protocol, your approval may be renewed for another year.

Yours sincerely,

*Albert L. Clark*

Chair, Health Sciences Research Ethics Board  
July 19, 2013

**Investigators please note that if your trial is registered by the sponsor, you must take responsibility to ensure that the registration information is accurate and complete**



UNIVERSITY OF  
SASKATCHEWAN

Behavioural Research Ethics Board (Beh-

**Certificate of Approval**

PRINCIPAL INVESTIGATOR  
Josh Lawson

DEPARTMENT  
Canadian Centre for Health and Safety in Agriculture 13-277

BEH#

INSTITUTION(S) WHERE RESEARCH WILL BE CONDUCTED  
University of Saskatchewan  
Queen's University  
Kingston ON K7L 3N6

SUB-INVESTIGATOR(S)  
Louise Hagel, William Pickett, James A. Dosman

STUDENT RESEARCHER(S)  
Yvonne DeWitt

FUNDER(S)  
CANADIAN INSTITUTES OF HEALTH RESEARCH (CIHR)

TITLE  
Saskatchewan Farm Injury Cohort Study - Phase 2, part 1 - Farm Family Cohort (BEH #11-270): High-Risk Environments and Agricultural Injury in Children and Youth

ORIGINAL REVIEW DATE	APPROVAL ON	APPROVAL OF:	EXPIRY DATE
	14-Aug-2013	Application for Behavioral Research Ethics Review Secondary analysis of de-identified data from study BEH 11-270	13-Aug-2014

Full Board Meeting ☐

Delegated Review ☒

**CERTIFICATION**

The University of Saskatchewan Behavioural Research Ethics Board has reviewed the above-named research project. The proposal was found to be acceptable on ethical grounds. The principal investigator has the responsibility for any other administrative or regulatory approvals that may pertain to this research project, and for ensuring that the authorized research is carried out according to the conditions outlined in the original protocol submitted for ethics review. This Certificate of Approval is valid for the above time period provided there is no change in experimental protocol or consent process or documents.

Any significant changes to your proposed method, or your consent and recruitment procedures should be reported to the Chair for Research Ethics Board consideration in advance of its implementation.

**ONGOING REVIEW REQUIREMENTS**

In order to receive annual renewal, a status report must be submitted to the REB Chair for Board consideration within one month of the current expiry date each year the study remains open, and upon study completion. Please refer to the following website for further instructions: [http://www.usask.ca/research/ethics\\_review/](http://www.usask.ca/research/ethics_review/)

Beth Bilson, Chair  
University of Saskatchewan  
Behavioural Research Ethics Board

Please send all correspondence to:

Research Ethics Office  
University of Saskatchewan  
Box 5000 RPO University, 1602-110 Gymnasium Place  
Saskatoon SK S7N 4J8  
Telephone: (306) 966-2975 Fax: (306) 966-2069





Biomedical Research Ethics Board (Bio-REB)

## Certificate of Approval

PRINCIPAL INVESTIGATOR  
Josh Lawson

DEPARTMENT  
Canadian Centre for Health and Safety in Agriculture

Bio #  
13-219

INSTITUTION(S) WHERE RESEARCH WILL BE CARRIED OUT  
University of Saskatchewan  
Saskatoon SK

Queen's University  
Kingston ON K7L 3N6

SUB-INVESTIGATOR(S)  
Niels Koehncke, Louise Hagel, William Pickett

STUDENT RESEARCHER(S)  
Yvonne DeWitt

FUNDER(S)  
EMPIRE LIFE RESEARCH FELLOWSHIP IN CHILD  
HEALTH

TITLE  
High-Risk Environments and Agricultural Injury in Children and Youth using Saskatchewan Farm Injury Surveillance Project data  
(Bio #04-204)

ORIGINAL REVIEW DATE  
18-Aug-2013

APPROVED ON  
09-Sep-2013

APPROVAL OF  
Research Project as Outlined in the  
Application to Access Existing Health Data  
for Research

EXPIRY DATE  
08-Sep-2014

Acknowledge Receipt of:  
Queen's University Health Sciences REB  
Approval  
TCPS2 Core Certificate of Completion  
(Yvonne DeWitt)

Delegated Review



Full Board Meeting



### CERTIFICATION

The study is acceptable on scientific and ethical grounds. The Bio-REB considered the requirements of section 29 under the Health Information Protection Act (HIPA) and is satisfied that this study meets the privacy considerations outlined therein. The principal investigator has the responsibility for any other administrative or regulatory approvals that may pertain to this research study, and for ensuring that the authorized research is carried out according to governing law. This approval is valid for the specified period provided there is no change to the approved protocol or consent process.

### FIRST TIME REVIEW AND CONTINUING APPROVAL

The University of Saskatchewan Biomedical Research Ethics Board reviews above minimal studies at a full-board (face-to-face) meeting. If a protocol has been reviewed at a full board meeting, a subsequent study of the same protocol may be reviewed through the delegated review process. Any research classified as minimal risk is reviewed through the delegated (subcommittee) review process. The initial Certificate of Approval includes the approval period the REB has assigned to a study. The Status Report form must be submitted within one month prior to the assigned expiry date. The researcher shall indicate to the REB any specific requirements of the sponsoring organizations (e.g. requirement for full-board review and approval) for the continuing review process deemed necessary for that project. For more information visit [http://www.usask.ca/research/ethics\\_review/](http://www.usask.ca/research/ethics_review/).

### REB ATTESTATION

In respect to clinical trials, the University of Saskatchewan Research Ethics Board complies with the membership requirements for Research Ethics Boards defined in Part 4 of the Natural Health Products Regulations and Division 5 of the Food and Drug Regulations and carries out its functions in a manner consistent with Good Clinical Practices. Members of the Bio-REB who are named as investigators, do not participate in the discussion related to, nor vote on such studies when presented to the Bio-REB. This approval

Please send all correspondence to:

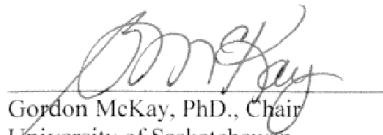
Research Ethics Office  
University of Saskatchewan  
Box 5000 RPO University  
1607 - 110 Gymnasium Place  
Saskatoon, SK Canada S7N 4J8

PRINCIPAL INVESTIGATOR  
Josh Lawson

- 2 -  
DEPARTMENT  
Canadian Centre for Health and Safety in Agriculture

Bio #  
13-219

and the views of this REB have been documented in writing. The University of Saskatchewan Biomedical Research Ethics Board has been approved by the Minister of Health, Province of Saskatchewan, to serve as a Research Ethics Board (REB) for research projects involving human subjects under section 29 of The Health Information Protection Act (HIPA).

  
Gordon McKay, PhD., Chair  
University of Saskatchewan  
Biomedical Research Ethics Board