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Fatal farm injuries to Canadian children

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ABSTRACT

Children on Canadian farms are at high risk for fatal injury. Ongoing surveillance of these deaths is required to affirm recurrent patterns of injury, and to determine whether historical approaches to prevention have resulted in declines in the occurrence of these traumatic events. We analyzed epidemiological patterns and trends in the occurrence of fatal pediatric farm injuries over 23 years. Records of deaths were obtained from the Canadian Agricultural Injury Reporting system. To contrast more recent data with injury patterns described historically, cases were compared between two time periods. An intentional consensus process was used to finalize key patterns and their clinical or social importance. 374 fatal farm injuries to children in Canada were identified over the 23 years of study; 253 in period 1 and 121 in period 2. While machinery and non-machinery causes of death varied between the two study periods, mean annual rates of fatal injury (approximately 4 per 100,000 children) remained similar. Notably emergent types of injury in recent years included those caused by all-terrain vehicles, skid steer loaders, and drownings. Observed declines in the numbers of fatal farm injuries are most likely attributable to analogous declines in the number of registered farms in Canada. Our findings call into question the effectiveness of pediatric farm safety initiatives that primarily focus on education. Second, while CAIR fatality data are maintained, surveillance of hospitalized injuries has been disbanded and the fatality records require updating. Only by doing so will such surveillance findings provide comprehensive information to inform prevention.

1. Introduction

Farming has long been recognized as a hazardous occupation, both in Canada (Pickett et al., 1999; Pickett et al., 2001) and in other countries (Rivara, 1997; Mitchell et al., 2001; Cameron et al., 1992). The importance of farm occupational hazards is uniquely relevant for children who grow up and work on farms. Farm children are exposed to a diversity of factors that leave them at risk for major injury (Pickett et al., 2005; Marlenga et al., 2007).

While childhood farm injuries are established as a public health priority (Pickett et al., 2005; Marlenga et al., 2007; Hard and Myers, 2006), fatalities still are uncommon, and only by monitoring the occurrence of these events in populations of sufficient size over sufficiently long periods of time will recurrent patterns become established. Data from ongoing farm injury surveillance efforts are essential for the development of evidence-based prevention priorities.

In 1996, with the support of the Canadian Agriculture Safety

Program, the Canadian Agricultural Injury Surveillance Program (later rebranded as *Canadian Agricultural Injury Reporting* or “CAIR” (Canadian Agricultural Injury Reporting, 2016)) was established. By working with partner agencies from across Canada, CAIR has sought to compile and describe cases of farm injury according to an established national protocol. This includes information on all cases of farm injury involving children. In the past, this has led to: 1) establishment of priorities for the prevention of work-related (Marlenga et al., 2007) and recreational (Pickett et al., 2005) injuries experienced by children on farms; 2) identification of high risk pediatric groups for targeted intervention including preschoolers (Brison et al., 2006), young workers (Marlenga et al., 2007; Zentner et al., 2005), and young children being supervised by adults in the agricultural worksite (Morrongiello et al., 2008), and; 3) evaluative studies that attempt to gauge the effectiveness of preventive interventions, coincident with changing work practices and associated safety protocols (Dosman et al., 2015).

Our Canadian agricultural industry has changed dramatically over

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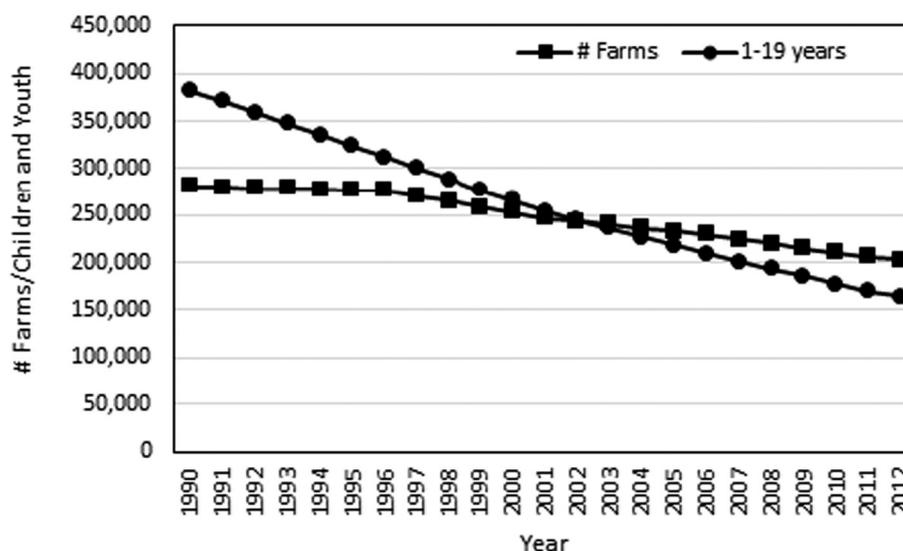


Fig. 1. Estimated number of farms and resident children aged 1–19 years on farms, Canada, 1990–2012. Source: Statistics Canada, Canada Census of Agriculture (Statistics Canada, 2016a).

the last three decades. While the family farm remains its cornerstone (MacArthur, 2015), since the 1990's Canadian farming has become more corporate in nature, and as a country we have seen a dramatic decline in the number of registered farms with a smaller workforce (Fig. 1) that on average manages larger enterprises and acreages (Statistics Canada, 2016a). Over time, farms have also become more mechanized, with newer and more efficient technologies being introduced to support production activities (Statistics Canada, 2016b). In addition, provincial governments have introduced new legislation aimed at improving farm safety using varying combinations of regulation and mandatory insurance programs to promote safe farm work environments (MacArthur, 2015). Broader societal concern for farm safety emerged with the recent landmark conviction of an Ontario farmer who was found negligent in the death of his four-year-old son (Bauman, 2019).

Hence, there have been many changes in the business of farming that have emerged in recent years. But what is not known is whether such changes, be they changes introduced to improve production, or those introduced to improve the safety of the work environment, have led to improvements in the safety of children on Canadian farms. In the current analyses, we examine the 23 most recent years of national CAIR fatality data to determine if farms had indeed become safer for children who lived and worked on them over a long period in Canada. This analysis was also performed to demonstrate the ongoing need for injury surveillance programs to be maintained and updated in our country.

2. Methods

2.1. Case identification

Records for all cases of farm injury to children were abstracted from the central CAIR registry (Canadian Agricultural Injury Reporting, 2016). Eligibility criteria were: (1) the death occurred in Canada during the calendar years 1990 to 2012; (2) the child was aged 0 to 19 years; (3) the circumstances leading to death met the CAIR definition of a farm fatality, i.e., “any unintentional injury resulting in fatality that involves any hazard of a farm or ranch environment in Canada (excluding fatal injuries that take place in the farm residence and are not work-related). This includes fatalities that occur away from agricultural work locations if agriculture-related work is being done.” (Canadian Agricultural Injury Reporting, 2016) Data collection involves a comprehensive abstraction of cases at provincial coroners' offices for all ten provinces of Canada using a

standardized reporting form. Records of cases are cross-referenced with police reports, occupational agency reports, vital statistics and media reports to ensure no deaths have been overlooked. Provincial partners provide case reports to a central repository where data are validated, cleaned and compiled to provide surveillance reports to provinces and the Canadian Agricultural Safety Association (Canadian Agricultural Injury Reporting, 2016).

2.2. Study population

For the calculation of fatality rates, estimates of the population of children aged 0–19 years living on Canadian farms were obtained from the 1996, 2001, 2006 and 2011 Canada Census of Agriculture (Statistics Canada, 2016a), with extrapolation for the years in which the census was not performed. Fig. 1 provides national estimates of these child populations as well as the number of farms in Canada, by study year.

2.3. Description of farm fatalities

Available descriptors for each fatality included: (1) demographic factors, including age and sex of the victim, and whether the victim resided on the farm or ranch involved in the fatality; (2) work involvement, including: a) whether the injury incident involved someone performing farm work, and b) if the victim themselves was working at the time of their injury; (3) mechanisms of injury, whether they were machinery-related or not machinery-related, and (if applicable) specific types of agricultural machinery involved.

2.4. Analysis

Analyses were conducted using SAS software version 9.4 (SAS Institute, Cary, NC). We calculated biannual rates and patterns of fatality to examine possible trends over time. When this provided no evidence of complex trends over time (e.g., Fig. 2), *a priori* the cases were divided into two time periods of primary interest. Cases from 1990 to 2001 (the historical period 1) have been previously analyzed and reported (Pickett et al., 2005; Marlenga et al., 2007), while more recent cases (2002 to 2012, period 2) have not. This grouping allowed us to roughly examine mechanist and demographic changes between time periods. Our use of two vs. higher numbers of time periods also enhanced statistical power for group comparisons, especially for less common patterns of injury. All analyses focused on patterns of injury



Fig. 2. Biannual rates (95% CI) of fatal farm injury to children aged 1-19y in Canada, 1990-2012.

Table 1
Demographic description of fatal farm injuries to children, 1990 to 2012, Canada.

	Period 1 (1990 to 2001)		Period 2 (2002 to 2012)		Period Difference (95% CI) ^a
Total fatalities – no.	253		121		
Mean per year	21.1		11.0		
Age – mean (IQR)	9.0 (3 to 15)		9.1 (4 to 15)		+0.1 (-1.2 to 1.4)
By age group – no. (%)					
0 to 6	118 (47)	51 (42)			-4.5 (-15.3 to 6.5)
7 to 18	135 (53)	70 (58)			
By sex – no. (%)					
Female	42 (17)	22 (18)			+1.6 (-6.5 to 10.6)
Male	211 (83)	99 (82)			
Resident on farm – no. (%)					
Yes	160 (63)	85 (70)			+7.0 (-3.6 to 16.9)
No	93 (37)	36 (30)			
Machine involved – no. (%)					
Yes	166 (66)	76 (63)			-2.8 (-13.5 to 7.6)
No	87 (34)	45 (37)			
Worked involved – no. (%)					
Yes	188 (74)	85 (70)			-4.1 (-14.3 to 5.6)
No	65 (26)	36 (30)			
Victim working – no. (%)					
Yes	80 (32)	41 (34)			+2.3 (-7.8 to 12.9)
No	173 (68)	80 (66)			

^a Difference period 2 minus period 1.

observed across these two periods and included estimates of absolute differences between periods with associated 95% confidence limits (Chan-Zhang exact limits (Chan and Zhang, 1999) for binary variables, and approximate limits based on the variability among years for continuous variables). We initially described patterns of injury by available demographic and work-related factors. We then estimated mean annual rates of fatal injuries per 100,000 population, both overall and by strata (5-year age groups and sex). We examined all machinery related fatalities experienced by working and non-working children, and then compared the two time periods based upon the proportions of fatalities

attributed to specific types of machinery. We followed this with a similar comparison of mechanisms that did not involve machinery. The final analysis examined machinery-related and non-machinery-related fatalities involving children aged 0-6 years, a group identified a priori as being particularly vulnerable to major injury events (Brisson et al., 2006).

Once the study findings were summarized into tables, all investigators systematically completed a short form developed by one investigator (JMR) to identify differences in patterns by person, place and time of injury occurrence between the study periods. She then

asked each of the authors to independently determine whether the patterns of injury were increasing, decreasing, or staying the same, and if a difference was observed whether it was a “socially important difference” (operationally defined as one where an investigator felt that it merited attention as a public health priority, irrespective of its statistical significance). We then convened the authorship team to view our mutual ratings and arrive at a consensus about each noted pattern. These interpretations were used to highlight important patterns of injury within and across time.

This study was approved by a Human Research Ethics Board at the University of Alberta (Pro00050195).

3. Results

A total of 374 fatal farm injuries to children in Canada were identified over the 23 years of study; 253 in period 1 and 121 in period 2. Characteristics of these deaths by age, sex, and farm residency status of the victim, and involvement of machinery and work in the event were similar between the two study periods (Table 1).

The mean annual rates of fatal injury per 100,000 children were similar between the two study periods, although rates for those aged 1–4 declined slightly in period 2 vs. 1 ($p < .05$) while rates for those aged 5–9 years increased slightly in period 2 ($p < .05$); (Table 2).

A diversity of equipment was involved in fatalities that involved agricultural machinery (Table 3). Tractor injuries (mainly caused by runovers of passengers ($n = 35$), rollovers ($n = 34$), and runovers of bystanders ($n = 23$)) were the leading causes of death in both time periods, among both working and non-working children. Increases in the proportion of deaths attributable to all-terrain vehicles and skid steer loaders were observed in period 2, along with decreases in deaths caused by motor vehicles. The remaining patterns of injury remained stable over the two time periods.

With respect to non-machinery causes of death (Table 4), drownings of children who were not working at the time of their injury predominated. These were associated with a diversity of water hazards, including dugouts ($n = 17$), sewage/manure pits ($n = 8$), and ponds (or lakes, swamps, sloughs, $n = 8$). The only cause of death for which there was some suggestion of a change between period 1 and 2 was asphyxiation, with a slight increase evident in period 2.

Leading causes of death to preschool-aged children were relatively stable over the two time periods (Table 5), with tractor injuries (passenger runovers $n = 27$, bystander runovers $n = 20$) and drownings ($n = 32$) predominating in both time periods, and slight increases in the proportion of deaths attributable to skid steer loaders and all-terrain vehicles evident for period 2.

4. Discussion

Findings from this national analysis, conducted with data spanning 23 years, are simple and telling. While many well-intended prevention

Table 2

Annual rates of fatal farm injuries to resident children per 100,000, 1990 to 2011^a, Canada.

Year	Period 1 (1990 to 2001)	Period 2 (2002 to 2011)	Period Difference (95% CI) ^b
	Mean rate (95% CI)	Mean rate (95% CI)	
All age groups	4.2 (3 to 5)	3.9 (3 to 5)	−0.3 (−1.4 to 0.8)
Ages 1–4	10.7 (8 to 13)	6.3 (3 to 10)	−4.4 (−8.0 to −0.8)
Ages 5–9	3.3 (2 to 5)	6.9 (4 to 10)	+3.6 (0.9 to 6.3)
Ages 10–14	2.4 (2 to 3)	2.1 (1 to 3)	−0.3 (−1.6 to 1.1)
Ages 15–19	2.6 (1 to 4)	2.2 (1 to 3)	−0.5 (−2.0 to 1.1)

^a Denominator not available for 2012.

^b Difference period 2 minus period 1.

efforts aimed at child safety on the family farm have been implemented in Canada over this time period, these initiatives appear to have ultimately been ineffective at achieving their end goal of reducing fatalities to farm children. While the total number of deaths has dropped substantially over time, this can be attributed to declining family farm population in Canada (Fig. 1) (Statistics Canada, 2016a). The fatality rate has remained stable at about 4 per 100,000 farm children per year, with some modest variations in contributing causes reported over time. To put this in perspective, this exceeds published rates of death from cancer or suicide (~2.5 and 0.9 per 100,000, respectively) for children in Canada (Ellison and Janz, 2015; Public Health Agency of Canada, 2019; Centre for Suicide Prevention, n.d.). The most current (2015) reported rates of unintentional injury death in Canada ranges from 3.0 per 100,000 for those aged 1–9 years, 2.8 for 10–14 year olds and 11.4 for 15–19 year olds (Health Canada, n.d.). These rates are about 60–80% lower than Canadian national unintentional injury mortality rates reported for 1990 (Pan et al., 2005). Farm children have not experienced the same reduction in injury mortality as other Canadian children have over the last decades.

The small number of deaths by mechanism precludes meaningful comparisons of injury mechanisms leading to death with the general child population in Canada. However, it is established that rural children experience greater risks for drownings, falls, burns and poisonings (Kim et al., 2012), and exposures to all-terrain vehicles (ATVs) are high in rural areas, contributing to excess burden (Fawcett et al., 2016). ATVs were introduced in Canada in the 1980's, and their use and application have grown dramatically as they became accessible to rural populations (Trauma Committee of the Canadian Association of Pediatric Surgeons, 2008). Coincident with this trend, considerable efforts have been expended to identify ATV-related hazards and therefore alert farmers to the dangers to themselves and their families (Vanlaar et al., 2015). However, this has ultimately not resulted in reductions in the behaviours that lead to major injury. Farm children also experience different exposures to work and related hazards than do non-farm children. Starting at a young age, decisions by adults to permit their children to be exposed to farm work and associated environmental hazards are intentional, often after weighing and balancing the perceived benefits versus risks of such practices (Elliot et al., 2018). Benefits include production and workforce needs, opportunities to develop occupational skills, and the ethics of work and pride in accomplishment. Collectively, these typically outweigh risks including exposure to chemicals and physical hazards associated with working with livestock and machinery. Teaching children how to manage risks while achieving common farm/family goals is a familiar theme reported by farm parents (Elliot et al., 2018). In addition, these exposures provide a means to instil traditional farm culture and values into the child, and are viewed as part of the child's development of an affinity for farm life. Parents may also subscribe to an overarching belief in the exceptionalism of the farm culture that proposes it is not just a job or business but a “way of life” (van der Ploeg, 2013).

Risk-taking by parents and other adults may also play an important role in the etiology of major injury to children on farms. Farmers commonly perform tasks that are deemed to be too dangerous for others on the farm, and such behaviours can be “maladaptive” when they are used by farmers to mitigate hazards rather than to modify the hazard through engineered solutions or training (Svennefelt et al., 2019). Risk-taking can be rewarding to farmers and farm workers, in terms of work accomplished and associated productivity (Sorensen et al., 2017). Farm children and youth are also known to exhibit high levels of risk-taking relative to urban counterparts, whether this is exhibited as work behaviours learned through parental farm work models (Fryling et al., 2011), or engagement in externalizing behaviours known to be direct causes of injury (Pickett et al., 2017).

In their past forms, government regulations appear to have had minimal impacts on child/youth safety on the family farm. Standard child labour laws and regulations are not typically applied to Canadian

Table 3
Types of agricultural machines involved in fatal farm injuries to working and non-working children (all ages), 1990 to 2012, Canada.

	Total	Working children (n = 88)				Period difference ^a	Non-working children (n = 154)				Period difference ^a	
		Period 1 (1990 to 2001)		Period 2 (2002 to 2012)			Period 1 (1990 to 2001)		Period 2 (2002 to 2012)			
		No.	(%)	No.	(%)		No.	(%)	No.	(%)		
Total machinery fatalities	242	60		28				106		48		
Tractor	106	30	(50)	13	(46)	-3.6 (-25.9 to 19.2)	47	(44)	16	(33)	-11.0 (-26.9 to 6.4)	
Motor vehicle	34	9	(15)	2	(7)	-7.9 (-21.2 to 9.8)	19	(18)	4	(8)	-9.6 (-20.1 to 3.9)	
ATV or off-road vehicle	31	1	(2)	4	(14)	+12.6 (0.9 to 31.0)	15	(14)	11	(23)	+8.8 (-4.2 to 24.3)	
Farm wagon or trailer	20	2	(3)	5	(18)	+14.5 (0.5 to 33.5)	10	(9)	3	(6)	-3.2 (-11.9 to 8.7)	
Combine or harvester	10	8	(13)	0	(0)	-13.3 (-24.6 to 1.9)	1	(1)	1	(2)	+1.1 (-3.8 to 10.5)	
Skid steer loader	10	1	(2)	1	(4)	+1.9 (-6.7 to 17.0)	3	(3)	5	(10)	+7.6 (-0.5 to 20.0)	
Auger	5	3	(5)	0	(0)	-5.0 (-14.2 to 7.8)	0	(0)	2	(4)	+4.2 (-0.3 to 14.4)	
Power-take-off	3	2	(3)	0	(0)	-3.3 (-11.8 to 9.6)	0	(0)	1	(2)	+2.1 (-1.8 to 11.2)	
Hay elevator	3	1	(2)	0	(0)	-1.7 (-9.4 to 11.4)	2	(2)	0	(0)	-1.9 (-6.8 to 6.2)	
Mower	3	1	(2)	0	(0)	-1.7 (-9.4 to 11.4)	2	(2)	0	(0)	-1.9 (-6.8 to 6.2)	
Fencing equipment	2	0	(0)	1	(4)	+3.6 (-3.1 to 18.6)	1	(1)	0	(0)	-0.9 (-5.4 to 7.0)	
Manure spreader	2	0	(0)	1	(4)	+3.6 (-3.1 to 18.6)	1	(1)	0	(0)	-0.9 (-5.4 to 7.0)	
Power tool	2	0	(0)	1	(4)	+3.6 (-3.1 to 18.6)	0	(0)	1	(2)	2.1 (-1.8 to 11.2)	
Baler	1	0	(0)	0	(0)	-	1	(1)	0	(0)	-0.9 (-5.4 to 7.0)	
Plough/disk	1	0	(0)	0	(0)	-	1	(1)	0	(0)	-0.9 (-5.4 to 7.0)	
Snow blower	1	0	(0)	0	(0)	-	0	(0)	1	(2)	+2.1 (-1.8 to 11.2)	
Swather	1	0	(0)	0	(0)	-	0	(0)	1	(2)	+2.1 (-1.8 to 11.2)	
Other	7	2	(3)	0	(0)	-3.3 (-11.8 to 9.6)	3	(3)	2	(4)	+1.3 (-5.0 to 11.9)	

^a Difference period 2 minus period 1.

family farms. Historically, farm operations were excluded from compulsory adherence to occupational health and safety regulations as they are sole proprietor enterprises, or, with respect to resident children, most were below the employee minimums for regulations to be applicable (MacArthur, 2015). Such employee minimums have been set to protect small farms from the perceived burdensome bureaucracy and expense associated with legislated safety standards.

The most efficient method to reduce the burden of child farm death in Canada is to eliminate exposures to the main hazards, through education, engineered solutions, or regulation. Based on the rates of injury observed here, efforts to reduce the burden of child/youth farm fatality over the last two decades have not been particularly effective, and only through farm population attrition has the death toll been abated. The best available evidence suggests that educational approaches to farm injury prevention are ineffective (Rautiainen et al., 2008), and that many existing interventions are aimed

(inappropriately) solely at children and not the responsible adult authorities who control the farm work environment (Hartling et al., 2004). Recent exceptions to this include educational materials such as the North American Guidelines for Children's Agricultural Tasks that address adult responsibilities in protecting their children against farm hazards (Gallagher, 2012), although the long-term effectiveness of these guidelines remains unestablished. In terms of more regulatory approaches, farms have largely been excluded from safety legislation that protects children in other industrial sectors. Those wishing to intervene to improve child/youth safety on farms will have to develop novel strategies to impress on farmers the need to adjust the cultural imperatives that keep children at risk.

Limitations of this research warrant comment, and point to additional research needs moving forward. First, no national level trauma data for survivors of farm injury were available for analysis. Significant improvements in trauma care realized over the 23 year period may

Table 4
Non-machinery causes of fatal farm injuries to working and non-working children (all ages), 1990 to 2012, Canada.

	Total	Working children (n = 33)				Period difference ^a	Non-working children (n = 109)				Period difference ^a	
		Period 1 (1990 to 2001)		Period 2 (2002 to 2012)			Period 1 (1990 to 2001)		Period 2 (2002 to 2012)			
		No.	(%)	No.	(%)		No.	(%)	No.	(%)		
Total	132	20		13				67		32		
Drowning	46	1	(5)	2	(15)	+10.4 (-12.4 to 40.1)	29	(43)	14	(44)	+0.5 (-20.2 to 21.7)	
Animal trauma	19											
Struck or crushed by animal	11	1	(5)	1	(8)	+2.7 (-18.8 to 31.0)	7	(10)	2	(6)	-4.2 (-15.7 to 11.6)	
Fall from animal	4	1	(5)	0	(0)	-5.0 (-24.9 to 21.6)	2	(3)	1	(3)	+0.1 (-8.2 to 13.7)	
Other animal trauma	4	1	(5)	0	(0)	-5.0 (-24.9 to 21.6)	2	(3)	1	(3)	+0.1 (-8.2 to 13.7)	
Struck by or against object	15	4	(20)	0	(0)	-20.0 (-43.9 to 6.0)	7	(10)	4	(13)	+2.1 (-10.9 to 19.3)	
Entrapment by object	14	0	(0)	1	(8)	+7.7 (-9.9 to 36.0)	9	(13)	4	(13)	-0.9 (-14.4 to 16.6)	
Radiation, caustic, or toxic object	10	6	(30)	4	(31)	+0.8 (-31.0 to 34.8)	0	(0)	0	(0)	-	
Asphyxiation in grain or soil	9	1	(5)	4	(31)	+25.8 (-1.0 to 55.9)	2	(3)	2	(6)	+3.3 (-6.0 to 18.2)	
Fire or explosion	6	1	(5)	0	(0)	-5.0 (-24.9 to 21.6)	5	(7)	0	(0)	-7.5 (-16.6 to 4.3)	
Fall from height	5	1	(5)	1	(8)	+2.7 (-18.8 to 31.0)	2	(3)	1	(3)	+0.1 (-8.2 to 13.7)	
Firearm discharge	3	1	(5)	0	(0)	-5.0 (-24.9 to 21.6)	1	(2)	1	(3)	+1.6 (-6.2 to 14.9)	
Contract with electric current	2	2	(10)	0	(0)	-10.0 (-32.0 to 15.7)	0	(0)	0	(0)	-	
Other	3	0	(0)	0	(0)	-	1	(2)	2	(6)	+4.8 (-3.5 to 19.5)	

^a Difference period 2 minus period 1.

Table 5
Leading causes of fatal farm injury to children age 6 and under, 1990 to 2012, Canada.

	Total	Period 1 (1990 to 2001)		Period 2 (2002 to 2012)		Period difference (95% CI) ^a
		No.	(%)	No.	(%)	
Machinery-related	105	73		32		
Tractors	53	40	(55)	14	(44)	-11.0 (-31.3 to 10.3)
Motor vehicle	13	12	(16)	1	(3)	-13.3 (-24.7 to 1.5)
Farm wagon or trailer	11	8	(11)	5	(16)	+4.7 (-8.9 to 22.5)
Skid steer loader	7	3	(4)	4	(13)	+8.4 (-2.6 to 25.0)
ATV or off-road vehicle	3	0	(0)	3	(9)	+9.4 (1.5 to 25.0)
Auger	2	0	(0)	2	(6)	+6.3 (-0.4 to 20.8)
Mower	2	2	(3)	0	(0)	-2.7 (-9.8 to 9.0)
Other	11	10	(11)	3	(9)	-1.6 (-13.5 to 15.3)
Non-machinery-related	64	45		19		
Drowning	32	22	(49)	10	(53)	+3.7 (-23.3 to 30.1)
Entrapment by object	11	8	(18)	3	(16)	-2.0 (-20.7 to 23.3)
Struck by object	7	6	(13)	1	(5)	-8.1 (-23.0 to 13.6)
Animal trauma	7	6	(13)	1	(5)	-8.1 (-23.0 to 13.6)
Asphyxiation	2	1	(2)	2	(11)	+8.3 (-5.1 to 30.9)
Other	4	2	(4)	2	(11)	+6.1 (-7.8 to 28.7)

^a Difference period 2 minus period 1.

have increased survival among child farm injury cases, reducing fatalities at the expense of increased morbidity due to better survival of difficult cases (Moore et al., 2017). If so, the true burden of these injuries may be underestimated by national fatality statistics alone, an idea that requires investigation. Hospitalization data for the province of Alberta (20% of Canadian farmers) indicate that rates of traumatic but non-fatal injury for children on farms have remained static since 1995 (unpublished data), refuting this hypothesis. Second, limited case numbers did not provide statistical power sufficient for detecting subtle time trends, and our comparisons are limited to comparing recent cases with those previously reported. Finally, it is also possible that some under-estimation of fatality rates may occur due to flaws in our case identification protocol. Yet, while there is also no gold standard for the identification of these deaths, we are confident that our cross-validation with multiple data sources provides a very close approximation of the true burden, particularly for child fatalities which have been shown to be highly publicized in the media (Ozegovic and Voaklander, 2011; Randall et al., 2020).

In conclusion, even in times of fiscal restraint, the current analysis provides one concrete example of the value of maintaining national registries for the study and surveillance of agricultural injuries in our country. While CAIR fatality data are maintained in the registry analyzed here, surveillance of hospitalized injuries has been disbanded, and its mortality records require updating. Only by doing so will findings from such surveillance systems provide comprehensive information from which to base prevention initiatives. Our study findings also call into question the effectiveness of pediatric farm safety initiatives that primarily focus on education, as opposed to engineered or regulatory strategies with known effectiveness.

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CRediT authorship contribution statement

Donald C. Voaklander: Conceptualization, Methodology, Data curation, Writing - original draft, Writing - review & editing, Supervision, Project administration, Funding acquisition. **Josie M. Rudolph:** Conceptualization, Methodology, Writing - original draft, Writing - review & editing. **Richard Berg:** Conceptualization, Formal analysis, Visualization, Writing - original draft, Writing - review & editing. **Colleen Drul:** Formal analysis, Writing - review & editing, Visualization. **Kathy L. Belton:** Data curation, Writing - review & editing, Supervision, Project administration, Funding acquisition. **William Pickett:** Conceptualization, Methodology, Writing - original draft, Writing - review & editing, Funding acquisition.

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