Fatal and hospitalized agricultural machinery injuries to children in Ontario, Canada

William Pickett, Robert J Brison, John R Hoey

Abstract

Objectives—To assess rates and patterns of agricultural machinery injuries in farm children in order to both determine priorities and develop strategies for injury control in this population.

Methods—Coroners' files and hospital discharge data were examined for Ontario farm children aged 0-19 who had agricultural machinery injuries over a five year period ending 31 March 1990. Injury rates were described by age, sex, geographic region, type of machinery, and mechanism of injury. Common patterns of injury deserving of priority for prevention were then identified and described.

Results—283 machinery injuries to children were identified. Injury rates were 116 and 25/100 000/year for boys and girls respectively. Boys were at increasing risk relative to girls as their ages increased. Young children were at greatest risk for fatal injury. There is a prominent summer peak in occurrence. The farm tractor was the machine most commonly associated with these injuries (33.2%), and entanglement, usually of clothing, was the mechanism cited most often (36.3%). The case fatality ratio (ratio of hospitalizations:deaths) was generally low whether assessed by machinery type or by mechanism of injury. This provides an indication of the lethality of these injuries.

Common patterns associated with injury risk included: (1) inadequate supervision of small children; (2) permitting children to be in the area of moving or unguarded machinery; (3) allowing children to accompany workers using farm machinery; and (4) having children performing work related tasks inappropriate for their age.

Conclusions—Machinery related injuries are not uncommon in farm children and have a high case fatality rate. These rates changed little over the five year study period. Feasible strategies for prevention of these injuries, four of which are presented here, need to be developed and implemented by public health professionals working in cooperation with members of the agricultural industry.

(*Injury Prevention* 1995; 1: 97-102)

Keywords: agriculture, trauma, epidemiology.

Despite increasing publicity about the family farm as a dangerous place to live,¹⁻³ the farm environment continues to be a setting that is burdened with a substantial childhood injury control problem.¹⁻⁶ Canadian data on childhood farm injuries are limited. However, the international literature describing these types of injury suggests that they are common and especially severe.⁷⁻¹³ In the United States, over 300 deaths and 25 000 medically treated injuries occur to children less than 16 years of age on farms annually.¹³ Population based studies that fully describe the incidence of these injuries and their etiology are needed to develop sensible priorities for preventive intervention.^{14 15}

The farm environment serves several important functions for farm children (who, in this paper, are defined as persons living on farms who are less than 20 years of age). As well as being a place of work, it also acts as a place of homelife and play. Demographic peaks in the incidence of childhood farm injury reflect these two functions. High risk age groups include the ages 2-5 (a result of children being surrounded by occupational hazards), and 12-15 (the ages at which children begin to contribute to the farm work load).¹⁶ Common risk factors for injury in the farm environment include powerful and often unguarded machinery or vehicles, large and unwieldy farm animals, and potentially toxic chemicals, gases, or biological agents.¹⁷ In addition, because farm children often live in relatively isolated areas, physical effects of injuries become exacerbated by the time involved in getting to emergency medical care.¹⁸

In this study we examined patterns of agricultural machinery injury experienced by children in the province of Ontario, Canada. Our objectives were: (1) to estimate rates of agricultural machinery injury resulting in fatality or hospitalization; (2) to quantitatively describe the nature of these injuries in terms of time, age group, sex, geographic region, type and anatomical site, agent and mechanism, and severity; (3) to qualitatively describe important patterns among these injuries; and (4) to discuss the implications of (1) to (3) for prevention.

Method

OVERVIEW OF STUDY DESIGN

The study population was defined as all residents of Ontario farms who were between the ages of 0-19 years during the five year study period ending 31 March 1990. Fatalities and hospitalizations for agricultural machinery

Department of
Community Health
and Epidemiology,
Queen's University at
Kingston; and Centre
for Injury Prevention
and Research,
Kingston, Frontenac,
Lennox and Addington
Health Unit, Kingston,
Ontario, Canada
W Pickett
JR Hoey

Department of
Community Health
and Epidemiology and
Department of
Emergency Medicine,
Queen's University at
Kingston, Ontario,
Canada
RJ Brison

Correspondence to:
W Pickett/Dr RJ Brison,
Department of Emergency
Medicine, Queen's
University, Kingston,
Ontario, Canada, K7L 3N6.

injuries experienced by these children were investigated. Two systems for the surveillance of traumatic farm injuries (one for each of fatal and non-fatal injuries) were used in their identification and description. Rates of injury were calculated for subgroups of children. Patterns of injury were described by several descriptive parameters. Examples typical of those observed in our surveillance systems were used to highlight important patterns of these injuries.

THE SURVEILLANCE SYSTEMS

(1) Fatal farm injury surveillance

Fatal childhood agricultural machinery injuries were identified using information obtained from these sources: (1) the in-house system of files maintained at the Office of the Chief Coroner of Ontario; (2) the death certificate registry maintained by the Registrar General of Ontario; and (3) a registry maintained at the head offices of the Ontario Farm Safety Association (FSA) which uses police reports, FSA field personnel, and a newspaper clipping service to identify injuries. Coroners' investigation reports were then obtained for all fatal childhood farm injuries identified by the three sources of information, and these were manually searched to describe the injuries.

(2) Non-fatal farm injury surveillance

Children hospitalized for agricultural machinery injuries were identified using hospital discharge data tapes maintained by the Hospital Medical Records Institute of Canada. These included all childhood farm injuries treated in an Ontario hospital and where the external cause of injury was coded as E919-0, injuries caused by agricultural machinery.¹⁹ Demographic information from computerized records was used to describe the persons involved, and the place and time of injury. The mechanisms and circumstances of injury were described by having medical records personnel at the hospitals that reported treatment of at least one of these injuries abstract information from individual medical charts. One hundred and fifty eight (98%) of the 162 Ontario hospitals who were approached provided the requested descriptions,¹⁶ and 259 (95%) of the 273 records sent to the hospital were returned. The surveillance system was, however, unable to capture farm machinery injuries that were coded incorrectly by medical records staff, and we are unable to address this as a source of bias in the study.

ANALYSIS

The surveillance information available to describe the injuries included the month and year of injury, the age and sex of the victim, their geographic region of residence, and the nature, anatomical site, agent, and mechanism of injury.

The numbers of agricultural machinery injuries identified among farm children were plotted by quarter of year for the five year study period. These quarters were: (1) January–

March, winter months in Ontario; (2) April–June which correspond with cultivating and sowing activities in most parts of the province; (3) July–September, tending and harvest seasons; and (4) October–December, late harvest and winter months. For comparative purposes, the number of machinery injuries among those older than 19 were plotted in a similar manner.

Total and stratum specific rates of fatal and hospitalized childhood injury were calculated by age group (0–4, 5–9, 10–14, 15–19 years), sex, and geographic region using denominator data from the 1986 Canada Census of Agriculture.²⁰ The primary injuries that were associated with each of the injury events were described by type and anatomical site using the *International Classification of Diseases*, 9th revision, clinical modification (ICD-9-CM N-codes).¹⁹ Injury rates were calculated for different agents of injury (the machines involved) and mechanisms of injury (what happened to cause the injury). Cross tabulations were also used in these descriptions. The relative severities were estimated by calculating the ratio of hospitalized injuries to fatalities for different agents and mechanisms, so that smaller case fatality ratios generally indicate more severe forms of injury. The case fatality ratio, although a crude measure of injury severity, is commonly used in the description of injuries and associated patterns.

Cases of injury typical of those observed in the two surveillance systems were used to illustrate important patterns. Actual case descriptions were not used so that individual data in the systems would remain confidential.

All data management and analysis performed during this study were done using RBase (Microrim, 1991).

Results

QUANTITATIVE ANALYSIS

Two hundred and eighty three childhood agricultural machinery injuries were identified for the five year study period (24 fatalities; 259 hospitalizations). The number of injuries ranged from a high of 69 in 1985–6 to a low of 48 in 1989–90. The figure shows a seasonal peak in incidence during the third quarter (July through September) of each study year which, although evident for both adults and children, was especially pronounced among the latter.

Fatal and hospitalized agricultural machinery injuries in Ontario, 1985–90, by quarter of year in those < 20 and ≥ 20 years of age.

Of the 24 fatalities which were recorded, 22 of 24 (92%) were identified in the FSA registry, 17 of the 24 (71%) were identified in the database search at the Office of the Chief Coroner, and nine of 24 (38%) were identified in the search of the Registrar General registry.

Rates of injury by age, sex, and region are shown in table 1. Injuries to boys outnumbered those to girls in all age groups, with an overall

ratio of boy to girl injury rates of 4.5:1. This ratio varied from a low of 1.7:1 for the 0–4 year age group, to a high of 12.0:1 for the 15–19 year age group. Annual regional rates ranged from 51/100 000 farm children in Southern Ontario to 136/100 000 farm children in Northern Ontario.

The natures of the primary injuries experienced by the 283 injury victims are described in table 2. Of those hospitalized, the most common were limb fractures, open wounds to a limb, fractures to the head, neck or trunk, and crushing injuries. Together with the 24 fatalities, these accounted for 201 of the 283 injuries identified. Over 40 different types of machinery were represented. The most common are described in table 3, as are the mechanisms of injury commonly associated with specific injury events. The leading agent of injury, accounting for just over one third of those observed, was the farm tractor. The leading mechanism was entanglement in machinery, which was always moving and usually unguarded. The severity of injuries associated with different agents and mechanisms varied widely. Seven of the categories described in table 3 were associated with case fatality ratios of 8:1 (or less)—a relatively high level of severity. Five mechanisms, although common, were associated with no fatalities and thus had an undefined case fatality ratio which suggests a lower level of severity. Among the hospitalized injuries, the natures of the primary injuries as well as the mechanisms of injury varied by the types of machines involved (table 4).

Table 1 Childhood agricultural machinery injuries, Ontario 1985 through 1990, by age, sex, and region

	Fatalities	Hospitalizations	Total	Rate*
Total No of injuries	24	259	283	70
Males (by age)				
0–4	3	35	38	95
5–9	5	40	45	99
10–14	5	60	65	113
15–19	5	79	84	136
Total (0–19)	18	214	232	116
Female (by age)				
0–4	6	17	23	58
5–9	0	8	8	18
10–14	0	13	13	24
15–19	0	7	7	11
Total (0–19)	6	45	51	25
Region of Ontario				
Western	9	78	87	67
Southern	4	65	69	51
Central	6	44	50	87
Eastern	5	48	53	88
Northern	0	24	24	136

*Number of fatalities and hospitalized injuries/100 000 farm children/year.

Table 2 Childhood agricultural machinery injuries, Ontario 1985 through 1990; description of primary injuries

Description	N-code	Injury	No (%)
Total injuries			283 (100.0)
Fatalities			24 (8.5)
Hospitalized injuries			
800–809		Fracture: head, neck/trunk	23 (8.2)
810–829		Fracture: upper/lower limb	71 (25.2)
850–854		Intracranial injury	11 (3.9)
860–869		Internal injury: chest, abdomen, pelvis	11 (3.9)
870–879		Open wound: head, neck, trunk	11 (3.9)
880–897		Open wound: limb	60 (12.3)
920–924		Contusion with intact skin	15 (5.3)
925–929		Crushing injury	22 (7.8)
		Other/unspecified	35 (12.4)

Table 3 Childhood agricultural machinery injuries, Ontario 1985 through 1990, by machine and mechanism of injury

	Hospitalizations	Fatalities	Total	Rate*	Ratio†
Total No of injuries	259	24	283	71	10.8:1
Machine					
Tractor	86	11	97	24	7.8:1
Conveyer	24	0	24	6	†
Hay wagon	20	3	23	6	6.7:1
Baler	13	0	13	3	†
Grain auger	12	0	12	3	†
Manure spreader	7	2	9	2	3.5:1
Combine	6	1	7	2	6.0:1
Power take off	11	1	12	3	11.0:1
Other (35+ machinery categories)	80	6	86	21	13.3:1
Mechanism					
Entanglement in machinery	94	5	99	25	18.8:1
Run over by machinery	36	8	44	11	4.5:1
Fell from, then run over by machinery	36	5	41	10	7.2:1
Struck or pinned by machinery	35	1	36	9	35.0:1
Fell from machinery	36	0	36	9	†
Roll overs	10	5	15	4	2.0:1
Other/unspecified	12	0	12	3	†

*Number of fatalities and hospitalized injuries/100 000 farm children/year. †Ratio of hospitalizations:fatalities. ‡Undefined ratio (division by zero).

QUALITATIVE DESCRIPTION OF IMPORTANT PATTERNS OF INJURY

Rather than restricting the analysis to a purely quantitative approach, other important patterns are illustrated by describing typical examples of non-fatal injuries and deaths.

Pattern 1. The farm child who is unsupervised during busy summer months.

A 3 year old boy was playing in the gravel drive leading to the barn on a family farm. He was being watched by his 8 year old sister while their father was busy with haying, and their mother was in the barn feeding livestock. The girl briefly went inside the farm house to get her brother a glass of water. During this time, the boy crawled under a wagon loaded with hay that was attached to a tractor which had been left idling. Not knowing that the boy was there, the tractor operator started moving the tractor and wagon and ran over the boy. Death was due to multiple abdominal injuries.

Clear seasonal peaks in both fatal and non-fatal injuries occur during the summer months. In Ontario, summer coincides with: (1) maximum exposure to field work and associated hazards on farms and (2) holidays from school. Caregivers of farm children are commonly required to participate in field work activities. This means that during the summer these caregivers have three basic options for child-care. They may seek other forms of supervision

Table 4 Hospitalized childhood agricultural machinery injuries: machinery types by primary injury and mechanism

	Tractor	Conveyer	Hay wagon	Baler	Grain auger	Power take off
Total No of injuries	86	24	20	13	12	11
Primary injury (%)						
Fracture	42	38	25	39	8	55
Open wound/contusion	19	42	35	39	67	27
Internal/crushing injury	23	4	15	23	0	0
Intracranial injury	4	4	5	0	0	9
Other/unspecified	13	13	20	0	25	9
Mechanism of injury (%)						
Entanglement	8	71	5	77	83	100
Run over	22	0	25	0	0	0
Fell from, then run over	29	0	40	0	8	0
Struck or pinned by	13	25	10	8	0	0
Fell from	14	4	20	8	0	0
Roll over	13	0	0	0	0	0
Other/unspecified	1	0	0	8	8	0

(which, if available, may be prohibitively expensive); they may allow children to accompany them while doing their field work (which may put the child in proximity to machinery hazards); or they may leave their children partially or totally unsupervised. There is clearly increased risk for injury associated with the latter two options.

Because children are small they may not be visible to operators of farm vehicles. As a group, forward and backward run over injuries associated with farm tractors and other agricultural equipment were the second leading mechanism of injury in the study. These were typically caused by a tractor operator being unaware of the presence of small child on the ground beside them. (Similar patterns of pedestrian injury have also been observed in urban settings, where young children are commonly backed over by motor vehicles in driveways.²¹)

Pattern 2. The farm child who is left in the proximity of unguarded or moving machinery.

A 12 year old girl was watching her older brother use an elevator to load hay bales into the loft of a barn. The girl slipped on the wet ground, and tried to regain her balance by grabbing onto the elevator. As she did so, her arm entered an unguarded portion of the elevator driver mechanism and her coat sleeve became entangled. Her arm was amputated at the shoulder.

The leading mechanism of non-fatal injury observed in this study was that of a child becoming entangled in a moving piece of agricultural machinery. Two factors generally contributed to the occurrence of these injuries: (1) children allowed to be in the proximity of operating machinery; and (2) machinery with either no safety guarding, or guarding that was inappropriate to protect smaller limbs or body parts.

Pattern 3. The farm child who is allowed to accompany workers in the proximity of moving farm machinery.

A 6 year old boy was riding on the fender of his father's tractor. As the tractor turned from a farm field onto a laneway, it jolted and the boy fell off. He was subsequently run over by the tractor tyre

and suffered multiple fractures of his legs and one arm.

There were numerous examples of fatal and non-fatal injuries identified that occurred when children were accompanying an older farm member during work. In doing so, the child was either assisting, or was being supervised while performing field work or other chores. 'Extra rider' injuries, where a child was riding on a piece of moving farm machinery, fell, and was subsequently run over, comprised the third leading mechanism.

Pattern 4. The farm child who is performing work tasks inappropriate for their age.

A 10 year old boy was driving a tractor back from a field where he had been helping with haying. He was found dead lying in the field with the tractor overturned in a nearby drainage ditch. It was speculated that the boy had hit a bump while driving, fallen off the tractor seat in front of the back wheel, and had been crushed by the wheel.

Children are an important source of labour on farms. As such, they are often called upon to be responsible for chores that are physically demanding, technically demanding, or repetitive. These often involve the operation of one or more types of large and dangerous pieces of machinery, which may or may not occur in the presence of an adult. Some of these tasks may stretch the capabilities of children to their limits.

Prevention

We propose four actions that we and other injury prevention specialists should take to improve the safety of children on farms. These come directly from the patterns of injury observed in the present study, and involve a combination of education, engineering control, and enforcement.^{22,23} Targeting of the proposed interventions is also discussed, followed by an interpretation of the role of public health professionals in ensuring the transfer of these findings into public health action.

(1) ENCOURAGE AND/OR SUBSIDIZE THE CONSTRUCTION OF BARRIERS ON FARMS TO PREVENT CHILDREN FROM ENTERING PARTICULARLY HAZARDOUS AREAS

This strategy would apply to the very young who are at high risk for run over and entanglement type injuries. Barriers could consist of items as simple as fenced off areas of the farm residence with self locking gates erected to keep toddlers and small children away from equipment. No one would advocate leaving small children unattended for periods of time longer than is appropriate for their age. However, it could be hypothesized that it may be safer to leave these children unattended in a self contained play area by the home than to allow them to accompany older members during work activities.

(2) WORK WITH GOVERNMENTS AND FARMING ORGANIZATIONS AT ALL LEVELS TO

DEVELOP PROGRAMS WHICH WOULD PROVIDE ADEQUATE CHILD CARE TO RURAL RESIDENTS OF OUR PROVINCE

This would ameliorate the need for young farm children to be in the vicinity of machinery hazards, especially during busy seasons. There is an obvious need to augment this system of child care during harvest seasons and the summer holiday for school children.

(3) WORK WITH GOVERNMENT AND FARMING ORGANIZATIONS TO DEVELOP AND ENFORCE STANDARDS FOR THE SAFEGUARDING OF ALL AGRICULTURAL EQUIPMENT

Concerns about the safety of agricultural equipment are not new and the past 20 years has brought with it vast improvements in the design of most agricultural vehicles and implements. Almost without exception, newly manufactured pieces of agricultural machinery pose far less of a threat to operators and bystanders than do older models. One of the problems with simply relying on this improved engineering as a primary means of injury control is that agricultural machinery tends to be used for many years, and the replacement of older machinery with newer, safer models cannot be expected to proceed quickly.²² Second, farming remains one of the most unregulated industries in terms of enforcement of safety standards. Even the most modern pieces of equipment are hazardous if shields and other passive safety devices are not maintained. Without enforcement of sensible standards for the guarding of agricultural equipment on a widespread and systematic basis, we can expect that the toll of childhood injuries associated with agricultural machinery to remain high.

(4) LOBBY THE GOVERNMENT TO PROHIBIT CHILDREN FROM OPERATING ANY FARM TRACTOR BEFORE THE AGE OF 14, AND TO INSTITUTE FORMAL TRAINING REQUIREMENTS FOR THEIR OPERATION

For reasons of public safety, no one in Ontario is allowed to operate a motor vehicle before they reach the age of 16, and even then there is a system of graduated licensing that limits the conditions under which a young person can drive. Paradoxically, no similar restrictions prohibit the operation of a farm tractor by children of any age on private farm property. While voluntary programs do exist for the training of people in safe tractor operation, there is no formal requirement for anyone who wants to use a farm tractor to go through such a program, and at the present time licensing of tractor operators is not required. This is the situation despite the fact that tractors are usually far more powerful than most motor vehicles in operation, and are the leading agent of unintentional childhood injury on farms.¹

We documented several cases of 9–12 year old children who were injured or killed while driving a farm tractor. We suggest that tractor

operation exceeds the physical abilities of most children in this age group, and that steps need to be taken to prohibit this situation from occurring. We do, however, recognize that it may not be feasible to set a regulated cut off age for farm tractor operation as high as 16 because of the demands for teenage labour in our agricultural industry. We propose as a compromise an age limit of 14, which, while recognizing the latter need, addresses the inherent risks involved in allowing younger children from operating equipment that is beyond their physical capabilities.

Targeting of preventive interventions

The patterns of injury observed might suggest that interventions aimed at the prevention of agricultural machinery injuries should be aimed at farms with one or more boys in residence, and farms in certain regions of our province that have higher rates of childhood injury (Central, Eastern, and Northern Ontario). Our interpretation of the observed variations in the incidence of these injuries is that they mainly reflect differences in exposure to agricultural machinery hazards by sex and between regions. However, exposures by children to the hazards associated with agricultural machinery are common to almost the entire farm industry,¹ and the targeting of preventive interventions should reflect this fact. Second, the strong seasonal pattern observed, with peaks occurring during the summer months, suggest a need for the targeting of farm safety programs in rural schools immediately before the summer school break.

Taking responsibility for translating this research into public health action

The science of public health practice involves several phases including the analysis of information about perceived health problems, the determination of risk factors or causal pathways, the development of interventions, and the evaluation of those interventions. This model has served public health practitioners well in the containment of infectious diseases, particularly for diseases preventable through vaccination. However, for the prevention of childhood injuries there is no single prevention strategy—there is no vaccine.

A need for injury control researchers to advance their field by extending research beyond the realm of surveillance and into the public arena has been recognized.²⁴ Specifically, researchers have a responsibility to describe how they will ensure that their results are turned into public health action. To this end, this paper proposes four strategies that could be used by injury researchers in public health settings to reduce the incidence of childhood farm machinery injuries. Each implies some level of community or government intervention to achieve the desired result.²⁴

The causal pathways associated with these injury events are complex and imperfectly understood, and our interpretations of these data will be richer if the process also involves

members of the community of affected individuals. To this end, we intend to share this information with members of the health and agricultural communities through publication in technical and non-technical formats, and by presentations at community based meetings. We also intend to involve ourselves in the development and implementation of preventive interventions. In recognition of the fact that interventions that seem feasible to the researcher and public health professional may not be implementable by the farm operator, the development of interventions should be a shared responsibility. However, not all intervention strategies suggested by the farm community will work. Public health interventions must be evidence based—otherwise we will do the public a disservice by continuing to use resources and community enthusiasm to no end.

Public health professionals must become involved in injury prevention on farms. Public health units can ensure that local and regional intervention strategies are developed, targeted, and evaluated based upon objective data. Health units also have expertise in the organization of coalitions that share the common goal of formulating workable interventions. In short, public health has a central part to play—but first, health units such as ours must recognize that injuries are their problem. They must assume ownership and responsibility.

Conclusion

Childhood agricultural machinery injuries are an important public health problem, as evidenced by the growing international body of scientific literature on the subject and the high rates of traumatic injury observed in the present study. These injuries occur regularly, are often severe, and are almost entirely preventable.

The childhood agricultural injuries that we observed generally occurred because a child was inappropriately situated in the vicinity of a machinery hazard. Sensible preventive interventions need to build on this fact by either preventing farm children from going into areas where major hazards are known to exist, or if this is not possible, reducing the potential for contact between the child and the hazard. To this end, this paper suggests a variety of preventive actions that could be applied, and the role of public health in ensur-

ing that our findings are translated into public health action.

We thank the Information, Planning and Evaluation Branch of the Ontario Ministry of Health, and the Office of the Chief Coroner of Ontario, the Registrar General for Ontario, and the Ontario FSA for their help with obtaining data access. The opinions expressed in this paper are those of the authors. Mr Pickett is a Career Scientist funded by the Ontario Ministry of Health.

- 1 Richards NR (chair). *Report of the Ontario Task Force on health and safety in agriculture*. Toronto: Ontario Ministries of Agriculture and Food, and Labour, 1985.
- 2 Salmi LR, Weiss HB, Peterson PL, Spengler RF, Sattin RW, Anderson HA. Fatal farm injuries among young children. *Pediatrics* 1989; 83: 267–71.
- 3 Bredfeldt RC, Heath AE, Junker JA, Cuddeback GA. Childhood farm injuries: a neglected aspect of patient and resident education. *Fam Med* 1989; 21: 217–20.
- 4 Pickett W, Brison RJ, Neizgoda H, Chipman ML. A population-based survey of farm injuries in Ontario. *Accid Anal Prev* (in press).
- 5 Letts RM, Gammon W. Auger injuries in children. *Can Med Assoc J* 1978; 118: 519–22.
- 6 Ontario Farm Safety Association. *Injury report*. Farm Safety Association Inc. Guelph: Farm Safety Association, 1973–93.
- 7 Cogbill TH, Busch HM Jr, Stiers GR. Farm accidents in children. *Pediatrics* 1985; 76: 562–6.
- 8 Stallones L. Fatal unintentional injuries among Kentucky farm children: 1979 to 1985. *Journal of Rural Health* 1989; 5: 246–56.
- 9 Walker RB, Raines D. Childhood accidents in a rural community: a five year study. *J Fam Pract* 1982; 14: 705–8.
- 10 Purschwitz MA. *Fatal farm injuries to children*, Marshfield, WI: Wisconsin Rural health Research Center, 1990.
- 11 Doyle Y, Conroy R. Childhood farm accidents: a continuing cause for concern. *Journal of the Society of Occupational Medicine* 1989; 39: 35–7.
- 12 Swanson JA, Sachs MI, Dahlgren KA, Tinguely SJ. Accidental farm injuries in children. *Am J Dis Child* 1987; 141: 1276–9.
- 13 Rivara FP. Fatal and nonfatal farm injuries to children and adolescents in the United States. *Pediatrics* 1985; 76: 567–73.
- 14 Layde PM. Beyond surveillance: methodological considerations in analytic studies of agricultural injuries. *Am J Ind Med* 1990; 18: 193–200.
- 15 Zejda JE, Semchuk KM, McDuffie HH, Dosman JA. A need for population-based studies of health and safety risks in Canadian agriculture [editorial]. *Can Med Assoc J* 1991; 145: 773–5.
- 16 Brison RJ, Pickett W. *Agricultural health and safety research program: final report*. Guelph: Ontario Ministry of Agriculture and Food, 1993.
- 17 Elkington JM. A case-control study of farmwork-related injuries in Olmsted County, Minnesota. Minneapolis, Minnesota: University of Minnesota, 1990. (Doctoral dissertation.)
- 18 Brison RJ, Pickett CWL. Non-fatal farm injuries on 117 Eastern Ontario beef and dairy farms: a one year study. *Am J Ind Med* 1992; 21: 623–36.
- 19 United States Department of Health and Human Services. *International classification of diseases, clinical modification*. 9th Ed. Pittsburgh, PA: US Department of Health and Human Services, (PHS) 89–1260, 1989.
- 20 Statistics Canada. *1986 Agricultural census for Ontario*. Ottawa: Statistics Canada, 1987 (Cat No 96–108).
- 21 Brison RJ, Wicklund K, Mueller BA. Fatal pedestrian injuries to young children: a different pattern of injury. *Am J Public Health* 1988; 78: 793–5.
- 22 Etherton JR, Myers JR, Jensen RC, Russell JC, Braddee RW. Agricultural machinery-related deaths. *Am J Public Health* 1991; 81: 766–8.
- 23 Ontario Farm Safety Association. Safety programs of the Farm Safety Association in Ontario, Canada. *Am J Ind Med* 1990; 18: 409–11.
- 24 Pless IB. Unintentional childhood injury—where the buck should stop. *Am J Public Health* 1994; 84: 537–9.