University of Alberta

A population-based comparison of injuries among farm children to non-farm children in Alberta, 1999-2010

by

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Abstract

Objectives - To systematically review literature on rural-urban differences in pediatric injury incidence and to examine incidence of all-cause injury, agricultural injury, and injury-related health care utilization for farm children compared to several groups of non-farm children under 18 years of age in Alberta, Canada.

Methods – A systematic review examined population-based observational studies published from 1970 to August 2013, that compared rates or health care outcomes of injury between rural and urban children (<18) living in Canada or the United States. Three of population-based retrospective cohort studies followed farm, rural, First Nations (FN), urban children from 1999 to 2010 to examine incidence of injury and related health services using the linkage of four administrative health databases (data from physician visits to deaths). Person-time incidence rates and adjusted hazard ratios were calculated based on injury episode.

Results – Systematic review demonstrated that rural children sustained a higher rate of overall injury, particularly from MVC and suicide than urban children. Primary studies showed farm and rural children, especially rural FN children, had higher rates and greater utilizations of overall injury, especially for severe injuries, than urban children. This trend was consistent for most injury mechanisms but more notably for other land transport (e.g., ATVs, animal riding, agricultural vehicle-related injuries), natural/environmental (e.g., bees, insects, animals-related), and unintentional firearm-related injuries. Farm and rural non-FN children were at a greater risk of agricultural injuries, more outstandingly

for farm-animal and machinery-related injuries, than rural FN and urban children. Agricultural injuries appeared to be more unintentional and lethal. Rural FN children, followed by rural non-FN and farm children, experienced greater utilization of higher levels of medical facilities, thinner shapes of injury pyramid, and greater proportions of pre-hospital deaths.

Conclusions – Greater burden of injury for farm and rural children and specific patterns per group indicate a need for targeted and specialized injury prevention strategies for higher-risk mechanisms in each group, attention for agricultural injury controls to extended populations, comprehensive intervention strategies for underlying inter-related causes of injury in rural areas, and an advanced pediatric trauma care for serious injuries the ED for efficient and timely care in rural areas.

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List of Abbreviations

ICD: International Classification of Disease

E-codes: External Cause of Injury Codes

EM: Emergency Department

FN: First Nations

HR: Hazard Ratio

LOS: Length Of Stay

MVC: Motor Vehicle Crash

NOS: The Newcastle-Ottawa Scales

OLT: Other Land Transport (land transport injuries other than motor vehicle traffic, pedal cyclist, pedestrian injuries; i.e., ATVs, animal riding, agricultural vehicle-related injuries)

OR: Odds Ratio

PHS: Personal Health Number

RR: Rate Ratio or Relative Risk

SE: Standard Error

SES: Socioeconomic Status

SMR: Standardized Mortality Ratio

U.S.: The United States

WHO: World Health Organization

95% CI: 95% Confidence Interval

Chapter 1. General introduction

1.1 Background

1.1.1 Agricultural injuries among children

Agriculture continues to be one of the most dangerous occupational sectors in Canada as well as across the world due to high rates of fatal injuries.[1-3] Agricultural hazards extend not only to farm workers but also to farm children for two primary reasons. Firstly, the working and living environments of farms can hardly be separated. In particular, for young farm children, play areas are often the same as the dangerous workplaces of their parents, which results in the highest agricultural death rate for young children, being under five years of age, than any other age group of children.[2,4,5] Secondly, farm children and adolescents participate in farm work. Farm children are commonly assigned work on their family's farms from as young as 7-9 years of age,[6] and adolescents make up a considerable proportion of the agricultural workforce.[7] Therefore, it may be assumed that that farm children have been suffering from more injuries than other groups, as farm children are exposed to an extra hazardous environment (farm work itself, machinery, toxic chemicals, dugouts for irrigation, etc.) that other children may not be exposed to.

Standard definition of injury by the World Health Organization (WHO) is "Injuries are caused by acute exposure to physical agents such as mechanical energy, heat, electricity, chemicals, and ionising radiation interacting with the

body in amounts or at rates that exceed the threshold of human tolerance. In some cases (for example, drowning and frostbite), injuries result from the sudden lack of essential agents such as oxygen or heat".[8] Injury is the leading cause of death for children, accounting for more than half of all deaths for children in Canada .[9] The hazardous environment surrounding farm children results in high rates of fatality and disability from agricultural injuries. Agricultural fatal injury rates for children in Canada and the U.S. ranged from 7.0 to 13.2 per 100,000 population per year.[10-12] More than 40% of farm injuries in children who visit emergency departments leave them with an ongoing disability.[13] In Alberta, 46 children under 20 years of age died from agricultural injuries between 1990 and 2006.[4]

1.1.2 Agricultural and non-agricultural injuries for farm children.

Injury for farm children can be classified into agricultural injury and non-agricultural injury. Agricultural injury refers injury that is related to farm/ranch operation or farm/ranch environmental hazards.[14] Agricultural injury includes both work-related and non-work-related injuries, such as deaths on agricultural vehicles being used for agricultural work or recreational purposes.[14] There are many factors related to agricultural injury for children including age, gender, cause, and season. Younger children (under 5 years) and adolescents aged 15-19 experienced more injuries than other age groups of children.[5,15] More males than females are injured on farms in almost all age groups.[16-19] The male to female ratio in fatality rates of farm-related injury consistently increase with age.[11,12] Machines/machinery is the greatest cause of fatal agricultural injures, accounting for 66% of agricultural deaths to children [10], and half of these machinery deaths

involve tractors [10,12].

Non-agricultural injury refers to injuries that do not involve agricultural work or hazards. For example, this category includes injuries from sports, motor vehicle collisions, school violence, etc. that are not related to the farm work/environment. Prior studies have primarily focused on agricultural injury, therefore, little is known about injury rates and patterns of non-agricultural injury for farm children. Due to lack of information on this injury category (non-agricultural injuries), overall injury rates for farm children have not been estimated.

The lack of information on all causes of injury for farm children may be related to the methods of prior studies in using administrative health databases. Previous studies have extracted agricultural injury data from administrative health databases using International Classification of Disease (ICD) codes.[4,12,12,19,20] This approach is efficient and effective to illustrate general problems from agricultural injury for all children in a population, but it has limitations to estimate a true incidence rate of agricultural injuries "for farm children". Without identifying farm children, it would not be possible to examine the incidence of other injury categories of injuries for them, either. Only an approach that specifically identifies farm children in a population-based fashion and then examines their specific injury experience can truly estimate injury incidence of injury in this population.

1.1.3 Comparison of children's injuries between different groups

The majority of prior studies are descriptive studies on the prevalence of agricultural injuries. Comparison studies with samples of farm children and

non-farm children are rarely performed. Some studies have attempted to compare the injury incidence for farm children and other groups of children, but they have limitations in the scope of injuries covered, the age range/characteristics of subjects, comparability, etc.

Miller et al.[21] found that the occupational injury rate among farm adolescents was one of the three highest among all industries based on Washington state workers' compensation claims. Hard and Myers [22] reported that occupational death rates to young workers in the agricultural sector was 3.6 times greater than that for young workers of all industries combined in the United States. This gap was highest in 15 year olds working in the crop production sector with a 6.1 fold increase in rates. Although these two studies obviously indicate that young farm workers suffer greater injuries than other young workers, these studies using compensation claims were not able to examine non-occupational injuries. Brison et. al.[20] compared fatality rates of preschool children on farms to those in Canadian children of the same age. The fatal injury rate from agricultural injuries for farm children was 1.7 fold higher than one of all-cause, unintentional injury among all Canadian children aged 1- 6. If data of farm children deaths included non-agricultural deaths, this difference would likely be larger. This study does provide valuable information about the very youngest children, but it did not provide any information on children that are transitioning into the farm workforce. Non-fatal injuries were also not examined in this study.

Some studies compared the injury rates and causes between rural and urban children. Differences in rates of all-cause injury between rural and urban

children were not significant.[23] However, non-fatal injury rates increased with an increase of rurality in the U.S.,[24] and rural children sustained significantly greater fatal injuries in some specific injuries compared to urban children in Colorado:[23] Increased motor vehicle deaths and firearms accidents/suicides were found in some age groups of rural children. A population-based study in Alberta, Canada[25] found that the risk of motor vehicle collision injury were significantly higher for rural children in comparison to urban children (3 times greater for injury requiring hospitalization, 5.4 times higher for fatality).

These studies indicate that injury patterns are different in rural and urban children, and rural children are at increased risk of some specific injury types. However, these data are not sufficient to estimate injury incidence for farm children, as rural children do not truly represent farm children, and differences and similarities in injury risk between farm and non-farm children in rural areas have not been examined.

As a result of these limitations, it has been difficult to determine whether farm children sustain more injuries, the extent to which they suffer more, and what specific injuries they are more vulnerable to, in comparison with other groups of children.

1.1.4 What prior studies are lacking

Although existing studies have provided useful and substantial information of farm-related injuries for children, there have been noticeable limitations in the scope of injury and estimation of the relative risk of injury for farm children; 1) conventional approaches have primarily dealt with agricultural injuries for

children, and all causes of injuries (agricultural and non-agricultural injuries) for farm children have not been studied in North America, 2) existing studies have a deficiency in overall comparison of injury incidence of farm children to other groups of children.

For an accurate and comprehensive understanding of injuries for farm children, it is essential to compare all causes of injury between farm and non-farm children. The derivation of the true risk and relative burden of injury for farm children is necessary to assist decision makers in the development of appropriate health and safety standards for farm children. The approach offered by this study as a population based epidemiologic study will offer new insight into the risks farm children are exposed to.

1.2. Objectives and research questions

1.2.1 Objectives

The proposed study examined the incidence and health care utilization of injuries for farm children under 18 years of age in comparison to non-farm children in Alberta from 1998-2010.

1.2.2 Research questions

1. What are the differences in injury rates between rural and urban children based on a systematic review of the literature?
2. What are the differences in rates and patterns of all-cause injury between farm, rural, and urban children in Alberta from 1998-2010?

3. What are the differences in rates and patterns of agricultural injury for farm and non-farm children in Alberta from 1998-2010?
4. What is the difference in injury-related health care utilization for farm, rural, and urban children in Alberta from 1998-2010?

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Chapter 2. Differences in incidence of injury between rural and urban children in Canada and the U.S.: a systematic review

2.1 Introduction

Injury is the leading cause of death for children aged 1 to 19 years in Canada and the United States (U.S.).[1,2] The World Health Organization (WHO) reported that on a daily basis, more than 2,000 children die worldwide from unintentional injuries, and at least half of these deaths are preventable if appropriate prevention measures are adopted.[3] Injury trends and problems vary between populations and communities, and an identification of specific injury problems for different populations is required to target injury control strategies.

Rural and urban children are surrounded by different physical and socio-economic environments and risk factors of injury. Prior studies have demonstrated differences in injury rates and patterns of injury between these groups (e.g., higher rates of overall injury and motor vehicle crash (MVC) injury for rural children than their rural counterparts).[4,5] However, review or systematic examination of injury differences between these two populations has not been performed previously. Stewart Fahs et al.[6] reviewed literature on risk behaviors including injury experience among adolescents in rural, suburban, and urban areas, but the study did not focus on comparisons of injury incidence between these geographic groups.

Canada and the U.S. share similarities in terms of geography, demographics, socio-cultural environment, economic growth, infrastructure, etc..[7] In both countries, rural areas comprise 93-95% of the land mass, but rural

populations make up 19-21% of the total population with declining trends over time, [8-11] and experience poor access to health care services and a shortage of health care providers (e.g., physicians).[10,12] Conversely, they have different health insurance systems (universal social system in Canada vs. mixed public-private system in the U.S.)[13] and firearm control laws (less restrictive regulations in the U.S. vs. Canada).[14]

The objective of this study is to systematically identify and synthesize the existing evidence to assess whether there are differences in injury incidence between rural and urban children (aged under 18) in Canada and the United States. Understanding the injury-related health disparity between rural and urban children would help to develop effective injury prevention strategies specific to each setting and, in particular, to raise the profile of injury sustained by rural children for additional funding and intervention initiatives.

2.2 Methods

A protocol of this study was developed in advance to outline the objective and methods. The review protocol has been registered in PROSPERO (registration number: CRD42011001244).

2.2.1 Search Strategy

A research librarian and the first author developed search strategies, and the first author conducted searches of the following electronic databases to identify reports: Cochrane Database of Systematic Reviews, MEDLINE, EMBASE,

Scopus, Web of Science, Health & Safety Science Abstracts, Safetylit, and ProQuest Dissertations and Theses Databases. Supplementary approaches were applied by searching websites of institutions and government agencies in Canada and the U.S. and checking reference lists of relevant studies. There was no restriction by publication status, but the searches were restricted to studies conducted in Canada or the United States and published in English. We used all appropriate search terms that imply the concepts of 'rural', 'urban', 'children', and 'injury', while applying them for controlled vocabulary as well as free text terms, when available. The search strategy for MEDLINE is presented in Appendix I, and this search strategy was modified as appropriate to the specifications of other databases.

2.2.2 Study Selection

Eligible studies for review were population-based observational studies or surveys that compared injury incidence (primary outcome) or injury-related health care outcomes (secondary outcomes including hospital length of stay (LOS), hospital costs, etc.) between rural and urban children within each study. Studies with a qualitative approach, reviews, and case series were excluded. Populations considered were children under 18 years of age living in Canada or the United States. If the upper age limit exceeded 18, studies were included if the majority of participants were <18 or subgroup data for that age group were provided. We included studies that classified rural/urban status either by area of residence or by area of injury occurrence. Injury outcomes comprised any cause or intent of injury regardless of severity of injury including mortality and morbidity (e.g., injury

causing medical attention or restricted activity) excluding risk behaviors (e.g., drug use experience or violence exposure).

To be included for review, the relative effect measures of injury for compared groups such as rate ratio (RR), odds ratio (OR), or Hazard ratio (HR) needed to be provided or be able to be calculated. Studies published from 1970 to August, 2013 were included given that large-scale injury prevention efforts began to emerge in the 1960s in the United States.[15]

For study selection, two independent reviewers first reviewed the titles and abstracts to remove obviously irrelevant reports being over-inclusive with broad inclusion criteria and secondly, assessed full-text reports of remaining studies using a standardized form that listed predefined inclusion criteria. Disagreements between reviewers were resolved by consensus or third reviewer adjudication.

2.2.3 Quality Assessment

The internal validity of included studies was assessed using the Newcastle-Ottawa Scales (NOS)[16] developed for cohort studies. The NOS evaluates selection bias, comparability, and outcome assessment with eight items. It scores the validity by awarding a maximum of two stars for an item of comparability and one star each for other items. Scores are summed and range from zero to nine stars. We modified the NOS by removing three items (outcome status at start of study, follow-up period, and follow-up) that were assumed irrelevant to injury studies, leaving us with five items for a maximum possible score of six stars. As criteria to assess comparability, we chose age as well as socioeconomic status (SES) or medical service environment as important factors to be controlled for or matched.

Two authors independently conducted critical appraisal of the included studies. Disagreements were resolved by consensus or by third reviewer adjudication.

2.2.4 Data extraction

Data were extracted from reports using a standardized data collection form to gather information on the study design, population, data sources, urban/rural definition, outcomes, results, and additional information for assessments of the risk of bias. In cases of multiple reports from one study, information was combined. Some data were extracted from graphs.[17,18] Data extraction was performed by the first author, and independently verified by the second author. More information was obtained by contacting investigators, if necessary. Data were extracted into an Excel database.

2.2.5 Data analysis and synthesis

Data were summarized and synthesized by the category of injury based on intent and cause of injury. The principle summary measure of the effect of residential area (rural vs. urban) on injury incidence was RR or OR. A Meta-analysis was not conducted due to large heterogeneity across studies as well as a lack of standard error (SE) in the majority of included studies as these studies mainly performed descriptive analysis with data for the whole population from administrative health databases. Therefore, data were synthesized qualitatively and displayed using a forest plot with point estimate of RR or OR without pooling of data. If a study classified rural/urban areas using more than two categories, RR for the most rural area vs. the most urban area was used. In cases of multiple RRs for the same study

outcome, a RR for the largest age group and higher level of severity was chosen for the forest plot, otherwise multiple results are descriptively presented and not included in the forest plot. Effects of several factors (severity of injury, age and sex of participants, urban/rural categorization methods, a level of data collection (i.e., national or local), etc.) on RRs were explored qualitatively. A test for publication bias was not performed because of an absence of standard error (SE) in most studies as well as there being few studies for each injury outcome. Forest plots were drawn using RevMan software (version 5.1 for windows; The Cochrane IMS).

2.3 Results

2.3.1 Description of included studies

The flow of study retrieval and selection is shown in Figure 2-1. Overall, 2,943 reports were identified from literature searches. The full texts of 244 reports were examined and, of these, 198 studies were excluded. A list of excluded studies is available by contacting the first author. A total of 41 unique studies (46 reports) were included for the review, all of which were population-based cross-sectional studies (seven surveys [19-25] and 34 studies using administrative health database).

Three studies [4,24,26] were reports from government agencies and the others were articles published in peer-review journals. The majority of studies (34 studies) were conducted for only a paediatric population, and seven studies [4,17,24,27-30]at the municipal level. Rural/urban areas were classified by participants' residential area (31 studies), school areas,[20,22,25] location of injury occurrence (for

MVC injury[28,33,36,41] and for firearm injury[37,42]) or location of hospitals (sport-related injury[39]). Definitions and categories of rural/urban areas varied across studies: The number of rural/urban categories included two categories (26 studies), three-five categories,[4,17,20,21,23,25-27,29,34,38,42-45] and 10 categories[37] (King et al.[43] applied two categories as well as four categories). Most of the study participants were children under 17 to 20 years of age (21 studies), children under 15,[26,27,29,30,36,40,41,45-47] mostly teenagers,[20-23,25,48] young children,[43,49] and children excluding young children.[34,39] Key features of included studies were summarized in Table 2-1.

2.3.2 Methodological quality of included studies

The internal validity of studies was moderate. In total, 95 percent of studies (39 out of 41 studies) received four or more stars out of a possible six on the NOS. Stars given to studies using administrative databases included full stars,[37,39,50] five stars,[4,26,30,31,33,36] and four stars (25 studies). Three surveys [21,23,25] obtained five stars and the other four surveys[19,20,22,24] were rated at three stars. The main reasons of lower star ranking were a lack of control for potential confounders and outcome assessment by self-report (Table 2-2).

2.3.3 Primary outcome (injury incidence)

Forty one studies compared injury incidence rates between rural and urban children. For effect measures, 32 out of 41 studies used unadjusted RRs, and the other studies reported adjusted RRs,[33,37,50] adjusted ORs,[21,23,25,39] or standardized mortality ratios (SMRs).[4,30] Studies[19-25] using survey methodology investigated

only one category of injury, while studies with administrative data reported on one or several causes of injury within a single study.

Overall injury

Twelve studies reported rates of overall injury (any cause/intent) varying in severity from any injury needing medical attention to fatal injury. Six studies[4,19,20,24,27,38] using national-level data consistently demonstrated higher risk of overall injury for rural children in comparison to urban children ranging from RR (rural vs. urban) = 1.04 to 3.53, whereas five studies[31,32,44,47,50] with state or province level data presented variations in terms of effect size/direction ranging from RR=0.54 to 2.20 (Figure 2-2). One study[18] conducted in Ohio reported that rural children (mostly Caucasian) experienced higher rates of fatal injury than urban Caucasian children, but lower than urban non-Caucasian children (mostly African American). Two studies examined traumatic brain injury. Reid et al.[54] reported higher risk of fatality for rural children (RR=2.37), and Gabella et al.[17] also found higher incidence rates for rural children in all ages groups and both genders, with the exception of the young boys' group (<5 years).

Injury by intent

Unintentional injury: Two studies [26,46] addressed unintentional injury demonstrating consistently higher injury rates for rural to urban children ranging from RR=1.30 to 1.45.

Intentional injury*:* Eleven studies [4,21,29,35,44,46,48-50,52,58] reported on intentional

injury and the main results are illustrated by subgroup (Figure 2-3). As with overall intentional injury, Hammig and Weatherly[46] described lower risk of injury for rural children (RR=0.5). For suicides/self-harm, four studies [4,31,46,50] consistently demonstrated higher rates for rural children with RR ranging from 1.22 to 2.70. Thomson[35] reported a higher suicide rate (RR=1.86) for rural boys to urban ones but no differences among girls. Regarding homicides/assaults, there was inconsistency in results among six studies [29,31,44,46,48,50] ranging from RR=0.05 to 1.81. Child abuse was reported in three studies[49,50,52] with inconsistency in results ranging from RR=0.56 to 1.82. Schnitzer et al.[49] also presented conflicting results of non-fatal child abuse by data source in the study with lower risk for rural children (RR=0.56) from medical data as well as inverse results (RR=1.49) from family services data. For fight-related injuries, one study[21] reported a lower rate of injury for rural children with an adjusted OR of 0.78.

Injury by cause

Motor vehicle crash (MVC) injury: Injuries from traffic collisions were examined in 13 studies, [4,5,28,30,31,33,34,36,41,43,44,46,50] all of which were based on administrative health records with severe injuries (deaths or hospitalizations). All studies on overall MVC injuries or ones as occupants/passengers/pedal cyclists consistently demonstrated higher risk of injury for rural than urban children. Relative risks (rural to urban) of overall MVC injuries, ones as occupants, as passengers, and as pedal cyclists ranged from 1.40 to 2.75,[4,5,31,46] from 1.20 to 5.40,[5,33,41,44,46,50] 1.97,[43] and from 1.06 to 2.30,[34,46] respectively (Figure 2-4).

In addition to results in Figure 2-4, for overall MVC injury, standardized mortality ratios (SMRs) were reported at greater than 100 for rural children (137.62 in rural vs. 73.87 in urban children).[30] Also, for pediatric occupant injury,[36] the same direction of effect but an extreme effect size for males (RR=11.58) were reported. On the other hand, for MVC injuries as pedestrians, there was inconsistency in the direction of effects across three studies (two studies [46,50] in Figure 4, and one study[28] reported RR of 1.0 to 1.5 by age subgroup). Oliver and Kohen[5] reported RR of 0.90 for MVC injuries as pedestrian- and cyclist-related combined.

Firearm-related injury: Seven studies (eight reports) in the U.S. [37,42,45,50,51,53,57] using administrative health databases reported on firearm-related injuries with severe outcomes (deaths or hospitalizations) (Figure 2-5). Overall, for firearm-related injuries, contrary results were found across three studies.[37,42,55] Homicides using firearms were examined in five studies[37,42,45,55,57] showing consistently lower rates for rural children with RR ranging from 0.02 to 0.42. As for unintentional firearm-related injuries, despite inconsistency in results among six studies, four[37,45,53,55] out of six studies[37,42,45,51,53,55] presented higher risk for rural children. For suicides, there was conflicting results from four studies.[37,42,45,50]

Other cause of injury: Nine studies reported on several other causes of injury (Figure 2-6). Drowning,[46,50] burns,[50] falls,[31,50] poisoning,[34,50] and bicycle-related injury[34,50] were described with higher risk for rural children, while risk of falls

from windows[40] was lower for rural children than urban children, although these are based on just one or two studies for each cause of injury. There were contrary results regarding work-related injury [22,25] and sports-related injury,[23,56] and no risk differences for suffocation were found from one study.[46]

2.3.4 Secondary outcomes (length of hospital stay, hospital costs, etc.)

Three studies[19,38,39] investigated secondary outcomes of injury. Two national surveys in the U.S. reported that health care costs for any injuries per injured child were higher for rural children compared to urban ones: for total cost $1200 for metropolitan children vs. $1800 for non-metropolitan children[19]; $608 for urban children vs. $661 for rural children in terms of emergency department expenditures.[38] Yang et al.[39] examined secondary outcomes for sports injury, reporting 46.1% higher hospital charges per discharge, and 5.61% longer LOS in urban hospitals than rural ones.

2.3.5 Effect of other factors on injury differences

Severity of injury: Eleven studies reported multiple data for the same outcome by severity of injury within a study (Table 2-1). Six[19,20,22,33,36,54] out of eight studies[19,20,22,26,31,33,36,54] that reported higher risk of injury for rural children consistently demonstrated increased RRs for more severe injuries and deaths. Three studies[23,44,57] reporting lower risk for rural children showed inconsistency in results in terms of effects of severity on injury disparity.

Age of participants: Eight studies [4,17,27,28,32,41,53,55] presented age-specific injury rates. Effect of age subgroups on RRs between urban and rural children were not consistent across other variables within a study or across studies for overall injury and MVC injury, but one study[55] presented a positive linear relationship between age and RR (rural to urban) of firearm-related deaths (Table 2-1).

Sex of participants: Seven studies [17,18,33,36,47,55] reported sex-specific injury rates. Sex effects on RRs were not consistent across age groups within a study or across studies for any injury.[4,17,18,47] However, relative risks (rural to urban) were higher for males than females in three[33,36,47] out of four studies[4,33,36,47] on MVC injury and in one study on firearm-related injury[55] (Table 2-1).

Urban/rural categorization: Fifteen studies[4,17,20,21,23,25-27,29,34,37,38,42-44] provided rural-urban category-specific injury rates for more than 2 urban-rural categories (Table 2-1). All except two studies [23,29] demonstrated that rural-urban disparity was generally or consistently intensified when comparing more extreme rural and urban areas. For example, if RR of rural to urban children was larger than 1 (higher risk for rural children), the RR increased as the urban group was compared with a more distant rural group and vice versa.

2.4 Discussion

2.4.1 Summary of evidence

Injury is a major public health issue for paediatric populations.[1,2] This systematic

review summarizes the available evidence regarding differences in risks of injury between rural and urban children in a qualitative fashion. A total of 41 population-based cross-sectional studies conducted in Canada and the U.S. were included for the review. Overall, our results show that rural children are at higher risk of overall injury, MVC injury, and suicide, whereas urban children in the U.S. experience higher rates of homicide from firearms. Rural-urban disparities for injury tend to be intensified with injury severity (for injuries that rural children are at higher risk for) as well as when comparing more extreme rural and urban region. Health care costs per child for overall injuries are higher for rural children. For other categories of injury, there was a lack of consistency in the results or an insufficient number of studies to review.

2.4.2 Interpretation

Higher risk of overall injury for rural children can be explained in multiple aspects. First, it may be attributed to the greater distribution of populations at high risk of injury (e.g., farm children [59,60] or Aboriginal children)[61] and hazardous environmental conditions related with farming, mining, fishing, and forestry[62] in rural vs. urban areas. Secondly, the disparity is more likely affected by apparent higher rates of MVC injury for rural children, which can be linked to several factors including higher driving speed in rural areas,[63] more frequent alcohol use,[64] lower restraint usage rates for rural children,[65] and delayed access to pediatric trauma care in rural areas.[66,67] Thirdly, the rural-urban injury disparity may be influenced by potential confounding factors including socio-economic status and the medical environment that were not controlled for in most of the

included studies. Lower income and education level of rural people[10,12,68] as risk factors of injury[32] may cause overestimation of relative risks of injury for rural vs. urban children. Poorer access to health service in rural areas[10,12] may confound the injury disparity in several ways: a possibility of underestimating minor injuries in heath databases[69] potentially due to distances required to receive care, an underestimation of hospitalized injuries because of greater pre-hospital deaths[66,67] and transfers to urban hospitals,[70] and increased case fatality due to delay in medical care.[71]

As for other injuries, studies were consistent in reporting higher risk of unintentional injury, traumatic brain injury, drowning, falls, and bicycle-related injuries as well as those involving motor vehicle crashes for rural children, although these were examined by only two studies for each injury. Regarding firearm-related injury, there were different patterns by intent of injury: higher rates of firearm homicides for urban children vs. a tendency of higher rates of unintentional injuries for rural children, which is consistent with findings from previous studies that were conducted for all ages.[72,73] One thing to be advised of is that all of seven studies of firearm-related injury were conducted in U.S. populations. Results on firearm-related injuries and intentional injuries in the U.S. may not be generalized to Canadian populations when reflecting on differences in firearm control regulations between the two countries. Interpretation of child abuse injury findings requires caution due to potential under-ascertainment of cases in hospital/ED discharge data[49] as well as limited search of social care databases in this review. Longer LOS and higher hospital charge of urban

hospitals for sport-related injury may partly be attributed by transfers of rural patients with severe injuries to urban hospitals.[70]

2.4.3 Investigation of heterogeneity

To investigate heterogeneity, effects of some factors on rural-urban differences of injury were examined. First, rural-urban injury disparity tended to increase for more severe injuries, in cases of there being higher risk of injury for rural to urban children. This trend can be explained by more severe injuries for rural children,[74] greater possibility of under-reporting of rural minor injuries,[69] and higher death rates due to delay in medical care.[71] Underestimation of rural minor injuries may be more notable in the U.S. where rural people have lower coverage of health insurance unlike Canada's universal coverage.[12]

Secondly, greater rural-urban injury disparities were likely to be found between more extreme rural and urban areas indicating a linear relationship between levels of rurality and injury rates. Thirdly, national-level data were more consistent across studies in general, while state or province-level data showed wider variations in effect size/direction as shown in figures. This implies more stability of national-level data as well as the need to consider local-level data when prevention strategies target local regions. Lastly, the effects of age and sex on rural-urban injury differences were not consistent across studies except effects of sex on MVC injury (i.e., greater RRs for males than females) and combined effects on firearm injury (i.e., greater RRs for older males). Although injury death rates for children have declined since the late 1970s,[15] whether the declines were comparable between rural and urban children over time was difficult to examine.

2.4.4 Strengths and limitations

This systematic review was methodologically rigorous with a protocol and contained a comprehensive search strategy to discover the body of evidence of this topic. This review covers every cause/intent of injury outcome, providing a full-spectrum of injury disparity patterns between rural and urban children. We included only population-based studies that provided injury rates so that the results from this review may be generalizable to paediatric populations in Canada or the United States.

There are some methodological limitations of the primary studies included. The risk of bias of primary studies may limit the validity of the results as the majority of the studies applied descriptive rather than analytical statistics by calculating injury rates without controlling for potential confounders. Descriptive statistics may be meaningful to show the real trends of incidence, however, they may not be sufficient to examine the effect of residential area on injury incidence due to potential confounding. In addition, some studies on non-fatal injuries made unit-of-analysis errors[75] in calculation of injury rates by not adequately considering multiple injury events for an individual (i.e., not using person-time at risk as a denominator). Although this can result in miscalculation of injury rates, it does not affect relative risk due to a 'nullifying' of denominators in calculations.

There was substantial heterogeneity among the included studies that originated from the clinical diversity (e.g., cause/intent of injury, severity of injury, and characteristics of participants including age, race, and study setting) as well as from methodological variations (e.g., study design, data sources,

urban/rural classification/definition, and statistical methods). The large heterogeneity precluded a statistical pooling of effect estimates and hindered valid comparisons of results across the studies.

Most of the included studies classified rural-urban status by residential area, but several studies on MVC injuries and firearm injuries classified by a place of injury occurrence. Findings about MVC injury and firearm injury may be biased as we combined studies that applied the different rural-urban classification methods. However, this bias may not be significant as prior studies reported that place of fatal crash primarily matches with driver's residential areas[76] and that for the majority of firearm deaths they occurred within a county of residence.[37]

Although the Newcastle-Ottawa quality assessment scale is recommended for a systematic review for non-randomized studies,[75,77,78] reliability or validity of the tool was not provided. Further, we had to modify this scale without verification due to inapplicability to injury studies. A quality assessment tool considering unique characteristics of injury outcome should be developed in future studies. Even though this review was comprehensive, publication bias and selection bias (e.g., not including publications in French language) may be possible.

2.4.5 Implications for research and practice

To be more rigorous for future systematic reviews, primary studies on this topic are recommended to use a standard rural-urban definition to reduce heterogeneity among studies, to report injury rates with proper denominators, to perform analytical statistics controlling for potential confounders and offering SE of

measure of comparison for meta-analysis, and to provide data with basic figures of variable-adjusted as well as variable-specific injury rates (e.g., injury rates for age subgroups).

More efforts should be made to reduce the greater burden of overall injury for rural children, especially, of severe injury for children in remote rural areas. Interventions to reduce the higher risk of MVC injury for rural children, especially males are in need through increased use of child restraints, intensified driver-safety regulations, and education. The clear pattern of higher suicide rates for rural children is alarming, and identification of risk factors focusing on this suicide disparity is required in future studies. Stricter firearm controls may help to decrease firearm-related injury for paediatric populations, in particular, older paediatric males in the urban U.S.. Finally, more studies are needed for a clear understanding of geographical disparity on minor injuries such as burns, drowning, and poisoning and other health-related outcomes (e.g., disability) that are likely to show rural-urban injury differences.

2.5 Conclusions

There were rural-urban differences demonstrated in rates and patterns of injury in children based on 41 studies having a moderate risk of bias. Rural children sustain a higher rate of overall injury, particularly from MVC and suicide, while urban children in the U.S. suffer from a higher rate of firearm-related homicides. Greater injury disparities tend to be found between more extreme rural and urban regions. In particular, children in remote rural areas are at increased risk of severe injuries

than urban counterparts, possibly due to more hazardous environment, lower SES, and delayed access to paediatric trauma care in remote rural areas. These findings indicate the need for developing preventive strategies specific to each setting. Design changes in primary studies could also increase the possible utility of future systematic reviews. Future research is required to investigate rural-urban disparity for less-studied injuries and related health outcomes as well as temporal trends of identified disparities.

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Table 2-1. Characteristics of the included studies

Study Study ID, design	Setting Location, period, data sources	Populations Age, sample size, compositions	Comparison Urban/rural definition, classification	Outcomes Category of injury, severity	Results Measure of difference (RR or ORs or SMRs)
Brownell, 2002[31] Administrative data	Canada (Manitoba) 1994-1997, 1994/95-1998/99 (Province wide) Vital statistics(1994-1997), hospital discharge data (1994/95-1998/99)	<20 312 fatal injuries, 12,100 Hospitalizations * Winnipeg (metro): 51% of paediatric population	(2 categories) 1) Winnipeg (metropolitan), 2) Non-Winnipeg (non-metro) * By residence area	Any injury (unintentional + intentional) * Deaths, Hospitalizations	Rate Ratio (Non-metro vs. metro) * Hospitalizations: 2.43 * Death: 2.20 (Falls 2.18, motor vehicle 2.75, violence by self 2.70, violence by others 1.46, other injury 2.62)
CIHI, 2006[4] Administrative data	Canada 1986-1996 (Nationwide) Canadian Mortality database	<20 Sample size: not found * Urban (CMA/CA): 78.5% of population of all ages	(5 categories) 1) Urban(CMA/CA), 2) Rural (4 subcategories of MIZ: Strong, moderate, weak, no MiZ) * By residence area	Any injury (unintentional + intentional) * Deaths	Standardized Mortality ratio * Overall injuries (ref: urban (CMA/CA) - 0-4yrs: strong MIZ 1.40, moderate MIZ 2.23, weak MIZ 2.55, no MIZ 4.24 - 5-19yrs: strong MIZ 1.66, moderate MIZ 2.01, weak MIZ 2.55, no MIZ 3.53 * Motor vehicle crashes (no MIZ vs. urban): 0-4yrs 3.22, 5-19yrs 2.93 * Suicide (no MIZ vs. urban): 5-19yrs 4.75 * See the article for RRs of overall injury, motor vehicle, and suicide by sex
Coben, 2009[27] Administrative data	The U.S. 2004 Nationwide Inpatient Sample (NIS)- discharge data of 20% hospitals of all the U.S. hospitals	<15 * Males: 50% of cases * Large urban: 51%, small rural: 9% of cases	(4 categories) 1) large urban: UIC code 1, 2) small urban: UIC code 2, 3) large rural: UIC code 3-6, 4) small rural: UIC code 7-9 * UICs: urban influence codes * By residence area	Any injury (unintentional + intentional) *Hospitalizations	Rate Ratio (ref: large urban) * 0-4yrs : small urban 1.05, large rural 1.17, small rural 1.11) * 5-14yrs : small urban 0.96, large rural 1.16, small rural 1.25
Coyne 1999[48] Administrative data	The U.S. (North Carolina) 1990-1995 (State wide) Medical Examiner database	11-18 419 victims * Males: 51% of population, 79% of victims * Urban:65% of population, 72% of victims	(2 categories) 1) Urban : Metropolitan statistical area (>50,000) 2) Rural: non-MSA * By county of residence	Homicide * Deaths	Rate Ratio (rural vs. urban): 0.72

Table 2-1. Continued

Study Study ID, design	Setting Location, period, data sources	Populations Age, sample size, compositions	Comparison Urban/rural definition, classification	Outcomes Category of injury, severity	Results Measure of difference (RR or ORs or SMRs)
Danseco, 2000[19] Survey	The U.S. 1987-1994 National Health Interview Survey (NHIS)	<22 3,073 injuries (3,058 children) * Males: 61%, metropolitan : 75%, white: 85% of all injuries, respectively	(2 categories) 1) Metropolitan: MSA-central city and MSA-non-central city 2) Non-metropolitan: non-MSA-non-farm and non-MSA-farm * By residence area	Any injury (unintentional + intentional) * Deaths * Non-fatal injury: medically attended or temporarily disabling	Rate Ratio (non-metro vs. metro) - Non-fatal: 1.25 - Fatal: 1.32 * Costs per child : metropolitan $1200 , non-metropolitan $1800
Gabella, 1997[17] Administrative data	The U.S. (Colorado) 1991-1992 (State wide) Hospital discharge data , death certificate data	<20 6,368 cases for all age groups including adults * Males: 67% of injures for all ages * CMSA: 54%, rural, remote: 3% of injuries for all ages	(4 categories) 1) CMSA : >1 million 2) Other metro (=MSA) : >100,000 or contain a place with >50,000 3) Rural, non-remote : adjacent to an MSA or 2,500 4) Rural, remote * By county of residence	Traumatic brain injury * Hospitalizations or deaths	Rate Ratio (rural remote vs. CMSA) - Male: 0-4 (0.18), 5-14(2.16), 15-19(1.38) - Female: 0-4 (1.11), 5-14(1.22), 15-19(2.02) * presented with graphs: see the article for rates by regional category
Gagne, 2009[26] Administrative data	Canada (Quebec) 2000-2004 (Province wide) Hospital data system	<15 24,540 injuries * Males: 64% of all injuries * CMSA of Mon.: 40% , small towns & rural area: 27%of injuries	(4 categories) 1) CMA of Montreal, 2) Other metropolitan (>100,000), 3) Agglomerations (10,000 to 100,000), 4) Small towns and rural area (<10,000) * By residence area	Any injury (unintentional) * Any hospitalizations * Severe cases: hospitalizations (≥3 days), admission to the intensive care unit, or death	Rate Ratio (ref : CMA(Montreal)) * Any injury: other metropolitan 1.20, agglomerations 1.51, small towns & rural 1.36 * Severe injury: other metropolitan 1.04, agglomerations 1.22, small towns & rural 1.45
Gilbride, 2006[32] Administrative data	Canada (Alberta) 1995/96 (State wide) Health databases (physicians, emergency, hospitals)	<18 182,759 children * Males: 49% of participants, 56% of injuries * Urban: 73% of participants, 74% of injuries	(2 categories) 1) Rural: second character of a postal code is "0“ 2) Urban: others * By residence area	Any injury (unintentional + intentional) * Injury seen by a physician	Rate Ratio (rural vs. urban) * Total (0-17): 0.94 * By age group: 1-4(0.98), 5-9(0.91), 10-14(0.91), 15-17(1.0)

Table 2-1. Continued

Study Study ID, design	Setting Location, period, data sources	Populations Age, sample size, compositions	Comparison Urban/rural definition, classification	Outcomes Category of injury, severity	Results Measure of difference (RR or ORs or SMRs)
Hammig, 2003[46] Administrative data	The U.S. (Illinois) 1988-1998 (State wide) Compressed Mortality File (CMF) of CDC	1-14 3,481 fatal injuries * Males: 64% of all deaths * Urban: 81% of all deaths	(2 categories) 1) Non-metropolitan: <50,000 * By county of residence	Any injury (unintentional + intentional) * Deaths	Rate ratio (rural vs. urban) * All unintentional : 1.3 - Motor vehicle: 1.4 (Occupant:1.2, Pedestrian: 0.7, Pedal cyclist: 2.3, Others 3.0); Drowning :1.4 ; Suffocation: 1.0, Fire: 1.0; All others: 2.3; * All intentional 0.5 (Homicide 0.4, Suicide 2.0)
Harruff 1992[51] Administrative data	The U.S. (Tennessee) 1961-1988 (State wide) Medical examiner reports	<20, 225 fatal injuries * White boys:58%, black boys: 25%, white girls: 11%, black girls: 5% of all deaths	(2 categories) 1) Urban counties : >100,000, 2) Rural counties: the others * By county of residence	Firearm (Unintentional) * Deaths	Rate Ratio (rural vs. urban): 0.53
Hopkins, 1990[18] Administrative data	The U.S. (Ohio) 1979-1986 (State wide) Death database	1-16 4,212 fatal injuries * Metro: 61% of study population (white 80%, non-white 20%) * Non-metro: 39% of study pop. (white: > 96%)	(2 categories) 1) Metropolitan counties : >50,000 persons, 2) Nonmetropolitan: the others * By county of residence	Any injury (unintentional + intentional) * Deaths	Rate ratio (ref: metro white) -Boys: Non-metro 1.21, metro non-white 1.45 - Girls: Non-metro 1.30, metro non-white 1.77) * 96% of metro: white * presented with graphs
Hwang, 1997[47] Administrative data	The U.S. (Colorado) 1980-1988 (State wide) Death certificate	<15, white 1,010 fatal injuries * MSA: 72% of study population, 71% of all injuries	(2 categories) 1) MSA (Metropolitan statistical areas), 2) Non-MSA * By county of residence	Any injury (unintentional + intentional) * Deaths	Rate Ratio (Non-metro vs. metro): 1.05 * Motor vehicle injuries -Boys: 0-4 yrs 2.4, 5-9yrs 2.7, 10-14yrs 2.0 - Girls: 0-4 yrs 1.6, 5-9yrs 2.1, 10-14yrs 1.9 * Other unintentional injuries -Boys: 0-4 yrs 1.7, 5-9yrs 3.0, 10-14yrs 1.7 - Girls: 0-4 yrs 1.7, 5-9yrs 0.3, 10-14yrs 0.6
Jason 1983[52] Administrative data	The U.S. (Georgia) 1975-1979 (State wide) Data from Georgia	<18 48 fatal injuries * Males: 63% of cases	(2 categories) urban, rural * By residence area	Child abuse (intentional) * Deaths	Rate ratio (rural vs. urban): 0.75

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Table 2-1. Continued

Study	Setting	Populations	Comparison	Outcomes	Results
Study ID, design	Location, period, data sources	Age, sample size, compositions	Urban/rural definition, classification	Category of injury, severity	Measure of difference (RR or ORs or SMRs)
Jiang, 2007[20] Survey	Canada 2002 (Nationwide) Health Behaviour in School-Aged Children (HBSC) Survey	11-15 7,235 adolescents (from 171 schools) * Males: 46% of participants * Large metro 15%, rural 22% of participants	(5 categories) * Beale urban-rural coding system: 1) large metro : >1 million, 2) medium metro : <100,000, 3) small metro : <250,000, 4) non-metro-adjacent : share a boundary with areas of >50,000, 5) rural : <50,000 * By location of a school	Any injury (unintentional + intentional) * Non-fatal injury : treated by a doctor or nurse * Serious injury: hospital admission or missing school or operation	Rate Ratio (ref: large metro) * Medically treated injuries (any injury) : medium metro 1.15, small metro 1.19, non-metro-adjacent 1.17, rural 1.13 * Serious injury: medium metro 1.24 , small metro 1.43, non-metro-adjacent 1.29, rural 1.29
Keck 1988[53] Administrative data	The U.S. (Oklahoma) 1982-1983 (State wide) Medical examiner records	<20 32 fatal injuries * Males: 85% of deaths * Rural: 85% of deaths	(2 categories) 1) Urban: >75,000, 2) Rural: <75,000 * By county of residence	Firearm (Unintentional) *Deaths	Rate Ratio (rural vs. urban) by age group: 0-19 (3.8), 5-9 (2.4), 10-14 (1.4)
King, 1994[43] Administrative data	The U.S. (Alabama) 1978-1989 (State wide) Death certificate data	<5 Sample size: not reported Composition: not provided	* 2 categories - Rural county : <50,000 * 4 categories: urban, suburban, rural manufacturing, rural agriculture * By county of residence	Motor vehicle traffic injury (as passenger) * Deaths	Rate ratio * Using 2 categories (rural vs. urban): 1.97 * Using 4 categories (ref: urban): suburban 1.32, rural manufacturing 2.01, rural agriculture 2.12
Kmet, 2006[33] Administrative data	Canada (Alberta) 1997-2002 (Province wide) Alberta Collision Information System	<20 383 fatal injuries, 3,367 hospitalizations * In Rural area: 70% of all crashes hospitalizations, 81% of all crash deaths	(2 categories) 1) Urban (2 health regions with densities of 160 persons/km2), 2) Rural (the remaining 15 health regions with densities of < 11 persons/km2) * By crash location	Motor vehicle traffic injury (occupants) * Deaths, Hospitalizations	Adjusted Relative Risk (rural vs. urban) * Hospitalizations: 3.0 (95% CI:2.8, 3.2) * Deaths: 5.4 (95% CI: 4.2, 6.9) - Boys: 0-14yrs 0.15, 15-19yrs 0.23 - Girls: 0-14yrs 0.14, 15-19yrs 0.14

Table 2-1. Continued

Study Study ID, design	Setting Location, period, data sources	Populations Age, sample size, compositions	Comparison Urban/rural definition, classification	Outcomes Category of injury, severity	Results Measure of difference (RR or ORs or SMRs)
Lapidus, 1998[44] Administrative data	The U.S. (Connecticut) 1988-1995, 1990-1944 (State wide) Vital statistics (1988-1995), hospital discharge data (1990-1994)	<20 1,403 fatal injuries, 21,148 non-fatal hospitalizations * Town size of >25,000: 62% of paediatric population	(4 categories) by town size 1) >100,000; 2) 50,000-100,000; 3) 25,000-50,000; 4) <25,000 * By residence area	Any injury (unintentional + intentional) * Deaths, non-fatal hospitalizations	Rate Ratio (ref: group 1 (metro)) * Overall non-fatal hospitalization: G2: 0.50, G3: 0.47, G4=rural: 0.54 * Overall deaths: G2: 0.62, G3: 0.57, G4= rural 0.54 * Homicide: G2: 0.17, G3:0.12, G4= rural 0.05 * Motor vehicle occupants deaths: G2: 1.06, G3: 1.15, G4= rural 1.82
Lowry 1998[21] Survey	The U.S. 1992/93 National survey (NHIS) - Youth Risk Behaviour Survey (YRBS)	12-21 10,269 adolescents * Males: 50% of participants * Urban 31%, suburban 45%, rural 24% of participants	(3 categories) 1) Urban: inside a central city within a MSA, 2) Suburban: a central city, but within a MSA, 3) Rural: outside an MSA * By residence area	Fight-related injury (intentional) * Non-fatal	Adjusted Odds ratio (ref: urban): suburban 0.94 , rural 0.78
Macpherson 2004[34] Administrative data	Canada 1994-1998 (Nationwide) hospital discharge records (from CIHI)	5-19 9,367 children injured * Urban 44% , mixed rural/urban 35%, rural 21% of children injured	(4 categories) : urban, mixed urban, mixed rural, rural (by population density) * By residence area	Bicycle-related injury * Hospitalizations (including hospital deaths)	Rate Ratio (ref: urban) * All bicycle injury: mixed urban 1.19, mixed rural 1.34, rural 1.47 * Bicycle-related injury involving motor vehicle collision: mixed urban 1.10, mixed rural 1.10, rural 1.06
Mueller, 1988[28] Administrative data	The U.S. (Washington State) 1981-1983 (State wide) Department of transportation records, Death certificate data	<19 * 293 fatalities for all ages including adults * Urban children: 88% of pedestrian-vehicle collisions	(2 categories) 1) Urban: ≥2,500 populations, 2) Rural: the others	Motor vehicle traffic injury (as pedestrians) * Deaths	* Rate Ratio (rural vs. urban): <5 yrs 1.4, 5-9 yrs 1.0, 10-14yrs 1.5

Table 2-1. Continued

Study	Setting	Populations	Comparison	Outcomes	Results
Study ID, design	Location, period, data sources	Age, sample size, compositions	Urban/rural definition, classification	Category of injury, severity	Measure of difference (RR or ORs or SMRs)
Nance 2010[37] Administrative data	The U.S. 1999-2006 (Nationwide) Vital statistics	<20 23,649 fatal injuries Composition: not provided	(10 categories) : RUC codes (9categories) + central counties (≥1 million populations) * By county of injury occurrence	Firearm (unintentional + intentional) * Deaths	Adjusted Rate Ratio (the most rural vs. the most urban) * Total firearm deaths: 0.91(0.63-1.32) * Firearm unintentional: 2.19 (1.27-3.77) * Firearm suicide: 2.01 (1.43-2.83) * Firearm homicide: 0.27 (0.5-0.15) * See the article for rates by regional category
Nance 2002[42] Administrative data	The U.S. (Pennsylvania) 1987-2000 (State wide) Trauma registry	<20 3,781 children injured * Male: 88-92% of all victims * Urban:77%, non-metro:22% of all victims	(4 categories) 1) Urban: 2 urban counties from code 0, 2) Suburban: remaining code 0 counties, 3) Metro: code 1-3, 4) Non-metro: code 4-9 * Based on modified Rural-urban continuum (RUC) codes (10 category) by county * By county of injury occurrence	Firearm (unintentional + intentional) * Hospitalizations (≥3 days) or deaths or transfer	Rate Ratio (ref: urban) * Total firearm injury: suburban 0.1, metro 0.08, non-metro 0.09 * Firearm-unintentional: suburban 0.39, metro 0.38, non-metro 0.72 * Firearm-assault: suburban 0.06, metro 0.05, non-metro 0.02 * Firearm-suicide: suburban 0.4, metro 0.45, non-metro 0.6
Niemcryk, 1997[41] Administrative data	The U.S. (Nevada) 1989-1992 (State wide) Nevada State Trauma registry	<15 860 injuries * Urban: 84% of paediatric population, 64% of all injuries	(2 categories) 1) Urban (Clark, Carson city, Washoe counties), 2) Rural (other counties) * By crash location	Motor vehicle traffic injury (driver and passenger) * Deaths or hospitalizations	Rate Ratio (rural vs. urban): 2.94 (0-4 yrs: 3.15, 5-14 yrs: 2.83)

Table 2-1. Continued

Study Study ID, design	Setting Location, period, data sources	Populations Age, sample size, compositions	Comparison Urban/rural definition, classification	Outcomes Category of injury, severity	Results Measure of difference (RR or ORs or SMRs)
Oliver, 2009[5] Administrative data	Canada 2001/2-2004/5 National Hospital discharge records with valid person identifier (HPOI)	<20 11,676 cases * Males: 62% of injuries * Urban: 66% of injuries	(2 categories) 1) Urban: CMAs and CAs, 2) Rural: others * CMAs: a total population of at least 100,000 of which 50,000 or more must live in the urban core *CAs: have an urban core of ≥ 10,000 * By residence area	Motor vehicle traffic injury (as occupants + as pedestrians/cyclists) * Hospitalizations	Rate ratio (rural vs. urban) * Motor vehicle traffic incident - as occupants, pedestrians/cyclists: 1.95 - as occupants: 2.44 - as pedestrians/cyclists: 0.90
Owens, 2008[38] Administrative data	The U.S. 2003 (Nationwide) 1) HCUP: ED visit records (15 states), 2) MEPS (national survey-36 states)	<18 1.46 million injuries * Males: 59% of injuries * Large metro: 35%, non-metro: 11% of injuries	(4 categories): 1) aggregate grouping of the urban influence code (UICs): Large metropolitan, Small metro., Micropolitan, nonmetro. & non-micropolitan 2) MEPS data : 2 categories (MSA, non-MSA) * By county of residence	Any injury (unintentional + intentional) * ED visits	* Rate Ratio (ref large metro): Small metro 1.18, Micropolilan 1.38, nonmetropolitan + non-micropolitan 1.47 * ED expenditures per child: urban $608, rural $661 (MEPS data)
Parker 1994[22] Survey	The U.S. (Minnesota) 1991 (State wide) School Survey (39 schools)	15-17 3,051 students * Males: 51% of populations * Urban:58% of populations	(2 categories) 1) Urban: schools with an average of 5% (range 1-13%) farm residents, 2) Rural: school with an average of 39 percent (range 19-67%) farm residents * By school classification according to the percentage of farm students	Injury from work * Any injury seeking medical care or restricted activity ≥ 1 day * Reportable injury: loss of normal activity >3 days and/or permanent problem	Rate ratio (rural vs. urban) * Any injury: 0.87 * Reportable injury: 1.21

Table 2-1. Continued

Study	Setting	Populations	Comparison	Outcomes	Results
Study ID, design	Location, period, data sources	Age, sample size, compositions	Urban/rural definition, classification	Category of injury, severity	Measure of difference (RR or ORs or SMRs)
Patterson 1990[45] Administrative data	The U.S. (Texas) 1984-1988 (State wide) Death certificate data	<15 337 fatal injuries Composition: not provided	(3 categories) 1) Urban 1 : Level A MSA (MSAs having a population of ≥1,000,000) 2) Urban 2: MSA 3) Rural: non-MSA * By county of residence	Firearm (unintentional + intentional) *Deaths	Rate Ratio (non-MSA vs. level A MSA): - Unintentional deaths: 2.89 - Homicide: 0.42 - Suicide: 0.56 * Rate or RR for three R/U categories: not provided
Reid, 2001[54] Administrative data	The U.S. (Minnesota) 1993 (State wide) Hospital discharge data, death certificate data	<20 977 children injured * Metropolitan: 64.5% of populations	(2 categories) 1) Metropolitan 2) Non-metropolitan * By county of residence	Traumatic brain injury * Hospitalizations or deaths	Rate Ratio (non-metro vs. metro): * Incidence: 1.05 * Mortality: 2.37
Riddick 1989[29] Administrative data	The U.S. (Alabama) July 1980-June 1982 (State wide) Records of homicide investigated by the Alabama Department of Forensic Science	<15 41 fatal injuries * Urban 44%, rural 46% of victims	(3 categories) 1) Urban: SMSA with a central city of 50,000 or more, 2) Suburban: SMSA without a central study, 3) Rural: others * By county of residence	Homicide * Deaths	Rate Ratio (ref: urban): suburban 0.38 , rural 1.04
Rose 2008[23] Survey	Canada (Calgary and surrounding area) 2004 School survey (24 high schools)	14-19 2,721 students * Males: 52% of participant* Urban city: 46% of participants	(4 categories) 1) Urban city: Calgary, 2) Other town: >1000, 3) Rural farm 4) Rural: others * By residence area	* Sports injuries * Non-fatal injury 1. Any injury answered 2. Injury treated by a medical person	Adjusted OR (ref: urban (Calgary)) * Any sports injury: other town 0.76 , rural 0.91, rural (farm) 0.98 * Medically treated sports injury: other town 0.78, rural 0.8, rural (farm) 1.08

Table 2-1. Continued

Study Study ID, design	Setting Location, period, data sources	Populations Age, sample size, compositions	Comparison Urban/rural definition, classification	Outcomes Category of injury, severity	Results Measure of difference (RR or ORs or SMRs)
Schnitzer 2004[49] Administrative data	US (Missouri) 2000 (State wide) 1) child abuse reports from Division of Family Services (DFS), 2) hospital discharges, ED visits data (PAS)	<10 5,657 cases * Males: 49% of cases * Urban: 61% of cases	(2 categories): urban, rural * By county of residence	Child abuse (intentional) * Non-fatal	Rate ratio (rural vs. urban) *1.30 (from reports + medical linked data) * 1.49 (from reports (DFS)); 0.56 (from medical data)
Stone 2000[40] Administrative data	The U.S. (Hamilton county, Ohio) 1991-1997 Cincinnati Children's Hospital Medical Center (CHMC) Trauma Registry (ED, hospital)	<15 86 cases * Males: 64% of cases * Urban: 74% of cases	(2 categories) 1) Urban: within the city limits of Cincinnati, 2) Nonurban: remaining Hamilton County area * By residence area	Falls from window (Unintentional) * Fatal + nonfatal injury (ED visits or hospitalizations)	Rate ratio (rural vs. urban): 0.24
Svenson, 1996[50] Administrative data	The U.S. (Kentucky) 1988-1992 (State wide) Vital Statistics	<18 1,024 fatal injuries *Males: 66% of traumatic deaths * Rural: 54% of Kentucky population * Urban children: 45% of deaths	(2 categories) 1) Rural: most of rural counties are located in the Appalachian region or have population of <10,000 2) Urban: the others * By county of residence	Any injury (unintentional + intentional) * Deaths	Adjusted Rate Ratio (rural vs. urban): All trauma 1.93; MVA as occupant 2.39; MVA as pedestrian 1.56; Bicycle 2.11; Burns 2.02; Poisoning 1.49; Drowning 1.62; Falls 1.73; Unintentional firearm-related 4.81; Abuse 1.82; Suicide 1.22; Homicide 1.81
(report 2) sevenson 1996[55]	1988-1993	<20	The same as above	Firearm injury * Deaths	Firearm overall1.26; homicide 0.88; suicide 1.28; unintentional 2.01 * See the article for rates by age and sex
Thompson 1987[35] Administrative data	Canada (Manitoba) 1971-1982 (State wide) Autopsy files of chief coroner	<21, Caucasian 115 fatal injuries * Males: 88% of deaths	(2 categories): urban, rural * By residence area	Suicide * Deaths	Rate Ratio (rural vs. urban) - 15-17 yrs males: 1.86 - 15-17 yrs female: 1.0 * Data of <15 yrs was not provided due to insufficient number of cases

Table 2-1. Continued

Study Study ID, design	Setting Location, period, data sources	Populations Age, sample size, compositions	Comparison Urban/rural definition, classification	Outcomes Category of injury, severity	Results Measure of difference (RR or ORs or SMRs)
Thouez, 1991[36] Administrative data	Canada(Quebec) 1983-1988 (Province wide) RAAQ (Quebec automobile related database)	<15 2,361 non-severe injuries, 271 severe injuries * Urban: 80% of non-severe injuries, 67% of severe injuries	(2 categories) 1) Urban (>1000 and >400 persons/km2), 2) Rural (others) * By crash location	Motor vehicle traffic injury (driver and passenger) * Non-severe injury, severe injury (hospitalizations)	Rate Ratio (rural vs. urban) * non-severe: male 1.19, female 1.05 * severe injuries: male 11.58, female 1.83 - Boys: non severe 1.19, severe 11.58 - Girls: non severe 1.05, severe 1.83
Wilder, 1984[24] Survey	The U.S. 1980-1981 National Health Interview Survey (NHIS)	<17 78,000 households surveyed for the survey of all ages * SMSA: 67% of all participants	(2 categories) Metro = SMSA (Standard metropolitan statistical areas) * By residence area	Any injury (unintentional + intentional) Requiring medical attention or restricted activity ≥ 1 day	Rate Ratio (Non-metro vs. metro): 1.04
Wright, 1985[30] Administrative data	The U.S. (Georgia) 1979 (State wide) Deaths database	<15, white 111 fatal injuries * Urban: 44% of all deaths	(2 categories) 1) Urban: SMSA, 2) Rural: non-SMSA * By county of residence	Motor vehicle traffic injury * Deaths	Standardized mortality ratios (SMRs) with the state of Georgia as standard: Rural 137.62 (p<0.05), Urban 73.87(<0.01)
Yang, 2007[39] Administrative data	The U.S. 2000-2003 Nationwide Inpatient sample (NIS) of HCUP project	5-18 7,979 injuries * Males: 87% of sports injuries * Urban hospitals: 87% of sports injuries	(2 categories) 1) MSA (Metropolitan statistical areas), 2) Non-MSA * By location of hospitals	Sports injuries * Hospitalizations (excluding inpatient deaths)	* Hospital charges per discharge: urban hospitals - 46.1% higher than rural hospitals. * LOS from sports-related injuries: urban hospitals - 5.61% longer
(report2) Ynag 2008[56]	2000-2004	Age: the same as above	The same as above	Sport-related concussions * Hospitalizations	* Adjusted Odds ratio (rural vs. urban): 1.75 (95% CI:1.11 to 2.77)

Table 2-1. Continued

Study	Setting	Populations	Comparison	Outcomes	Results
Study ID, design	Location, period, data sources	Age, sample size, compositions	Urban/rural definition, classification	Category of injury, severity	Measure of difference (RR or ORs or SMRs)
Zavoski 1995[57] Administrative data	The U.S. (Connecticut) 1998-1992, 1986-1990 1) Death certificate data (1988-1992), 2)hospital discharge data (1986-1990)	<20 219 deaths, 533 hospitalizations * Males: 91% of deaths, 93% of hospitalizations * Urban: 78% of all deaths, 76% of hosp.	(2 categories) 1) Urban: Connecticut's five largest urban centers (≥100,000) 2) Nonurban: others * By residence area	Firearm (unintentional + intentional) * Deaths, hospitalizations	Rate Ratio (rural vs. urban) * Homicides by firearm: 0.11 * Hospitalizations for assaults: 0.11
Zierold 2004[25] Survey	The U.S. (Wisconsin) 2001 School survey (Five state-representative school districts , one large urban school in Wisconsin)	10-14 5,464 adolescents(3,189 injured) * Large city 8%, medium city 70%, rural 11% of the injured	(4 categories): Large city, medium city, small town, rural * By location of a school	Injury during summer work * Non-fatal	Adjusted OR (ref: large city): medium city 0.55, small town 0.58, rural 0.51

Table 2-2. Methodological quality of included studies using the modified NOS

< Surveys>

Study	Selection			Comparability	Outcome	Overall NOS score*
	Representativeness of the exposed	**Selection of the non-exposed**	**Ascertainment of exposure**	**Comparability of cohorts**	**Outcome assessment**	
Wilder 1984[24]	Representative *	Same commu.*	Secure record *	No	Self report	3/6
Danseco 2000[19]	Representative *	Same commu.*	Secure record *	No	Self report	3/6
Jiang 2007[20]	Representative *	Same commu.*	Secure record *	No	Self report	3/6
Lowry 1998[21]	Representative *	Same commu.*	Secure record *	Adjusting for age, gender, race, physical fighting, weapon-carrying **	Self report	5/6
Parker 1994[22]	Representative *	Same commu.*	Secure record *	No	Self report	3/6
Rose 2008[23]	Representative *	Same commu.*	Secure record *	Adjusting for age, gender, ethnicity, parent's education, sport exposure, BMI **	Self report	5/6
Zierold 2004[25]	Representative *	Same commu.*	Secure record *	Adjusting for age, gender, race, hours worked, training, etc**	Self report	5/6

Table 2-2. Methodological quality of included studies using the modified NOS (continued)

< Studies with administrative health databases>

Study	Selection			Comparability	Outcome	Overall NOS score*
	Representativeness of the exposed	Selection of the non-exposed	Ascertainment of exposure	Comparability of cohorts	Outcome assessment	
Brownell, 2002[31]	Representative *	Same commu.*	Secure record *	Age, sex standardization*	Record*	5/6
CIHI, 2006[4]	Representative *	Same commu.*	Secure record *	Age*	Record*	5/6
Coben 2009[27]	Representative *	Same commu.*	Secure record *	No	Record*	4/6
Coyne 1999[48]	Representative *	Same commu.*	Secure record *	No	Record*	4/6
Gabella 1997[17]	Representative *	Same commu.*	Secure record *	No	Record*	4/6
Gagne 2009[26]	Representative *	Same commu.*	Secure record *	Adjusted for age and sex*	Record*	5/6
Gilbride 2006[32]	Representative *	Same commu.*	Secure record *	No	Record*	4/6
Hammig 2003[46]	Representative *	Same commu.*	Secure record *	No	Record*	4/6
Harruff 1992[51]	Representative *	Same commu.*	Secure record *	No	Record*	4/6
Hopkins,1990[18]	Representative *	Same commu.*	Secure record *	No	Record*	4/6
Hwang, 1997[47]	Representative *	Same commu.*	Secure record *	No	Record*	4/6
Jason 1983[52]	Representative *	Same commu.*	Secure record *	No	Record*	4/6
Keck 1988[53]	Representative *	Same commu.*	Secure record *	No	Record*	4/6
King 1994[43]	Representative *	Same commu.*	Secure record *	No	Record*	4/6
Kmet, 2006[33]	Representative *	Same commu.*	Secure record *	Adjusting for age, sex, calendar year*	Record*	5/6
Lapidus, 1998[44]	Representative *	Same commu.*	Secure record *	No	Record*	4/6
Macpherson 2004[34]	Representative *	Same commu.*	Secure record *	No	Record*	4/6
Mueller 1988[28]	Representative *	Same commu.*	Secure record *	No	Record*	4/6

Table 2-2. Methodological quality of included studies using the modified NOS (continued)

Study	Selection			Comparability	Outcome	Overall NOS score*
	Representativeness of the exposed	Selection of the non-exposed	Ascertainment of exposure	Comparability of cohorts	Outcome assessment	
Nance 2002[42]	Representative *	Same commu.*	Secure record *	No	Record*	4/6
Nance 2010[37]	Representative *	Same commu.*	Secure record *	Adjusting for various social, demographic, economic factors**	Record*	6/6
Niemcryk, 1997[41]	Representative *	Same commu.*	Secure record *	No	Record*	4/6
Oliver 2009[5]	Representative *	Same commu.*	Secure record *	No	Record*	4/6
Owens 2008[38]	Representative *	Same commu.*	Secure record *	No	Record*	4/6
Patterson 1990[45]	Representative *	Same commu.*	Secure record *	No	Record*	4/6
Reid 2001[54]	Representative *	Same commu.*	Secure record *	No	Record*	4/6
Riddick 1989[29]	Representative *	Same commu.*	Secure record *	No	Record*	4/6
Schnitzer 2004[49]	Representative *	Same commu.*	Secure record *	No	Record*	4/6
Stone 2000[40]	Representative *	Same commu.*	Secure record *	No	Record*	4/6
Svenson, 1996[50]	Representative *	Same commu.*	Secure record *	Adjusting for age, sex, 911 service, etc. **	Record*	6/6
Thompson 1987[35]	Representative *	Same commu.*	Secure record *	No	Record*	4/6
Thouez, 1991[36]	Representative *	Same commu.*	Secure record *	Age standardization*	Record*	5/6
Yang, 2007[39]	Representative *	Same commu.*	Secure record *	Adjusting for age, sex, income, etc**	Record*	6/6
Wright 1985[30]	Representative *	Same commu.*	Secure record *	Age*	Record*	5/6
Zavoski 1995[57]	Representative *	Same commu.*	Secure record *	No	Record*	4/6

* The NOS score was calculated by awarding a maximum of two stars for an item of comparability and one star each for other items. Scores are summed and range from zero to six stars.

Figure 2-1. Flow of study retrieval and selection

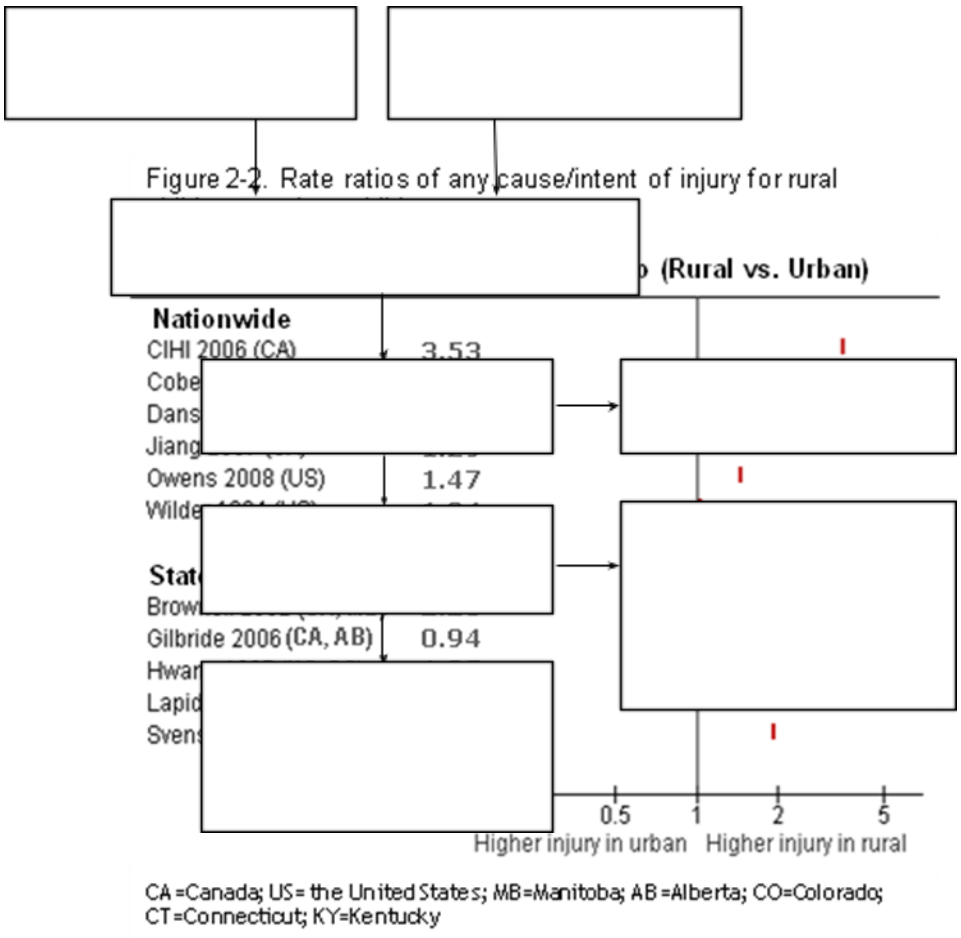
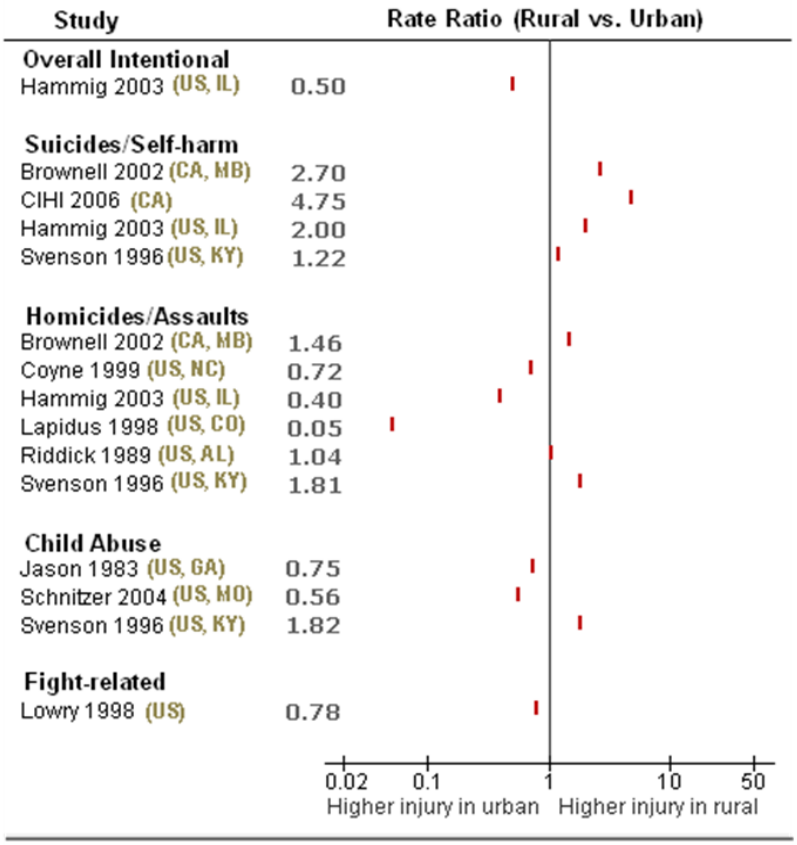
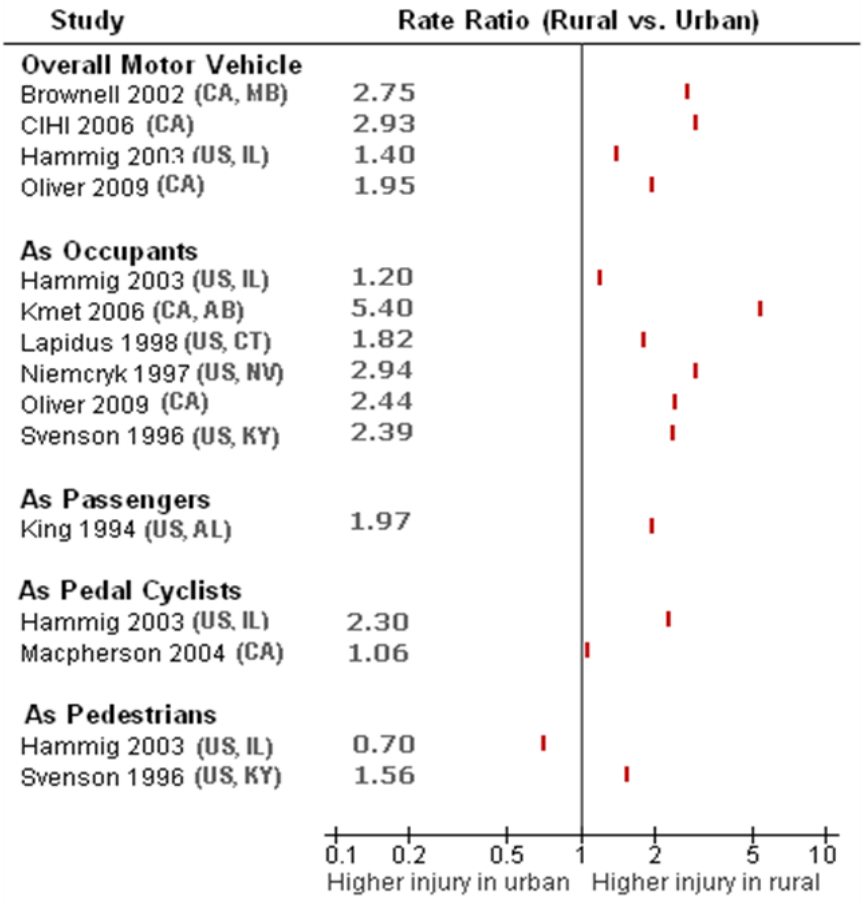


Figure 2-3. Rate ratios of intentional injury for rural children to urban children



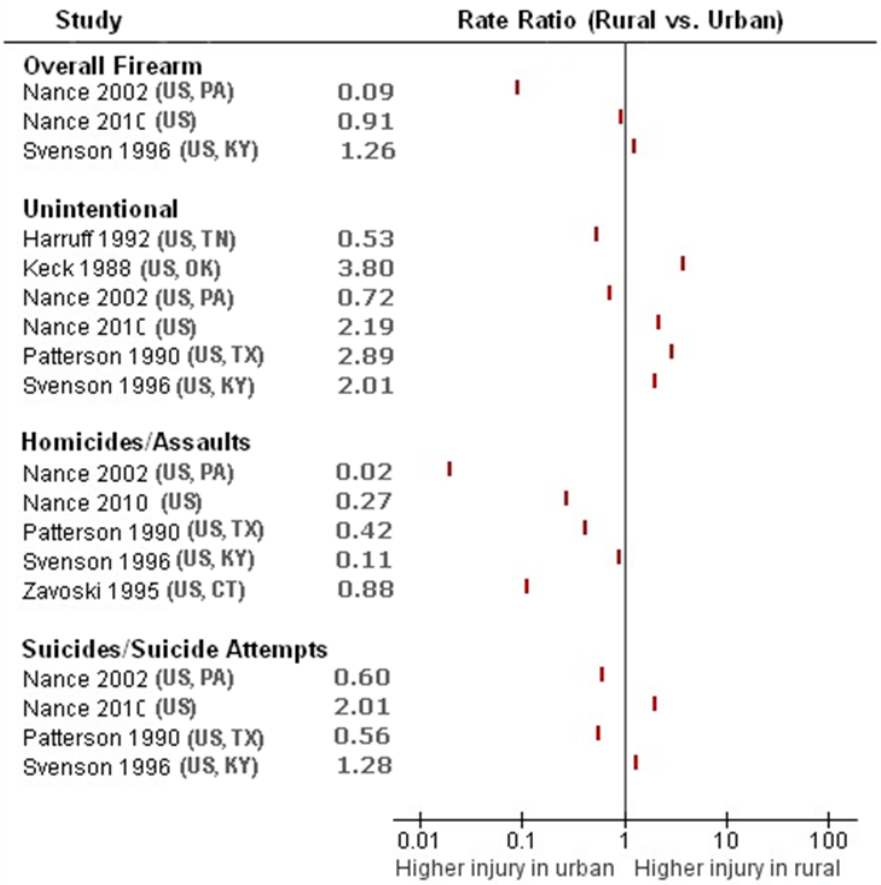
US=the United States; IL= Illinois; CA=Canada; MB=Manitoba; KY=Kentucky; NC=North California; CO= Connecticut; AL=Alabama; GA=Georgia; MO=Missouri

Figure 2-4. Rate ratios of motor vehicle crash-related injury for rural children to urban children



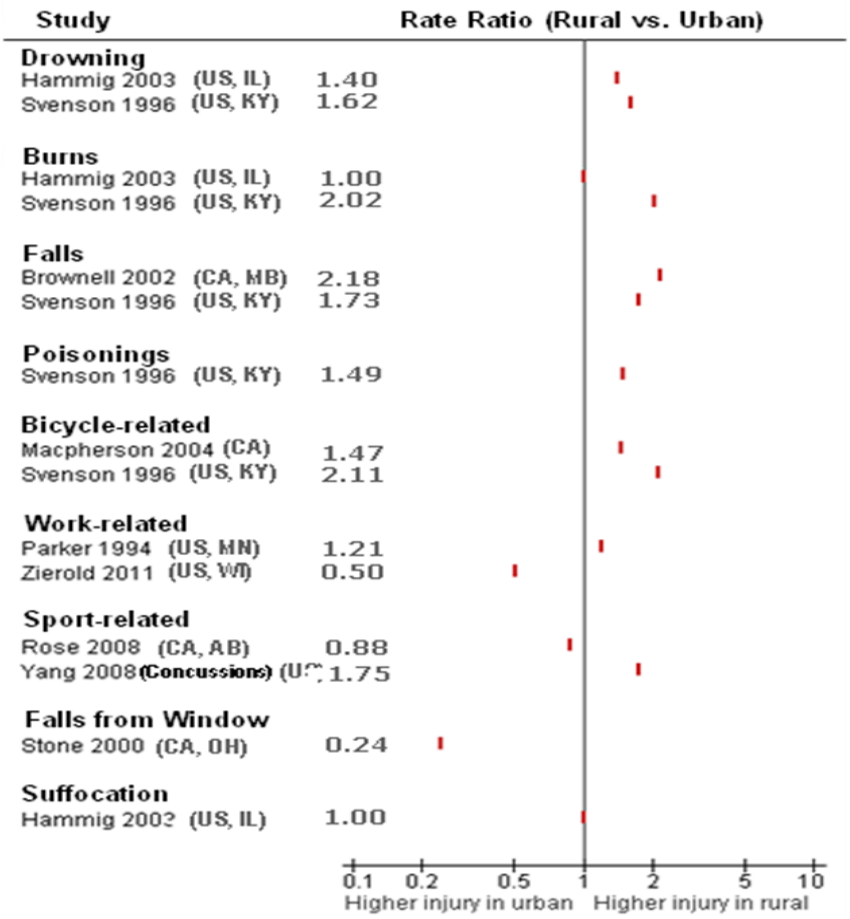
CA, Canada; MB, Manitoba; US, The united states; IL, Illinois; AB, Alberta; CT, Connecticut; NV, Nevada; KY, Kentucky; AL, Alabama

Figure 2-5. Rate ratios of firearm-related injury for rural children to urban children



US=The united states; PA=Pennsylvania; KY=Kentucky; TN=Tennessee; OK=Oklahoma; TX=Texas; CT=Connecticut

Figure 2-6. Rate ratios of other cause of injury for rural children to urban children



US=The united states; IL=Illinois; KY=Kentucky; CA=Canada; MB=Manitoba; MN=Minnesota; WI=Wisconsin; AB=Alberta; OH=Ohio

Chapter 3. Differences in incidence of all-cause injury between farm, rural, and urban children in Alberta

3.1 Introduction

Injury is known as a major cause of death in children in Canada.[1] A wide range of socio-economic, cultural, physical environment factors and living conditions that children are exposed to can play a significant role in determining their health including the incidence of injury.[2,3] It is assumed that farm children suffer from high rates of injury due to complex environmental hazards related to both farms and life in rural areas. Firstly, agriculture is one of the most dangerous occupational sectors in Canada,[1,4] and farm children are often exposed to agricultural hazards in their daily life either by working on farms[5,6] or by living on farms, which have resulted in high paediatric agricultural injury rates.[7-11] Secondly, farm children are also exposed to health-related rural conditions including exposures to diverse dangerous primary industries,[4,12] risky rural driving/road conditions,[13-15]) poorer access to health services,[12,16] and lower socio-economic status.[17,18] Prior studies have reported that rural children were at a higher risk of overall injury[19,20], motor vehicle injury[19,21,22], and suicide[19,21] than urban children in Canada. A systematic review on pediatric injuries in Canada and the United States[23] reported that children living in more remote rural areas are likely to be at a higher risk of overall injury, especially of severe injury, than their urban counterparts.

Despite of the likelihood of high risk of injury for farm children, the

comparative approach to examine the relative risks of overall injury for farm children compared with ones for other pediatric groups have rarely been examined in previous research. Most studies involving farm children as participants have addressed only agricultural injury. More precisely, there have been a substantial number of studies on farm-related injuries among all children in a general population[7,9,24-26], a few surveys on all agricultural injury occurred on farms,[27-30] and some studies on occupational injury for young workers in agriculture in comparison with those in other industries.[11,31] These prior studies have applied an agricultural injury-focused approach rather than farm children-oriented one. To our knowledge, an examination of the risk of all-cause injury including both agricultural and non-agricultural injuries for farm children has not been conducted in North America. Another shortfall in the literature is a paucity of injury rate comparisons between farm and other or general paediatric populations.

A substantial number of studies examined differences in injury rates between rural and urban children.[19,32-37] However, comparisons of overall injury incidence between heterogeneous rural paediatric groups, particularly, between farm and non-farm children have not been performed in North America. Rose (2008)[38] conducted a survey to compare the injury experience for children living in urban city, town, rural areas, and farms, but this study examined only sports-related injury for adolescents.

In Alberta, there was a unique opportunity to set up farm population list in 1998, from which an Alberta farm children list can be derived. In the present study, the farm children list was linked to multiple administrative health databases

so that all injury records for identified farm children could be tracked from 1999 to 2010.

The aim of this study was to examine risk and patterns of all-cause incident injury for farm children compared to non-farm children (rural, urban children) under 18 years of age in Alberta using the linkage of multiple administrative databases. Comprehensive understanding of the relative burden and patterns of injury for farm and non-farm children would contribute to the development of appropriate injury prevention initiatives and safety standards for farm and other groups of children.

3.2 Materials and methods

3.2.1 Study Design

A population-based retrospective cohort study with a closed population was conducted to examine incidence of injury for pediatric subjects using the linkage of the multiple administrative databases from January 1, 1999 to December 31, 2010. All subjects that met the inclusion criteria in the fiscal year of 1998 were selected and followed up until they became 18 years of age within the study period.+

3.2.2 Study participants

In 2006, Alberta's population consisted of an 82.1% urban and 17.9% rural

populations where a quarter of those located rurally are farm families.[39] Alberta farms accounted for 31.2% of all farms in Canada, and main farming practices were cattle (beef) ranching and grain/oilseed farming in 2006.[40] The study population consisted of farm and three groups of non-farm children under 18 years of age (rural-non-First Nations (FN) children, rural-FN children, urban children) who lived in Alberta in the fiscal year of 1998/99 and were not lost to follow up before the start of the study period (January 1, 1999). As a closed population, there was no new entry into the study population after the initial selection of subjects. Subjects left the study due to death, migration or by becoming 18 years of age.

Farm children were identified from the all-ages Alberta farm population list that captured virtually all farm residents in Alberta. The all-ages farm population list was set up by probabilistically linking the Farm Fuel Tax subsidy list in 1998 and Health Care Insurance Plan Registry file in the same year to identify farm families. Two groups of non-farm children (rural and urban children) were extracted from two representative samples of all-ages non-farm rural and urban population that were randomly selected from the Alberta Health Care Insurance Plan registry with the equivalent sample size to the farm population, respectively. Rural children were classified into FN and non-FN based on the Alberta health insurance premium status. Classification of rural or urban residence of subjects was based on their postal code in 1998 from the registry file: a postal code with a "0" as the second character denotes a rural area where there are no letter carriers and residents go to the corner postal box or the post office to pick up their mail.[41]

3.2.3 Data Sources

Injury data for 12 calendar years (1999 to 2010) were derived from four administrative health databases that are maintained by Alberta Health, Government of Alberta. The Alberta Health databases capture information on medical services of all individuals in Alberta eligible for Alberta Health care coverage. Alberta has a social health care system where all medically necessary services are universally provided according to the Canada Health Act.[42] Four heath databases included Alberta Vital Statistics File, Hospital Discharge Abstract Database, the Ambulatory Care Classification System, and Physician Claim File that contain data for mortality, hospital admissions, emergency department (ED) visits, and physician visits, respectively. The Physician Claim File consisted of services performed in a physician office, in hospital, in the ED, or diagnostic & therapeutic centers.

Demographic information of subjects (age, sex, 3 digits of postal code, migration, health zone, and Alberta health insurance premium status) was obtained from the Health Care Insurance Plan Registry file. The insurance premium status was used as a proxy measure of socioeconomic status (SES) and categorized into high SES (i.e., no subsidy group) and low SES (i.e., FN treaty-status Aboriginals, full premium subsidy, and partial premium subsidy groups) in this study. All the health databases and the Health Care Insurance Plan Registry file were deterministically linked using scrambled personal health number (PHN) and merged into a single file arranging all injury records and demographic information by each study subject.

3.2.4 Injury identification

Injury data were medical records that contained the following International Classification of Disease (ICD) diagnostic codes or external causes of injury codes (E-codes) for "injury and poisoning" in any of diagnostic fields, including early complication or sequelae of trauma but excluding complications of medical and surgical care and misadventures;

a. Diagnostic codes: 800-995 except 909(.3, .5) (ICD-9) or SOO-T98 except T80-T88 (ICD-10)

b. E-codes: E800-E869, E880-E929, E950-E999 (ICD-9) or V01-Y36, Y85-Y87, Y89 (ICD-10)

The body site, nature, mechanisms, and intent of injury were classified into subcategories based on categorization tables for ICD diagnostic codes or external causes of injury codes (E-codes) for ICD 9th and ICD 10th revision coding system, respectively. The categorization tables followed previously published frameworks or matrices including the Barell Injury Diagnosis Matrix, Injury Mortality Diagnosis Matrix, and ICD-10 and ICD-9 comparability table for mechanism and intent codes.[43-45] The categorization table also covered the injury data that were coded with ICD 9th revision Clinical Modification (ICD-9-CM) and ICD 10th revision Canada (ICD-10-CA) system, because sufficiently broad subcategories (8 body sites, 16 nature, 5 types of intents, and 19 mechanisms) were used to reduce the possibility of diagnostic categorization error occurrences due to different ICD versions.

3.2.5 Injury episode

One injury event may result in multiple services. As a unit of injury case, an episode of injury was created by integrating all the related medical records for the same injury event into one injury episode across the four combined databases. To construct the injury episode, all injury data from multiple sources were merged together and sorted by subject's identification (ID) and medical service date. Beginning with the first injury record for each child, the immediate next injury record for the same child was determined whether the record is a follow-up visit of the previous record or another new injury episode for the child with the criteria. The criteria were built from a detailed data examination and modification of the criteria used in previous publications, [46-48] while trying to be conservative in determining a record as a follow-up visit not to lose any incident case. An additional three years of injury records prior to 1999 were used to eliminate any incident injuries that occurred before 1999 and were treated resultantly after 1999.

To be determined as a follow-up visit of the previous injury record, the injury record should meet at least one of the following criteria compared with the previous injury record: the injury record (1) had ICD codes for sequelae or late effect of injury; (2) appeared on the same day; (3) occurred within 7 days in the same category of body region or the nature of injury; (4) occurred within 180 days in the same category of both body region and nature of injury; or (5) occurred within 180 days with the exactly same diagnostic codes in all ten ICD diagnostic fields compared with the previous injury record. Episode identification for fatal cases was manually conducted, as the Vital Statistics database contains only a

single E-code without any supporting diagnostic codes.

For each injury episode, only the record at the highest level of care was extracted and used in the analysis while serving a role as a proxy of severity of an injury episode. If there were multiple records at the same highest level of care (e.g., two hospitalization records for a child), the earlier record was chosen. A single episode of injury might contain multiple E-codes for mechanisms (e.g., fall and burn). An episode with multiple E-codes was counted once for the calculation of overall injury rate, but counted multiple times in respective E-code categories for the generation of cause-specific injury rates.

A child may experience multiple episodes of injury during the study period. To consider this, a time to multiple injury episodes model was used in all analysis, where all injury episodes of interest for a subject were taken into account, and time at risk of an injury episode for the subject continued after an injury episode until the true end of follow-up of the child.

3.2.6 Statistical analysis

Descriptive analysis for demographic variables (age, gender, proxy SES, and health service zone by residential area) and for injury episodes were generated by children's groups and proxy severity of injury (i.e., the highest level of care per episode) using frequencies, proportions, and rates. Differences in demographic variables between children's groups were tested using one-way ANOVA and chi-square statistics. Injury episodes for hospitalizations, emergency department (ED) visits, and deaths that contained valid E-codes for injury and poisonings

were classified by mechanism and intent of injury: physician claims do not contain E-codes.

Overall and variable-specific crude incidence rates (i.e., injury episodes per 100,000 person-years) were calculated, where the numerator was the number of injury episodes allowing multiple episodes per child, and the denominator was the sum of time at risk (i.e., total follow-up time) of all subjects. For overall injury, age-and sex-adjusted incidence rates by the level of care were generated with 95% confidence interval (CI) using the direct standardization method[49] and the 2006 Canadian Census population[50] as the standard. For variable-specific injury, crude relative risks (or rate ratios: RRs) of injury for a children's group compared to urban children were calculated with 95% CI. Regarding the follow-up time of an individual, the time point of the end of follow-up of an individual was the earliest time point of the following time points: the first move-out from Alberta; the first move-out from rural to urban areas or vice versa; the first discontinuance of registration of Alberta Health Insurance plan; becoming 18 years of age; and the end of study period. Crude incidence proportions (injuries per 1000 children per year) were calculated for the purpose of a comparison with crude incidence rates.

As an analytical analysis, to examine the relationship between injury incidence and covariates, a recurrent event survival analysis[51-53] using Cox Proportional-Hazard (PH) regression with counting process formation and clustered robust standard errors was carried out. From the Cox Proportional-PH regression, hazard ratios (HRs) of injury for each children's group in comparison

to urban children were estimated with a 95% confidence interval adjusting for potential confounders (i.e., age, sex, and proxy SES). Clustered robust standard errors were estimated to consider correlations within multiple outcomes of data for a child. In the recurrent event survival analysis, a time to multiple injury episodes model was used by allowing multiple injury episodes for a subject, and segmenting the total follow-up time of the subject by multiple time points of injury episodes. Therefore, if a child had multiple events, the child had more than one record (i.e., long data structure), and time at risk of a recurrent event for the child was from the time point of the previous injury episode to that of the next injury episode (i.e., counting process formation) and it was assumed that the recurrent events of the child are independent. Data management was conducted using SPSS Version 18.0 and statistical analyses were carried out using STATA Version 12.1.

3.3 Results

From 1999 to 2010 of 115,378 children under 18 years of age, a total of 275,442 injury episodes (124,594 physician office visits, 145,656 ED visits, 5,029 hospitalizations, 163 deaths as the highest level of care received per episode) were identified. A total of 95.1% of ED visits, 99.0% of hospitalizations, and all of the fatal episodes containing valid E-codes for injury and poisonings were used for the analysis of mechanism and intent of injury. Farm children consisted of rural-living (77.4%) and urban-living farm children (22.7%). As homogeneities

were found in injury patterns and rates between rural- and urban-living farm children, results from the two farm groups were presented in combination. Non-farm rural children were composed of 83.0% non-FN and 17.0% FN children. Since there were considerable heterogeneities between rural FN and non-FN children, results from the two rural groups are presented separately. Rural FN children represented a majority of all FN children in the study population (87.2%). The rest of FN children (12.8% of all FN, 1034 urban-living FN children) were classified into urban children comprising 3% of urban children.

3.3.1 Demographic Characteristics

Demographic characteristics of the four groups of children are illustrated in Table 3-1. Rural FN children were younger (mean age: 8.9 years, $p<0.05$) and more likely to live in the north health services zone of Alberta (53.6 %) than other groups of children. Farm and rural FN children were at a lower SES status (any subsidy for health care premium: 29.1 %, 100%, respectively) than the other groups ($p<0.001$). Two groups of rural children experienced greater loss to follow-up before they reached 18 years of age during the study period (rural non-FN 38.0%, rural FN 26.3%) than other groups ($p<0.001$), mainly due to moves to urban areas (81.6 %, 86.6% of all losses, respectively), while farm children showed the most stable residency with the fewest losses to follow-up (9.1 %).

3.3.2 Incidence rate of injury by the level of care

When all causes and intents of injuries are considered together, farm and rural (FN, non-FN) children consistently experienced higher injury rates than urban children across both sexes and all levels of care, except at the physician office visit level: rates for the physician office visit-level injuries were the highest in urban children across both sexes. Rural FN children sustained the greatest rates (age-and sex-adjusted) of injury-related ED visits (25158.0 episodes per 100,000 person years), hospitalizations (1538.6 episodes per 100,000 person years), and deaths (84.3 deaths per 100,000 person years) across sexes. Rural non-FN children documented the second highest rates for ED visit-level injuries, but for serious injuries (hospitalizations and deaths), farm children ranked second next to rural FN (Table 3-2). As for injuries at all levels of care from physician office visits to deaths combined, the risk if injury was significantly, but slightly higher among farm and rural children than urban children (adjusted hazard ratios: 1.09-1.14). However, when considering injuries at the ED visit level and above combined, hazard ratios of overall injury for farm, rural non-FN, and rural-FN children (reference category: urban) increased to 1.32 (95% CI: 1.30-1.35), 1.43 (1.40-1.46), and 1.60 (1.55-1.66), respectively after adjusting for age, sex, and proxy SES. The adjusted hazard ratios of severe injuries (hospitalizations and deaths combined) further increased to 1.77 (1.64-1.91), 1.7 (1.57-1.87), and 2.67 (2.36-3.02), respectively (Table 3-3).

Overall, injury rates for males were significantly higher than females (adjusted hazard ratios of injuries at the ED visit level and above combined: 1.52, 95% CI: 1.50-1.55). When describing in more detail, injury rates for males were

consistently higher than females across all children's groups and the care levels. The sex disparity consistently increased with proxy severity of injury among urban and farm children (unadjusted RR for males to females for urban and farm children, respectively: 1.18, 1.17 for physician office visits; 1.45, 1.60 for ED visits; 1.81, 1.99 for hospitalizations; 3.90, 2.74 for deaths). However, for two rural groups, there were similar trends as above for physician office and ED visits, but comparable risk of fatal injuries between sexes were found (unadjusted RR: 1.15 for non-FN. 1.06 for FN).

According to the results from multivariate Cox PH regression for injuries, children at a low SES were at a lower risk of overall injury (four databases combined; Hazard ratio: 0.97, 95% CI: 0.96-0.99) but at a higher risk of serious injury (hospitalizations and deaths; Hazard ratio: 1.15, 95% CI: 1.07-1.24) adjusting for children's group, age, and sex.

3.3.3 Intent of injury

With regard to injuries at the ED visit level and above combined, unintentional injuries followed the same patterns as overall injury: farm and rural children consistently had higher rates than urban group across all levels of care, with the highest rate for rural FN group, especially for deaths (Table 3-4). Rural FN children were also at the greatest risk for intentional injuries (crude RR=3.13 for self-inflicted, 4.37 for purposely-inflicted injuries), with a remarkably increased risk for suicide deaths (crude RR=21.1). Farm children were at the lowest risk of

intentional injuries (crude RR=0.56 for violent, 0.33 for self-inflicted injuries), despite a higher rate of death by suicides than rural non-FN or urban children.

When injury episodes at the ED visit level and over were combined, overall, males sustained higher rates of unintentional injuries (crude RR of male to female =1.6) and assaults (crude RR=2) than females , while females sustained higher rates of self-inflicted injuries (crude RR of female to male =2.9), which existed across all children's groups. The proportion of intentional injury tended to increase with the severity of injury: 2.4% at the ED visit-level injuries vs. 22.1% for fatal injuries (suicides 17.8 %, homicide 4.3 %), when all children's groups were combined. A greater proportion of suicides (15.0%) for rural FN children and homicides (28.1%) for urban children than other groups were observed.

3.3.4 Mechanisms of injury

Examination of mechanism-specific injury rates showed that the top three causes of non-fatal injuries (ED visits and hospitalizations) were falls, struck by or against, and transport-related injuries across most children's groups (Figure 3-1). As for fatal injuries, the most likely contributing cause was transport-related injuries across children's groups (crude rate: 4.3-31.5 deaths/100,000 person-years, 47-63% of deaths by children's group) followed by suffocation (crude rate: 0.9-16.8) (Figure 3-2).

When compared with urban children, for injuries at the ED visit level and above combined, farm and rural children experienced higher rates of injury for most mechanisms, notably for Other Land Transport (OLT: land transport injuries

other than motor vehicle traffic, pedal cyclist, pedestrian injuries; i.e., ATVs, animal riding, agricultural vehicle-related injuries; crude RR=2.9~4.3), natural/environmental injuries (i.e., injuries due to natural hazards including animals, plant, lightning, excessive heat or cold, etc., crude RR=2.4~3.2), and firearms (crude RR=2.0-10.3). More remarkably increased risk of firearm (crude RR=10.3, 73% of them unintentional) and suffocation (crude RR=5.6, self-harm 52%, unintentional 48% of them) for rural FN children, and machinery for farm (crude RR=5.2) and rural non-FN children (crude RR=2.6) were observed. In addition to these mechanisms, rural children (FN and non FN) had greater than 2 times the risk for cuts, fire/hot objects/substance, and non-motor vehicle traffic (MVT) pedestrian injuries compared with urban children. When compared with farm children, urban children sustained higher rates of poisonings (crude RR of farm to urban=0.64) and pedal cyclist injuries (crude RR=0.20 for MVT, 0.71 for non-MVT pedal cyclist injuries) across all levels of care (Table 3-5).

When compared within farm and rural children, for injuries at the ED visit level and above combined, the rank of risk for overall injuries among children's groups (rural FN > rural non-FN > farm) were held for all mechanisms except for farm hazard-related ones (specifically, animal-riding OLT, agricultural vehicle-related OLT, farm animal-related natural/environmental injuries, and machinery). As for these mechanisms, the risk rank was opposite (farm> rural non-FN> rural FN) (Table 3-5).

With regard to the detailed causes of transport and natural/environmental injuries, firstly, the leading mechanism of transport injuries was OLT for ED visits

and hospitalizations (overall, 37.7%, 52.3%) and MTV for deaths (70.7%), overall. For injuries at the ED level and above combined, farm children experienced the greatest rate of OLT, followed by rural non-FN, rural FN, and urban children in a descending order. Among OLT injuries, 38.6-57.4% by children's group involved in off-road vehicles (e.g., All Terrain Vehicles (ATVs)) and 19.1-32.7% were animal-riding injuries. Secondly, natural/environmental injuries were mainly composed of bees/wasps/hornets, mammals (ie., dogs and farm animals), and non-venomous insects. Greater risk of dogs and non-venomous insects injuries for rural FN (crude RR=3.1, 3.4), and notably increased risk of farm animal-related injury for farm children (crude RR=6.7) as well as for rural non-FN children (crude RR=3.5) were documented.

3.3.5 Mechanisms of intentional injuries

Intentional injuries were mainly associated with five mechanisms including poisoning, suffocation, cutting/piercing, firearm-related, and struck by or against. Composition of intentional injuries for these mechanisms varied by proxy severity of injury: the higher proxy injury severity was, grater intentional injuries were sustained.

When injuries at the ED visit level and over combined, rural FN children suffered from a strikingly increased risk of unintentional firearm-related injuries (crude RR=11.2), self-inflicted suffocation (crude RR=11.2, for death, RR=39.3) and self- and purposely-inflicted cuts (crude RR=3.2, 5.7, each). Main mechanisms for suicides were suffocations among rural FN children (81.8% of

suicides) and firearms and suffocation among farm children (41.6% of suicides, each). Intent types of firearm injuries varied by children's group: firearm injuries were mostly unintentional (75.0% of ED visits) or assaults (50% of hospitalizations and all deaths) for urban children, but mainly intentional (82.1% of ED visits and 100% of hospitalizations) or suicide (62.5% of deaths) for farm children. Struck by or against were involved in unintentional or assaults across groups.

3.4 Discussion

This study focused on the differences in rates, intents, and causes of injury incidences between farm and several non-farm children's groups. Overall, rural FN children sustained the greatest burden of injury, followed by rural non-FN and farm children, while urban children had the lowest. For injuries at the ED visit level and over combined, farm, rural non-FN, and rural-FN children were 1.32 times, 1.43 times, and 1.6 times more likely to sustain all-cause injuries compared with urban children after adjustment for potential confounders. Farm children were at a higher risk of severe injuries (hospitalizations and deaths) than non-FN rural children. We believe our results on incidence rates and relative risk of all-cause injury for farm children compared to specific groups of non-farm children are novel, as there has rarely been literature available to identify farm children in administrative health data and examine all-causes of injury including both agricultural and non-agricultural injuries for them.

Patterns of injury disparity among farm, rural, and urban children were different by proxy severity of injury (i.e., level of care). Urban children had higher rates of minor-severity injuries (physician office visits), but farm and rural children consistently had higher rates of injuries at the ED visit level and over along with increased injury disparities for more severe injuries (a clearly linear relationship between injury disparity and injury severity). Increased rates of minor-severity injury for urban children could be attributed either by a greater risk of less severe injuries or by relatively superior medical access in urban areas than in rural areas. These findings also imply the importance of proper selection of data sources or injury severity in research, as considerably different pictures of injury disparity (sometimes opposite directions) can be obtained.

Our results on overall patterns for injuries at the ED visit level and above combined confirms the findings from previous publications that have reported higher risk of overall injury for rural children than urban children,[19-21,33] the tendency of increased injury disparities between rural and urban children for more severe injuries,[20,34,37,54] and higher injury risk for FN children compared with non-FN children. [55-57]

Findings on injury mechanisms and causes based on three databases (ED visits, hospitalizations, deaths) were able to present similarities regarding the most common causes of injuries, but distinguishing injury issues for each children's group for less frequent mechanisms of injuries were as follows: 1) struck by or against and falls were the most common causes but appeared to be not considerably different in risk across children's groups; 2) farm children appeared

to sustain a greater burden of unintentional injuries associated with the farm environment including farm machinery, OLT (animal-riding- and agricultural vehicle-related), natural/environmental injuries (farm-animals), and drowning deaths than other groups. Farm children were at a lowest risk for self-harm and violent injuries except suicidal deaths; 3) rural non-FN children appeared to be between farm and rural FN children in terms of injury risk and patterns: rural non-FN children were at a higher risk than farm children but lower than rural FN children for non-traffic pedestrian, poisoning, suffocation, poisoning, overall self-harm and violent injuries. However, rural non-FN children had increased risk of farm hazard-related injuries than rural FN children; 4) FN children living in rural areas had distinct differences in injury incidence from other groups. Besides OLT, natural/environmental, and non-traffic pedestrian injuries that were common for farm and rural groups, remarkably increased risk of unintentional firearm as well as intentional injuries (especially, self-inflicted suffocation and self- and purposely-inflicted cut) were the main issues noted in the analysis.

Regarding the findings for mechanisms and intent, there is consistency with previous publications that have found that struck by or against, fall, and transport injuries are top three causes of non-fatal unintentional pediatric injury[58,59] and that that MVT injury was the leading cause of unintentional fatal injury, [58,59] although the figures of MVT-related death rates in prior research are closer to ones in urban children in the present study they were considerably lower than ones in farm or rural children. The present research also appears to be concordant with prior findings that have revealed the following: machinery

injuries and farm animal-related injuries were the leading cause of agricultural fatal and non-fatal injuries, respectively[30]; ATV-related injuries were more prevalent for rural residents than urban [60]; there were a tendency of greater self-harm for rural children[19,21] and more for assault-related injuries for urban children [21,61]; First Nations children suffered a high risk of unintentional injury, self-harm and assaults-related injury than non-FN children.[55,56,62] Findings from previous research were limited to just one group or simple rural-urban comparisons, but in this study we were able to conduct a valid comparison between farm and diverse non-farm pediatric populations.

When looking at injury-risk differentials between groups in a comprehensive perspective, it was recognized that injury disparity between the farm/rural group and the urban group of children was consistent and universal for most injury mechanisms. There were typical injury mechanisms that had substantially greater risk of injury for specific groups (e.g., farm hazard-related injuries for farm and rural non-FN children, firearms and suffocation for rural FN children) that needs special attentions and preventive efforts to. However, as a whole, the increased risk for farm/rural group was also noteworthy implying the need for intervention efforts for underlying risk factors among farm and rural children, particularly for FN children. Previous research has reported adverse health determinants in rural areas including inferior medical environment (i.e., availability and quality of health care services and programs),[12,16,17,63] lower SES (e.g., income, education, employment)[12,17,18] and higher levels of risky behaviors,[14] in addition to diverse physical hazards.[12,13] Furthermore, FN children

may be affected by social stressors such as cultural alienation, discrimination, and intergenerational effects of Indian Residential Schools.[12,64,65] For this generic and inter-related causes of injury in rural areas, new intervention strategies such as a community-based participatory approaches for rural populations,[12,66,67] multifaceted approaches for farm safety,[68,69] and cultural healing and restoring identity for FN,[70,71] along with common education approaches (e.g., workshops, booklets, awareness campaign, etc.) have recently been introduced and emphasized.

With regard to methodology for injury risk assessment, the relative risk of injury between children's groups appeared to be influenced by the different methods applied to estimate the risk of injury. RR for rural non-FN compared with the urban children was observed to be different when we used incidence density rate (i.e., injuries/1000 person-years) compared with using incidence proportion (i.e., injuries per 1000 children). This may be attributed to a relatively greater loss to follow-up for rural non-FN participants due to a greater number of relocations to urban areas or to other provinces than other children's groups: shorter follow-up time would have led to a reduced denominator in person-time rate resulting in increased incidence density rate. It implies the use of incidence proportions can lead to a relatively greater underestimation of injury risk for populations with a greater tendency to move than other comparison populations.

There were some limitations of the present study. Firstly, this study has limited information on circumstances that lead to injuries, changes in farming status over time, and various risk factors other than age, sex, and a proxy of

socio-economic status. These are inherent weakness of administrative health records that are routinely collected for non-research purposes. Therefore, the potential for misclassification of participant demographic information and injury episode and residual confounding remained.

Second, the possibility of misclassification of injuries exists from errors in coding and charting of injury code and diagnostic errors in administrative data. However, this misclassification is not likely to occur differentially between groups as we have data from a single health system.

Third, some differential misclassification of injury events may occur if healthcare seeking behaviors or accessibility to health care services are different between farm and non-farm residents. If rural populations are less likely to seek or get treatment from the health care system possibly due to the longer distances traveled to health care facilities, rates of injury, particularly for minor injury, may be underestimated.

Forth, the possibility of misclassification of a proxy of socio-economic status for FN children exists. All FN treaty-status Aboriginals in the insurance premium status in Alberta were classified into children in a low SES status in this study, but all FN children may not be in low SES status. However, children's SES status does not appeared to considerably affect the results as there were not much differences between adjusted and unadjusted hazard ratios of injury.

Nevertheless, the strengths of this study in methodology included: 1) increased external validity (i.e., a population-based design with a large sample size); 2) high coverage of injuries (i.e., the use of multiple data sources capturing

all records in the health care system) and provision of comprehensive view of injury rates by the proxy severity of injury; 3) valid assessment of incident injury and the determination of proxy severity of each episode (i.e., identifying injury incidence episodes by linking medical records from all available data sources as well as determining the facility where the highest level of care was received); 4) accurateness in calculating injury rates (i.e., the use of injury density rates by using person-time at risk of each individual and allowing multiple injury events per a child), and; 5) reduced selection bias for the sample and information bias (i.e., observer bias, recall bias) through the use of administrative data. Along with these strengths, the present study was able to provide a broader picture of injury incidence for detailed, specified children's groups covering every cause and intent of injury.

3.5 Conclusions

This study followed farm and three groups non-farm Albertan children (115,378 children) under 18 years of age from 1999 to 2010 to compare rates, cause, and intent of their incident injuries using multiple, linked administrative data. Rural FN children sustained the greatest burden of overall injury, followed by rural non-FN, farm, and urban children (in descending order) and the rank was largely consistent for most mechanisms of injury. Considerably increased risk of OLT, natural/environmental, and unintentional firearm-related injuries were noted for farm and rural children. Greater risk of farm hazard-related injuries (e.g.,

farm-animal and machinery-related injuries) were noted for farm and rural non-FN children, and markedly higher risk of unintentional firearm-related injuries and suicidal suffocation were of greater concern for rural FN children. Findings from this study clearly indicate a need for targeted and specialized injury prevention strategies for higher-risk mechanisms in each group as well as attention for general risk factors among farm and rural pediatric populations.

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Table 3-1. Subject demographics

	Urban (N=34,386)	Farm (N=39,658)	Rural non-FN (N=34,288)	Rural FN (N=7,046)
Sex (male)*	50.7%	51.9%	51.2%	51.5%
Age (years, mean ± SD)**	9.6±4.9	9.9±4.9	9.7±4.9	8.9±4.8
Socio-economic status**				
Low status[1]	18.8%	29.1%	17.9%	100.0%
Health services zone				
Edmonton	38.4%	7.1%	7.6%	3.7%
Calgary	38.8%	10.4%	17.4%	10.7%
North	8.2%	28.4%	31.9%	53.6%
Central	8.4%	34.2%	28.8%	18.4%
South	6.3%	20.0%	14.2%	13.6%
Loss to follow up ** before 18 years of age	14.3%	9.1%	38.0%	26.3%
Person-years followed				
Males	118,604	143,021	94,898	24,654
Females	115,552	133,064	89,078	22,975
Total**	234,156	276,085	183,976	47,629

* $p<0.05$, ** $p<0.001$ regarding differences between groups

[1] Any subsidy received for health care insurance premium

FN: First Nations

Table 3-2. Incidence rate and proportion of any-cause injuries

Level of care	Urban			Farm			Rural non-FN			Rural FN		
Crude incidence rate (injuries/100,000 person-years) (95% CI)												
PO visits	**18539.8**	(18365.4	18714.2)	**16513.8**	(16362.2	16665.3)	**15960.8**	(15778.2	16143.3)	**13071.9**	(12747.2,	13396.6)
ED visits	**14995.2**	(14838.3	15152.0)	**20397.7**	(20229.2	20566.2)	**23273.1**	(23052.7	23493.6)	**23960.3**	(23520.7,	24399.9)
Hospitalizations	**424.1**	(397.7,	450.5)	**765.0**	(732.4,	797.6)	**736.5**	(697.3,	775.7)	**1192.6**	(1094.5,	1290.6)
Deaths	**8.5**	(4.8,	12.3)	**25.7**	(19.7,	31.7)	**21.7**	(15.0,	28.5)	**67.2**	(43.9,	90.5)
Age-and sex-standardized incidence rate (injuries per 100,000 person-years) (95% CI)												
PO visits	**21049.4**	(20533.3	21565.5)	**19138.8**	(18688.7	19588.9)	**18251.7**	(17732.8	18770.7)	**15890.6**	(14770.3,	17010.9)
ED visits	**15812.6**	(15390.1	16235.2)	**21976.9**	(21518.5	22435.3)	**24704.1**	(24132.4	25275.8)	**25158.1**	(25031.2,	25284.9)
Hospitalizations	**478.1**	(401.1,	555.1)	**868.0**	(773.6,	962.3)	**838.0**	(728.3,	947.6)	**1538.6**	(1169.8,	1907.4)
Deaths	**14.6**	(-1.9,	31.2)	**32.6**	(13.1,	52.1)	**25.8**	(6.4,	45.2)	**84.3**	(4.0,	164.6)
Crude injury proportions (injuries/100,000 children/year) (95% CI)												
PO visits	**15210.7**	(15067.6	15353.8)	**13851.0**	(13723.8	13978.1)	**10318.0**	(10200.0	10436.0)	**10646.0**	(10381.6,	10910.5)

ED visits	**12302.5**	(12173.9,	12431.3)	**17108.7**	(16967.3,	17249.9)	**15045.2**	(14902.6,	15187.6)	**19513.7**	(19155.7, 19871.8)
Hospitalizations	**348.0**	(326.3,	369.6)	**641.7**	(614.3,	669.0)	**476.1**	(450.8,	501.5)	**971.2**	(891.4, 1051.1)
Deaths	**7.0**	(3.9,	10.1)	**21.6**	(16.6,	26.6)	**14.1**	(9.7,	18.4)	**54.7**	(35.8, 73.7)

FN: First Nations, PO: physician office, ED: emergency department

Table 3-3. Hazard ratios of any-cause injuries from Cox proportional hazard model (Reference group: urban children)

	Farm		Rural non-FN		Rural-FN	
	HR	95% CI	HR	95% CI	HR	95% CI
Unadjusted						
All levels of injuries	1.09	1.08-1.11	1.11	1.1-1.13	1.1	1.07-1.12
ED visits and above	1.32	1.30-1.35	1.44	1.41-1.47	1.53	1.49-1.58
Severe injuries (hospitalizations, deaths)	1.83	1.69-1.97	1.73	1.59-1.88	2.91	2.61-3.24
Adjusted*						
All levels of injuries	1.09	1.08-1.11	1.11	1.09-1.12	1.14	1.11-1.17
ED visits and above	1.32	1.30-1.35	1.43	1.40-1.46	1.6	1.55-1.66
Severe injuries (hospitalizations, deaths)	1.77	1.64-1.91	1.71	1.57-1.87	2.67	2.36-3.02

* Adjustment for age, sex, and a proxy of socio-economic status

FN: First Nations

Table 3-4. Crude rate and rate ratio of any-cause injuries by the intent of injury

Intent of injury	Level of care	Urban	Farm	Rural non-FN	Rural FN	Farm			Rural non-FN			Rural FN		
		Rate (injuries per 100,000 person-years)				Rate ratio (95% CI), Reference group: urban								
Unintentional	ED visits	13290	19263	21997	21539	**1.45**	(1.44,	1.46)	**1.66**	(1.64,	1.67)	**1.62**	(1.60,	1.64)
	Hospitalizations	372	727	655	941	**1.95**	(1.87,	2.03)	**1.76**	(1.67,	1.85)	**2.53**	(2.41,	2.64)
	Deaths	6	21	17	44	**3.22**	(2.65,	3.79)	**2.63**	(2.01,	3.25)	**6.88**	(6.22,	7.55)
Suicide/ self-inflicted	ED visits	115	21	74	262	**0.19**	(-0.10,	0.47)	**0.65**	(0.44,	0.85)	**2.28**	(2.07,	2.50)
	Hospitalizations	38	25	57	202	**0.64**	(0.33,	0.96)	**1.48**	(1.20,	1.77)	**5.24**	(4.96,	5.53)
	Deaths	1	4	3	19	**5.09**	(3.59,	6.59)	**3.82**	(2.22,	5.42)	**22.12**	(20.59,	23.66)
Violence/ Purposely inflicted	ED visits	348	196	410	1531	**0.56**	(0.46,	0.67)	**1.18**	(1.08,	1.28)	**4.40**	(4.30,	4.50)
	Hospitalizations	17	7	18	67	**0.43**	(-0.10,	0.97)	**1.11**	(0.65,	1.57)	**4.03**	(3.57,	4.50)

	Deaths	1	1	1	2	**0.57**	(-1.22,	2.35)	**0.42**	(-1.84,	2.69)	**1.64**	(-0.62,	3.90)
Undetermined	ED visits	38	53	70	220	**1.38**	(1.11,	1.64)	**1.82**	(1.56,	2.09)	**5.74**	(5.45,	6.02)
	Hospitalizations	4	6	8	38	**1.45**	(0.63,	2.27)	**2.04**	(1.21,	2.86)	**9.45**	(8.65,	10.25)
	Deaths	0	0	1	2	**-**	-	-	**-**	-	-	-	-	-

FN, First Nations; ED, emergency department; 95%CI, 95% Confidence interval

Table 3-5. Crude rate and relative risk of injuries at the emergency department visit level and above combined by mechanism and intent

Mechanism	Urban	Farm	Rural non-FN	Rural FN	Farm			Rural non-FN			Rural FN		
	Crude rate (injuries per 100,000 person-years)				Crude rate ratio (95% CI), Reference: urban								
Struck by or against	3733	5050	5735	5721	**1.35**	(1.33,	1.38)	**1.54**	(1.51,	1.56)	**1.53**	(1.49,	1.58)
Struck_unintentional	3470	4875	5384	4527	**1.40**	(1.38,	1.43)	**1.55**	(1.52,	1.58)	**1.30**	(1.26,	1.35)
Struck_violence	262	172	347	1188	**0.66**	(0.54,	0.78)	**1.33**	(1.22,	1.44)	**4.54**	(4.43,	4.65)
Fall	3824	4179	5179	5656	**1.09**	(1.07,	1.12)	**1.35**	(1.33,	1.38)	**1.48**	(1.44,	1.52)
All Transport	1454	2560	2692	2986	**1.76**	(1.72,	1.80)	**1.85**	(1.81,	1.89)	**2.05**	(1.99,	2.12)
MVT	509	741	807	1041	**1.45**	(1.38,	1.53)	**1.58**	(1.51,	1.66)	**2.04**	(1.94,	2.15)
Pedal cyclists:non-traffic	522	369	724	932	**0.71**	(0.62,	0.79)	**1.39**	(1.31,	1.46)	**1.78**	(1.68,	1.89)

Pedestrians: non-traffic	19	25	41	52	**1.33**	(0.95,	1.71)	**2.20**	(1.83,	2.57)	**2.79**	(2.30,	3.28)
OLT	318	1366	1040	932	**4.30**	(4.22,	4.38)	**3.27**	(3.19,	3.36)	**2.93**	(2.82,	3.05)
OLT-ATVs	123	552	500	535	**4.51**	(4.38,	4.63)	**4.08**	(3.95,	4.21)	**4.37**	(4.20,	4.54)
OLT-animal riding	63	446	226	178	**7.06**	(6.89,	7.23)	**3.58**	(3.39,	3.77)	**2.82**	(2.56,	3.09)
OLT-agri. vehicle	2	16	5	2	**9.117**	(8.09,	10.14)	**3.18**	(2.02,	4.34)	**1.23**	(-0.96,	3.42)
Other transport	85	57	76	25	**0.668**	(0.46,	0.88)	**0.90**	(0.68,	1.12)	**0.30**	(-0.28,	0.88)

Table 3-5. (Continued)

Mechanism	Urban	Farm	Rural non-FN	Rural FN	Farm			Rural non-FN			Rural FN		
	Crude rate (injuries per 100,000 person-years)				Crude rate ratio (95% CI), Reference: urban								
Cut or pierce	863	1510	1876	2401	**1.75**	(1.70,	1.80)	**2.18**	(2.12,	2.23)	**2.78**	(2.71,	2.86)

Cut_unintentional	797	1490	1824	2104	**1.87**	(1.81,	1.92)	**2.29**	(2.23,	2.34)	**2.64**	(2.56,	2.72)
Cut_self harms	40	5	29	130	**0.14**	(-0.41,	0.68)	**0.72**	(0.38,	1.05)	**3.24**	(2.92,	3.56)
Cut_violence	20	3	7	111	**0.15**	(-0.60,	0.90)	**0.33**	(-0.30,	0.97)	**5.66**	(5.27,	6.06)
Overexertion	1360	1560	1794	1384	**1.15**	(1.10,	1.19)	**1.32**	(1.27,	1.37)	**1.02**	(0.93,	1.10)
Natural or environmental	377	905	902	1216	**2.40**	(2.32,	2.48)	**2.39**	(2.31,	2.47)	**3.22**	(3.12,	3.33)
Bees/wasps/hornets	165	344	354	321	**2.08**	(1.97,	2.20)	**2.14**	(2.02,	2.27)	**1.94**	(1.76,	2.13)
Dogs	128	116	197	397	**0.90**	(0.75,	1.06)	**1.54**	(1.39,	1.69)	**3.11**	(2.93,	3.29)
Non-venous insects	71	127	186	244	**1.79**	(1.60,	1.97)	**2.61**	(2.43,	2.80)	**3.41**	(3.18,	3.65)
Mammals except for dogs	50	345	174	120	**6.96**	(6.77,	7.15)	**3.52**	(3.31,	3.73)	**2.42**	(2.10,	2.73)
Poisoning	363	232	355	806	**0.64**	(0.54,	0.74)	**0.98**	(0.88,	1.08)	**2.22**	(2.10,	2.34)

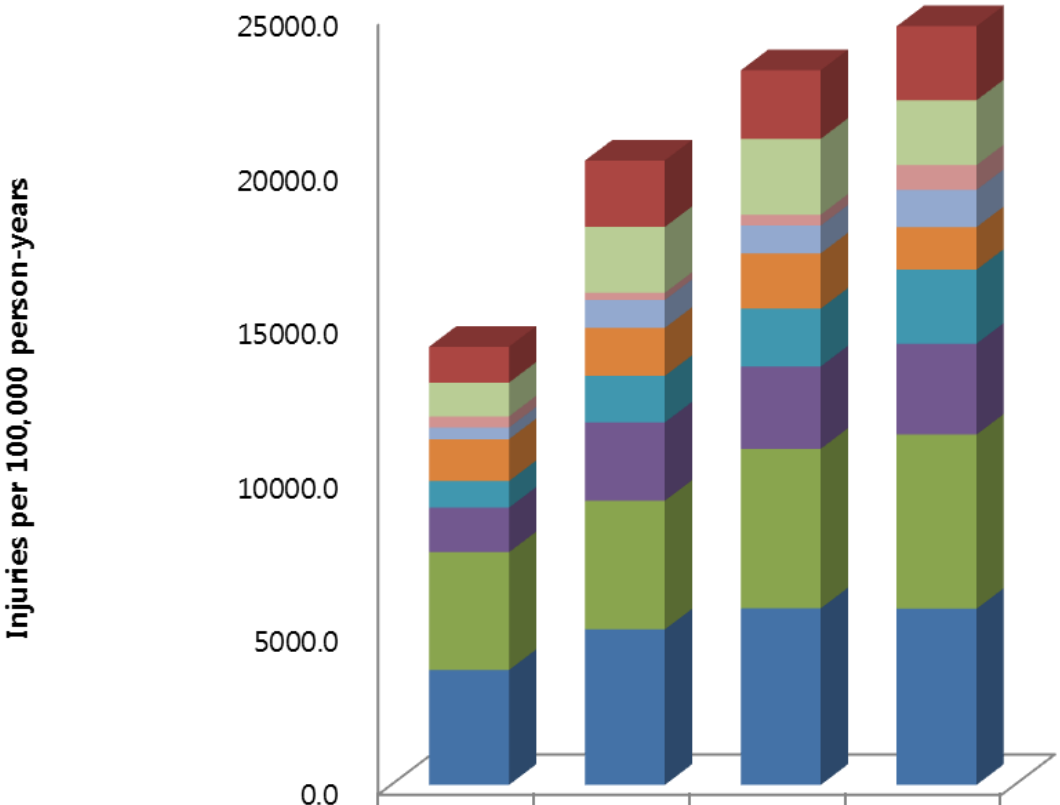
Poison._unintentional	234	177	228	409	**0.76**	(0.63,	0.88)	**0.98**	(0.85,	1.10)	**1.75**	(1.59,	1.92)
Poison._self harms	104	38	93	262	**0.37**	(0.14,	0.60)	**0.90**	(0.71,	1.10)	**2.53**	(2.31,	2.74)
Poison_violence	3	1	3	4	**0.21**	(-1.34,	1.76)	**0.80**	(-0.32,	1.910	**1.23**	(-0.32,	2.78)
Poison_Undetermined	23	16	30	130	**0.71**	(0.31,	1.10)	**1.32**	(0.95,	1.69)	**5.64**	(5.28	6.01)

Table 3-5. (Continued)

Mechanism	Urban	Farm	Rural non-FN	Rural FN	Farm			Rural non-FN			Rural FN		
	Crude rate (injuries per 100,000 person-years)				Crude rate ratio (95% CI), Reference: urban								
Fire or hot objects	142	261	298	338	**1.83**	(1.70,	1.96)	**2.09**	(1.96,	2.23)	**2.38**	(2.19,	2.57)
Machinery	41	214	105	48	**5.22**	(5.01,	5.44)	**2.57**	(2.33,	2.82)	**1.18**	(0.72,	1.63)
Suffocation	18	29	40	101	**1.64**	(1.26,	2.01)	**2.21**	(1.83,	2.59)	**5.62**	(5.20,	6.03)
Suffo._unintentional	13	26	34	48	**2.00**	(1.58,	2.42)	**2.59**	(2.16,	3.02)	**3.65**	(3.11,	4.19)

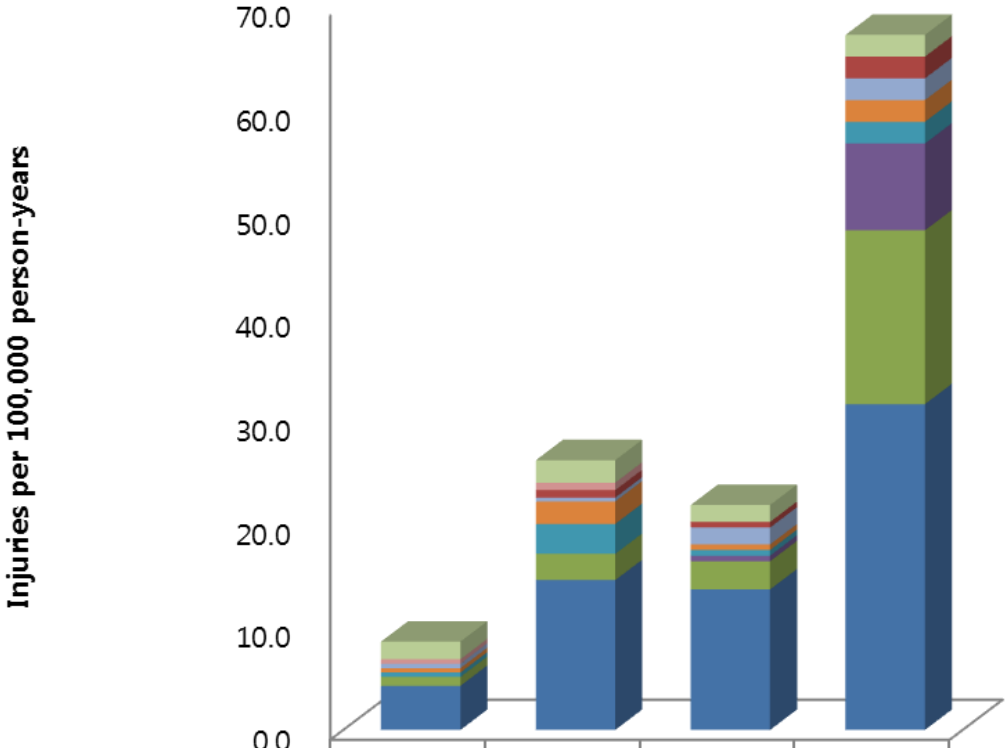
Suffo._self harms	5	2	5	52	**0.39**	(-0.67,	1.44)	**1.04**	(0.16,	1.92)	**11.17**	(10.46,	11.88)
Firearm	9	18	19	92	**2.02**	(1.51,	2.53)	**2.12**	(1.58,	2.66)	**10.30**	(9.78,	10.82)
Firearm_unintentional	6	15	15	67	**2.48**	(1.88,	3.09)	**2.55**	(1.90,	3.19)	**11.24**	(10.61,	11.87)
Firearm_self harms	0	2	1	2									
Firearm_violence	2	0	1	2	**0.17**	(-1.98,	2.32)	**0.51**	(-1.13,	2.15)	**0.98**	(-1.16,	3.13)
Drowning	6	7	6	15	**1.30**	(0.61,	2.00)	**1.08**	(0.27,	1.88)	**2.65**	(1.73,	3.57)
Other specified, classifiable	749	1417	1508	1510	**1.89**	(1.84,	1.95)	**2.01**	(1.95,	2.07)	**2.02**	(1.93,	2.10)
Other specified, not elsewhere classified	203	222	254	325	**1.09**	(0.98,	1.21)	**1.25**	(1.12,	1.38)	**1.60**	(1.42,	1.78)
Unspecified	1098	2140	2466	2112	**1.95**	(1.90,	2)	**2.25**	(2.20,	2.30)	**1.92**	(1.85,	2.00)

FN, First Nations; OLT, other land transport; 95%CI, 95% Confidence interval



	Urban	Farm	Rural non-FN	Rural FN
All others	1165.0	2158.0	2225.0	2404.0
Unspecified	1098.0	2140.3	2466.1	2108.0
Poisoning	362.6	231.8	353.3	804.1
Natural or environmental	377.1	905.2	901.2	1207.3
Overexertion	1360.2	1560.4	1793.7	1383.6
Cut or pierce	862.2	1509.7	1876.3	2401.9
Transport	1449.9	2545.2	2678.1	2954.1
Fall	3823.5	4178.4	5179.5	5656.2
Struck by or against	3733.0	5049.9	5735.0	5721.3

Figure 3-1. Crude incidence rate of non-fatal injuries (emergency department visits and hospitalizations) by the mechanism of injury



	Urban	Farm	Rural non-FN	Rural FN
All others	1.7	2.2	1.6	2.1
Fall	0.4	0.7	0.0	0.0
Fire or hot object/substance	0.0	0.7	0.5	2.1
Poisoning	0.4	0.4	1.6	2.1
Drowning	0.4	2.2	0.5	2.1
Firearm	0.4	2.9	0.5	2.1
Natural or environmental	0.0	0.0	0.5	8.4
Suffocation	0.9	2.5	2.7	16.8
Transport	4.3	14.5	13.6	31.5

Figure 3-2. Crude incidence rate of fatal injuries by the mechanism of injury

Chapter 4. Agricultural injury for farm and non-farm children in Alberta

4.1 Introduction

Agriculture has been recognized as one of the most dangerous occupational sectors in Canada as well as across the world due to the high rates of fatal injuries.[1-3] A farm is a unique environment where the farming workplace and living environment cannot easily be separated. Therefore, the paediatric population participating in farm work at a young age are exposed to agricultural hazards such as tractors, animals, machinery, chemicals and bodies of water [4-6] as well as by residing or playing on farms where these hazards exist. Among all farm-related deaths of children, 69.1-82.0 % occurred among non-working children, [7-9] and 70.5% of those non-occupational deaths were to young children aged 6 and under.[7] The hazardous agricultural environment has resulted in high rates of fatality for children in Canada and the U.S. ranging from 6.1 to 13.7 per 100,000 population per year.[3,10-14] Approximatley 40% of farm injuries in children seen in emergency departments leave them with long-term disabilities.[15] In Alberta, 69 children and youths under 20 years of age died from agricultural injuries between 1990 and 2009.[16]

Despite prior efforts to reveal the risk of paediatric agricultural injuries, there have been limitations in the provision of the following accurate information on agricultural injuries: 1) the relative burden of agricultural injuries in different paediatric populations exposed to farm hazards and; 2) comparisons and burden of

non-agricultural injuries versus agricultural injuries. Firstly, farm-related injuries can be experienced by a range of paediatric populations including children living on farms as well as ones visiting, neighbouring, or being hired on farms. However, the majority of prior studies on farm-related injuries using administrative health databases have aimed at examining agricultural injuries for the general paediatric population as a whole.[7-14] This existing approach may be efficient to illustrate general problems from agricultural injury for all children in a population, but has restrictions in accessing children's group-specific risks of agricultural injuries.

A few studies examined the demographic composition of paediatric agricultural injuries reporting that 51-77.8% of agricultural injuries occurred to children living on a farm [7,8,17] and that 60.2-76.0% were to a child of a farm owner.[7,8,11] Results from these studies suggest that while the majority of agricultural injuries occurred to farm children, a substantial proportion of farm injuries are suffered by non-farm children. Although these publications provide an image of the diverse groups of children affected by farm hazards, a detailed profile of agricultural injury in terms of incidence rates, relative risks, and causes particular to each specific group of children has not been raised. Secondly, there has been a lack of comparative information on agricultural paediatric injuries contrasted with overall or non-agricultural events in terms of distinctive features and the relative size of injury problems, since the majority of prior research on farm-related injuries have focused on detailed descriptions of only agricultural injury.

The objective of this study was to compare the rates and patterns of agricultural injury incidence between farm and several groups of non-farm children under 18 years of age in Alberta, and to investigate characteristics of agricultural injury in comparison with non-agricultural injuries. Comprehensive and precise understanding of the risk of agricultural injury sustained by diverse groups of children would help to set up the context to apply farm safety standard regulations and to develop target-specific practical guidelines for paediatric farm safety interventions.

4.2 Materials and methods

4.2.1 Study Design

A retrospective cohort study was designed with a fixed population, where children who met the inclusion criteria in the fiscal year of 1998 were selected and followed until they became 18 years of age within the study period (January 1, 1999 to December 31, 2010). A population-based approach utilized the linkage of multiple administrative health databases to examine the incidence of all-cause injury.

4.2.2 Study location

Alberta farms occupied 21.6% of all farms in Canada representing the third

largest province in Canada with regards to the number of farms.[18] The main types of farming undertaken in Alberta were cattle ranching and oilseed/grain farming.[18] In 2006, Alberta's population comprised 82.1% urban residents and 17.9% rural ones, with a quarter of those located rurally were farm families.[19] Alberta has a social health care system where all medically necessary services are universally provided in accordance with the Canada Health Act.[20]

4.2.3 Study participants

The study population consisted of virtually all farm children and representative samples of non-farm children younger than 18 years of age who lived in Alberta in the fiscal year of 1998/99 and were not lost to follow up before January 1, 1999. As a closed population, there was no new entry into the study population after the initial selection of subjects. Subjects left the study due to death, migration or by becoming 18 years of age.

Farm children were identified from the all-ages Alberta farm population list, which was set up from a probabilistic linkage of the Farm Fuel Tax subsidy list in 1998 and the Health Care Insurance Plan Registry file in the same year. Farm children were classified into rural-living and urban-living farm children by their residential areas in 1998. Classification of rural or urban residence was based on postal code from the registry information: a postal code with a "0" as the second character denotes a rural area where there are no letter carriers and residents go to the corner postal box or the post office to pick up their mail.[21]

Non-farm children (rural and urban children) were extracted from two

representative samples of all-ages non-farm rural and urban population that were randomly selected from the Alberta Health Care Insurance Plan registry with the equivalent sample size to the all-age farm population, respectively. Non-farm rural children were further subdivided into First Nation (FN) and non-FN children based on health insurance premium status, for consideration of differing injury characteristics for FN children from non-FN children.[22,23]

4.2.4 Data Sources

Injury data for 12 calendar years (1999 to 2010) were gathered from three databases maintained by Alberta Health (AH), Government of Alberta. Three heath databases included Alberta Vital Statistics File, Hospital Discharge Abstract Database, and the Ambulatory Care Classification System that contain data for mortality, hospital admissions, and emergency department (ED) visits, respectively. The three health databases were deterministically linked to the Health Care Insurance Plan Registry file using scrambled personal health number (PHN) being merged into a single file.

The Health Care Insurance Plan Registry file provided demographic information of subjects including age, sex, 3 digits of postal code, migration, health zone, and Alberta health insurance premium status. The insurance premium status was used as a proxy measure of socioeconomic status (SES) and categorized into high SES (i.e., no subsidy group) and low SES (i.e., FN treaty-status Aboriginals, full premium subsidy, and partial premium subsidy groups) in this study.

4.2.5 Injury identification

Injury data included all medical records that contained the following International Classification of Disease (ICD) diagnostic codes or external causes of injury codes (E-codes) for "injury and poisoning" in any of diagnostic fields, inclusive of early complication or sequelae of trauma but removing complications of medical and surgical care and misadventures;

a. Diagnostic codes: 800-995 except 909(.3, .5) (ICD-9) or SOO-T98 except T80-T88 (ICD-10)

b. E-codes: E800-E869, E880-E929, E950-E999 (ICD-9)or V01-Y36, Y85-Y87, Y89 (ICD-10)

Agricultural injuries were identified when any of the following E-codes are founded in the health database coded with ICD-9 or ICD-10;

a. E849.1 (ICD-9) or U98.7 (ICD-10): occurred on a farm (farm buildings and land under cultivation excluding farm house and home premises of farm).

b. E919.0 (ICD-9) or W30 (ICD-10): contact with agricultural machinery

c. V84 (ICD-10): occupant of agriculture machines injured in transport accident

d. E863, E950.6, E980.7 (ICD-9) or X48, X68, Y18 (ICD-10): poisoning by agricultural chemical

Non-fatal agricultural injuries were captured by linking multiple data sources and manually checking and filling the E-codes of farm injuries within the same injury episode. However, as for fatal agricultural injuries, virtually all agricultural machinery deaths but only a portion of non-machinery agricultural deaths were be able to be detected. Death certificates usually contain only a maximum of one E-code for the cause of death so that E-codes for agricultural machinery injuries generally were included, but E-codes for the place of occurrence were usually not included resulting in limited availability to describe non-machinery agricultural injuries. In this study, non-machinery agricultural

deaths treated in any medical facility for the fatal injury were identified through multiple data linkage, but ones without any associated medical facility visits could not be identified.

Injury records were classified by nature, body site injured, mechanisms, and intent of injury into subcategories based on categorization tables, where detailed ICD diagnostic codes or external causes (E-codes) were assigned to each category for each version of the ICD coding system. The categorization tables followed previously published frameworks or matrices including the Barell Injury Diagnosis Matrix, Injury Mortality Diagnosis Matrix, and ICD-10 and ICD-9 comparability table for mechanism and intent codes.[24-26] To reduce the potential errors due to diagnostic differences or coding discrepancies between different ICD versions, sufficiently broad categories of injury (8 body sites, 16 natures, 5 types of intents, and 19 mechanisms) were utilized. A single injury case might contain multiple E- codes for mechanisms (e.g., fall and burn). An injury case with multiple E-codes was counted once for the calculation of overall injury rate, but might count multiple times in respective E-code categories for the generation of cause-specific injury rates.

4.2.6 Injury episode

As a unit of injury case, an episode of injury was created to reduce the likelihood of false injury incidence counts where there were multiple visits for an injury event. Across the four combined databases, all the subordinate visits for one injury event were included within one injury episode. To construct the injury

episode, first, all injury data from multiple sources were merged together and sorted by the subject's id and medical service date. Beginning with the first injury record for each child, the immediate next injury record for the same child was determined to examine whether the record was a resultant visit of the previous injury record or another new injury episode for the child based on criteria below.

The criteria were built from detailed data examination and modification of the criteria used in previous publications,[27-29] while trying to be conservative in determining a record as a follow-up visit so as not to lose any incident cases. To be determined as a follow-up visit of a previous injury record, the injury record needed to meet at least one of the following criteria compared with the previous injury record: the injury record (1) had ICD codes for sequelae or late effect of injury, (2) appeared on the same day, (3) occurred within 7 days in the same category of body region or the nature of injury, (4) occurred within 180 days in the same category of both body region and nature of injury, or (5) occurred within 180 days with the exactly same diagnostic codes in all ten ICD diagnostic fields compared with the previous injury record. An episode identification for fatal cases was manually conducted, as the Vital Statistics database contained only a single E-code without any supporting diagnostic codes. An additional three years of injury records prior to 1999 were used to eliminate any incident injuries that occurred before 1999 and were treated subsequently after 1999. For each injury episode, only the record at the highest level of care was extracted and used in the analysis while playing a role as a proxy of severity for an injury episode. If there were multiple records at the same highest level of care (e.g., two hospitalization

records for a child), the first record was chosen.

A child may experience multiple episodes of injury during the study period. To consider this, a time to multiple injury episodes model was used in all analysis, where all injury episodes of interest for a subject were taken into account, and time at risk of an injury episode for the subject continued after an injury episode until the true end of follow-up of the child.

4.2.7 Statistical analysis

Descriptive statistics for demographic variables (age, gender, proxy SES, and health service zone by residential area) and episodes of agricultural injury were generated by children's group and proxy severity of injury (i.e., the highest level of care per episode) using frequencies, proportions, and rates. Differences in demographic variables between children's groups were tested using one-way ANOVA and chi-square statistics. Characteristics of agricultural injuries in comparison with non-agricultural injuries were examined including demographics of children injured, lethality using the injury pyramid, intent, mechanisms, and nature of injury.

Overall and variable-specific crude incidence rates of agricultural injury (i.e., injury episodes per 100,000 person-years) were calculated, where the numerator was the number of injury episodes allowing multiple episodes per child, and the denominator was the sum of time at risk (i.e., total follow-up time) of all subjects. For overall injury, age-and sex-adjusted incidence rates by the level of care were generated with 95% confidence interval (CI) using the direct

standardization method[30] and the 2006 Canadian Census population[31] as the standard. For cause-specific injury, crude relative risks (or rate ratios: RRs) of injury for a children's group compared to urban children were calculated with 95% CI. Regarding the follow-up time of an individual, the time point of the end of follow-up was the earliest time point of the following time points: the first move-out from Alberta, the first move-out from rural to urban areas or vice versa, the first discontinuance of registration of the Alberta Health Insurance plan, becoming 18 years of age, or the end of study period.

As an analytical analysis, to examine the relationship between injury incidence and covariates, a recurrent event survival analysis[32-34] using Cox Proportional-Hazard (PH) regression with counting process formation and clustered robust standard errors was carried out. From the Cox Proportional-PH regression, hazard ratios (HRs) of injury for each children's group in comparison to urban children were estimated with a 95% confidence interval adjusting for potential confounders (i.e., age, sex, and proxy SES). Clustered robust standard errors were estimated to consider correlations within multiple outcomes of data for a child. In the recurrent event survival analysis, a time to multiple injury episodes model was used by allowing multiple injury episodes for a subject, and segmenting the total follow-up time of the subject by multiple time points of injury episodes. Therefore, if a child had multiple events, the child had more than one record (i.e., long data structure), and time at risk of a recurrent event for the child was from the time point of the previous injury episode to that of the next injury episode (i.e., counting process formation) and it was assumed that the

recurrent events of the child are independent. Data management and statistical analyses were conducted using SPSS 18.0 and STATA MP 12.1.

4.3 Results

From 1999 to 2010 (12 years of follow-up) there were a total of 1,839 agricultural injury episodes (1,616 ED visits, 225 hospitalizations, and 8 deaths as the highest level of care received per episode) among 115,378 children under 18 years of age. All of the episodes contained valid E-codes for injury and poisonings. The majority of farm children (77.4%) lived in rural areas, but 22.7% of farm children resided in urban areas. Rural children were composed of 83.0% of non-FN and 17.0% of FN children. FN children living in rural areas represented 87.2% of all FN children in the study population. The rest of FN children (12.8% of all FN, 1034 urban-living FN children) were classified into urban children comprising 3% of urban children.

4.3.1 Demographic Characteristics

Demographic characteristics of five groups of children (urban, rural FN, rural non-FN, rural-farm, and urban-farm) are reported in Table 4-1. The majority of farm children lived in rural areas, but 22.7% of farm children resided in urban areas. The FN children's group residing in rural areas represented 87.2% of all FN children in the study population. Rural FN children were younger (mean age: 8.9 years, $p<0.05$) and more likely to live in the north health services zone of Alberta

(53.6%) than other groups of children. Farm (urban, rural-living) and rural FN children were more subsidized (22.1%, 31.1%, 100%, $p<0.001$) than the other groups (18.8%, 17.9%). The two groups of rural children experienced more loss to follow-up before 18 years of age during the study period than other groups, mainly due to relocation to urban areas (81.6% of all losses for rural children), while farm children (urban or rural-living) showed the most stable residency with the fewest loss to follow up (7.4% and 9.7% respectively).

4.3.2 Frequency and incidence rate

The age- and sex-adjusted rate of agricultural injury episode at the ED visit level and above combined was the highest in rural-living farm children (672.3 injuries/100,000 person-years; 95% CI, 577.2-767.4), followed by urban-living farm children (369.4; 95% CI, 243.6-495.2) and rural non-FN children (180.2; 95% CI, 130.1-230.3) while being the lowest in urban children (23.7; 95% CI, 6.0-41.3) (Table 4-2). As for agricultural injuries at the ED visit level and above combined, hazard ratio (HR) of injury was significantly higher for farm (adjusted HRs: 16.63-26.91) and rural children (adjusted HRs: 2.68-8.21) compared with urban children (Table 4-3).

According to the results from multivariate Cox PH regression for agricultural injuries at ED visit level and above combined, injury rates significantly and consistently increase with age, and children at a low SES experienced significantly higher rates of injury compared to children with no-subsidy for health care insurance premium (adjusted HRs= 1.44, 95% CI,

1.30-1.59) (Table 4-3).

Sex

Males experienced higher rates of agricultural injury than females across children's groups and most care levels (Figure 4-1), accounting for 71.7% of all injured individuals with agricultural injury episodes, overall. Hazard ratio of agricultural injury for males was significantly higher than females (Adjusted HR=2.30, 95% CI, 2.07-2.55) (Table 4-3). The sex disparity of agricultural injuries tended to be intensified for children's groups at a higher risk of agricultural injuries as well as more serious injuries, presenting increased risk of severe agricultural injuries for farm and rural males: when injuries at the ED visit level and above combined were considered, the relative risk of farm injury for males to females were the highest for rural-living farm children (RR=2.78) followed by urban-living farm children (2.06) and rural non-FN children (1.72).Among rural-living farm children, the RR increased with proxy severity of injury with a RR of 2.73 for ED visits, 3.07 for hospitalizations, and 4.68 for deaths (Table 4-4).

Mechanisms of injury

For most mechanisms of injury, cause-specific incidence rates of non-fatal injuries (ED visits and hospitalizations combined) were the highest in rural-living farm children, followed by urban-living farm children and rural non-FN children (Table 4-5). The most common cause of non-fatal agricultural injuries was

natural/environmental injuries (i.e., injuries due to natural hazards including animals, plant, lightning, excessive heat or cold, etc.) across all children's groups (19.5-22.2% by children group) (Table 4-6). Natural/environmental injuries, machinery, and falls were the top three mechanisms across the two farm groups and the rural non-FN group who were at higher risk of overall agricultural injury. Among rural-living farm children, the top three mechanisms were natural/environmental (115.6 injuries/100,000 person-years), machinery (105.3) and falls (81.0). Urban children suffered greater proportion of other land transport (OLT; land transport injuries other than motor vehicle traffic, pedal cyclist, pedestrian injuries) (17.8%) than other groups (Table 4-6).

For fatal injuries, agricultural machinery was the leading cause of agricultural deaths (6 out of 8 deaths). Deaths occurred mainly among rural-living farm children (6 deaths), for males (7 deaths), and at 5-9 years of age at the time of event (5 deaths). It should be noted that there was a possibility of underestimation of non-machinery deaths in this study.

Agricultural injury within the context of overall injuries

Agricultural injury comprised a small portion of overall injuries in urban and rural FN children, but represented a larger proportion on serious injuries for farm and rural children. For rural-living farm children, agricultural injuries accounted for 9.0% and 11.3% of any-cause hospitalized injuries and fatal injuries, respectively. Agricultural injuries also comprised a considerable

proportion for a number of specific mechanisms or nature of injury events that

were more likely related to farm hazards including machinery-related injuries, amputations and crush injuries. Overall, agricultural machinery injuries accounted for 35.3% of all machinery injuries in the entire study population combined. Farm-related amputations accounted for 13.9 % of all amputations for all participants and 22.9% of those for rural-living farm children. Farm-related crush injuries comprised 7.2% and 12.7% of all crush injuries for all participants and for rural-living farm children, respectively.

4.3.3 Agricultural versus non-agricultural injury

Injury pyramid

Agricultural injuries represented a different shape for the injury pyramid than those of non-agricultural injuries. For agricultural injuries, there were fewer hospitalizations and ED visits per one death (a ratio of 1: 28: 201 for death, hospitalizations, ED visits) than in non-agricultural injuries (1: 31: 886).

Sex and age at the injury

For both agricultural and non-agricultural injuries, males were injured more often than females, but the sex disparity in injury risk was greater for agricultural injuries compared with non-agricultural injuries: for injuries at ED visit level and above combined, males were at 2.39 times (95% CI: 2.15-2.64) greater risk for non-agricultural injuries than females versus 1.52 times (95% CI: 1.50-1.53) for non-agricultural injuries. In terms of age at the time of injury event, the proportion

of older patients increased with the proxy-severity of injury in non-agricultural injuries, while agricultural injuries showed the opposite pattern with there being an increased risk of more severe injury for

younger children: for non-agricultural injuries, older children aged 15-17 years comprised 36.9%, 42.2%, and 59.4% of ED visit, hospitalization, and deaths, respectively, but 43.3%, 25.3%, and 25.0% for agricultural injuries.

Intent

Agricultural injuries were more likely to be unintentional than non-agricultural injuries. In non-agricultural injuries, 92.6%, 89.7%, and 74.8% of ED visits, hospitalization, and deaths were unintentional, while in farm-related injuries, unintentional injury explained 99.6 %, 99.6% and 100% of ED visits, hospitalization, and deaths, respectively.

Mechanisms

There were considerable differences in the mechanisms responsible for agricultural and non-agricultural injuries. Almost half non-agricultural injuries were due to ‘struck by or against’ and ‘falls’, whereas agricultural injuries were mainly attributed by ‘natural/environmental’, ‘machinery’, and ‘falls’ (Table 4-7). Even within the same category of injury mechanisms, the detailed mechanisms were different. For example, for natural/environmental injuries, the majority of these injuries involved farm animals (i.e., related with mammals except dogs, 87.6%) in agricultural injuries, but other kinds of living things (i.e., related with

nonvenomous insects/arthropods or hornets/wasps/bees, 78.7%) in non-agricultural injuries. Another example, OLT injuries were mainly related with agricultural-vehicle (43.6%), animal riding (42.9%), and a small portion of all-terrain vehicles (ATVs) (5.3%) in agricultural injuries. However, in non-agricultural injuries, OLT mostly consisted of ATVs (44.2%) and animal riding injuries (27.1%).

Nature of injury

The main types of nature of injury were similar for both agricultural and non-agricultural injuries: wounds, contusions, fractures, and dislocations, although the proportion and rank of each were slightly different. The most common nature of injury was wound (32.0%) for agricultural injuries and dislocations (21.5%) for non-agricultural injuries (Table 4-7). Amputations and crush injuries were notably more common among agricultural injuries than in non-agricultural injuries. Agricultural amputations mostly occurred to farm children (27 out of total 29 amputations) and males (24 amputations), among farm children, and 41.4% of agricultural amputations (12 episodes) were due to farm machinery.

4.4 Discussion

This study explored the incidence and characteristics of agricultural injuries among five children's groups as well as in comparison with non-agricultural

injuries or injury overall. Previous research has mainly conducted a non-comparative evaluation of a burden of agricultural injuries (i.e., rates and main causes of agricultural injuries) for general pediatric populations combined,[7-14] or compared occupational injuries for young workers.[14,35] Using a different approach that tracked all injuries (both agricultural and non-agricultural injuries) for children identified, this study was able to provide a valid and comparative assessment of the incidence of agricultural injuries between children's groups.

Agricultural injury rates appeared to be the highest among rural-living farm children (583.7 injuries/100,000 person-years) and the lowest among urban children (19.2 injuries/100,000 person-years). By applying these injury rates and the size of each group's population in Alberta, the actual burden of agricultural injuries by children's group could be roughly estimated. Given the fact that the size of the rural (non-farm) and urban (non-farm) population in Alberta were about 2.9 and 17.4 times greater than farm children,[19] it is assumed that approximately 50%, 30%, and 20% of agricultural injuries at the ED visit level and above were sustained by farm, non-farm urban, and non-farm rural children, respectively, indicating the wide extent of the population at considerable risk of agricultural injuries. These results are similar to the findings from previous research that have reported that a majority of agricultural injuries occurred to children of farm owners (69.4-76.0%)[7,8] or farm residents' children (51-77.8%)[7,8,17] and that 60.2% of fatal pediatric agricultural injuries were to the children of the farm owner/operators, followed by farm visitors (10.6%), other

relatives of owner (9.9%), and hired workers (9.1%).[11] Natural/environmental injuries (mainly due to farm animals) dominated ED visit injuries for most children's groups implying a need for attention to carefully consider the populations involved with these types of injuries. Animal-related injuries have been reported as one of the main mechanisms of non-fatal agricultural injuries.[36-38]

The rates of agricultural injury from this study appeared to be lower in general than ones from previous studies: 2.8 deaths and 70.2 hospitalizations per 100,000 person-years from this study versus 6.1-7.0 deaths [3,11] and 98.3 hospitalizations[39] per 100,000 people per year in Canada in prior reports. However, it may be difficult to compare the present results with earlier reports because of differences in the study designs in terms of the calculation of injury rates (episode vs. services, person time vs. injury proportions), study designs (cohort study vs. cross-sectional study), and study populations (specific groups vs. general populations).

Agricultural injuries were found to have different features from non-agricultural injuries in that agricultural injuries were more likely to be unintentional and lethal than non-agricultural injuries. Also, those with agricultural injuries were more likely to be serious, males, and younger. Previous research has reported that young farm children were more vulnerable to agricultural injuries, particularly to machine injury even when not participating in work (e.g., run over by a tractor when a bystander),[7,9,40] and that parent supervision in close proximity (e.g., while working on the farm) increased the injury rates for children.[7] The leading mechanisms of farm-related injuries at the

ED visit level and above combined were natural/environmental injuries, machinery, and falls, while the main mechanisms of non-agricultural injuries were struck by or against, fall, and transport-related injuries. Agricultural machinery injuries were the most lethal, and of more concern for farm children. Among children, various types of machinery has been reported as the main cause of agricultural deaths comprising 47-68.0% of agricultural deaths in Canada[8,11,41] and 25-29.5% in the U.S.[9,12,13] in the 1990s with a higher proportion for occupational agricultural injuries[9,13]. Machinery has also been reported as the cause of 46-53.3% of pediatric agricultural hospitalizations.[11,37]

There were possibilities that farm-related injuries, especially fatal injuries were underestimated in the present study. It was observed that E-codes for on-farm injuries were more likely to be missed than diagnostic codes, especially for the ED visit records, and particularly for visits following the initial visit for the same injury episode. Although this study tried to capture agricultural injuries at the most comprehensive level using the linkage of multiple data sources, a complete capturing of agricultural injuries could not be guaranteed if none of the medical records of an episode reported the E-code for the place of injury occurrence. For agricultural fatal injuries, there was possibility that a risk of the injury was underestimated if they occurred outside of any health facility and were non- machinery agricultural death. The proportion of machinery deaths among agricultural deaths seems to be higher compared with prior studies (75% vs. 47-68.0%[8,11,41]). Despite the small number, as well as a potential underestimation of agricultural deaths in the present study, the inclusion of death data provided a

chance to roughly depict the injury pyramid of the incidence of agricultural injury compared with non-agricultural injuries.

When examining the injury pyramid in this study, agricultural injuries were found to be more lethal than non-agricultural injuries, but considering the possibility of underestimation of agricultural deaths, the lethality of agricultural injuries might be even more problematic. Concerns of underestimation of agricultural injuries emphasize the need to incorporate E-codes for the place of injury occurrence in administrative health databases, especially in vital statistics death data. Also, continuous and extended operations of agriculture-specific injury surveillance[42] are required to complement the limitations of administrative databases.

Although a reduction of overall pediatric injury rates over time has consistently been presented from prior publications,[43,44] there have been mixed results (no large differences vs. reduction) regarding the temporal trend of agricultural injury rates.[11,13,45,46] Diverse intervention programs and efforts to prevent childhood agricultural injuries have been tried, but the impact of the initiatives on the reduction of injury rates have rarely been evaluated in a valid way.[47,48]

As for recommendation for prevention strategies, 1) Government regulations need to be instituted, which include a minimum age for operating farm equipment, tractor certification and using helmets for ATVs; 2) Regular education for farm safety lessons **at** school[55-57] would be effective for both farm and non-farm children who could visit a farm; 3) Education for the parents of farm

children would be essential. Providing safe play areas (i.e., separated from farm work place) and adequate supervision for young children as well as an appropriate assignment of farm work to children using NAGCAT[53,54] are needed; 4) Along with traditional educational initiatives for farm safety, new interventional approaches recently introduced including multifaceted interventions[49,50], community-based interventions[51,58,59], participatory programs[51,52] can be actively applied for the pediatric farm safety. The precise picture of farm injury risk among subgroups of children from this study would help to set specified and targeted intervention strategies for each pediatric population.

Limitations of the present study included the following: 1) agricultural injuries, especially agricultural deaths, might be underestimated in this study, if E-codes for on-farm injuries were not recorded in any of medical databases for an episode, although this underestimation would likely be non-differential among comparison groups; 2) the use of administrative databases has inherent weaknesses including the possibility of misclassification of injuries due to errors in coding and charting of the injury code, and limited information on circumstances that led to injuries (e.g., occupational injury or not), and various risk factors other than age, sex, and proxy socio-economic status. However, these limitations are not likely to exist differentially between groups as the data came from a uniform health system; 3) misclassification of a proxy of socio-economic status for FN children may occur. All FN treaty-status Aboriginals in the insurance premium status in Alberta were classified into children in a low SES status in this study, but all FN children may not be in low SES status. However,

children's SES status does not appeared to considerably affect the results as there were not much differences between adjusted and unadjusted hazard ratios of agricultural injury; 4) there is a possibility that some differential misclassification of injury events occurred if healthcare seeking behaviors or accessibility to health care services differ between farm and non-farm residents. If rural populations are less likely to seek or get treatment, possibly due to the longer distances to health care facilities,[60,61] their injury rates, especially for minor injuries,[62] may be underestimated. One other thing to be aware of is that the results of this study are more likely be influenced by older age groups as this study followed up a fixed study population over time without the addition of young children into the study population.

The present study has several strengths. This study likely captured most, if not all, injuries that were treated in medical facilities by using multiple sources of information; especially the detection of agricultural injuries was enhanced through manual searching for potential agricultural injury records within an injury episode in the multiple databases linked. This study was able to provide an accurate picture of injury by the highest level of care received, removing all the subsequent medical records for an episode. The highest level of medical care was used as a proxy severity of injury. Thirdly, valid and accurate assessment of incident injury rates (i.e., person-time incidence rates) were available by identifying injury incidence (i.e., injury episodes, numerators in the rate calculation) through multiple medical records with an allowance of multiple injury events per child, and by using person-time at risk of each individual as the denominator in the rate

calculation. Also, external validity of the results from this study increased as it was population-based with a large sample size. Lastly, the use of administrative databases reduced selection bias for the sample as well as information bias (i.e., observer bias, recall bias). Because of these strengths, the present study was able to provide a comprehensive and accurate picture of incident agricultural injuries within all injuries as well as among specified pediatric populations.

4.5 Conclusions

This study followed five groups of Albertan children (115,378 children) under 18 years of age for 12 years to compare rates and cause of incident agricultural injuries using multiple administrative databases that were linked. Incidence rates of agricultural injuries were highest for the rural-living farm children, but considerable incidence rates were observed among urban-living farm children and non-FN rural children providing insight into the impact of agricultural injuries on broader pediatric populations. Agricultural injuries appeared to have distinct characteristics in various aspects (e.g., sex and age distributions of victims, and intent, severity, mechanisms and nature of injuries) from non-agricultural injuries. These findings suggest the need for specialized approaches to prevent agricultural injuries as well as the need to extend agricultural injury controls to non-farming populations, along with specified strategies to each pediatric population classified in this study.

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Table 4-1. Subject demographics

	Urban (N=34,386)	Rural FN (N=7,046)	Rural non-FN (N=34,288)	Farm-U (N=8,956)	Farm-R (N=30,702)
Sex (male)*	50.7%	51.5%	51.2%	52.0%	51.8%
Age (years, mean ± SD)**	9.6±4.9	8.9±4.8	9.7±4.9	10.0±4.8	9.9+4.9
Socio-economic status**					
Low status[1]	18.8%	100.0%	17.9%	22.2%	31.1%
Health zone					
Edmonton	38.4%	3.7%	7.6%	19.5%	3.4%
Calgary	38.8%	10.7%	17.4%	10.7%	10.3%
North	8.2%	53.6%	31.9%	18.7%	31.3%
Central	8.4%	18.4%	28.8%	34.9%	34.0%
South	6.3%	13.6%	14.2%	16.3%	21.0%
Loss to follow up ** before 18 years of age	14.3%	26.3%	38.0%	7.4%	9.7%

Person-years followed					
Males	118,604	24,654	94,898	32,617	110,403
Females	115,552	22,975	89,078	29,834	103,230
Total	234,156	47,629	183,976	62,452	213,633

* p<0.05, ** p<0.001 regarding differences between children's groups

[1] Any subsidy received for health care insurance premium

FN: First Nations, Farm-U: Farm in Urban areas, Farm-R: Farm in Rural areas

Table 4-2. Incidence rate of agricultural injury

Level of care	Urban			Rural FN			Rural non-FN			Farm-U			Farm-R		
Crude incidence rate (injuries per 100,000 person-years) (95% CI)															
ED visits	**17.9**	(12.5,	23.4)	**58.8**	(37.0,	80.6)	**138.1**	(121.1,	155.0)	**305.8**	(262.5,	349.2)	**510.7**	(480.4,	541.0)
Hospitalizations	**1.3**	(-0.2,	2.7)	**8.4**	(0.2,	16.6)	**24.5**	(17.3,	31.6)	**36.8**	(21.8,	51.9)	**70.2**	(59.0,	81.5)
Deaths[1]	**0.0**	(0.0,	0.0)	**0.0**	(0.0,	0.0)	**0.5**	(-0.5,	1.6)	**1.6**	(-1.5,	4.7)	**2.8**	(0.6,	5.1)
Total	**19.2**	(13.6,	24.8)	**67.2**	(43.9,	90.5)	**163.1**	(144.6,	181.5)	**344.3**	(298.2,	390.3)	**583.7**	(551.3,	616.1)
Age-and sex-standardized incidence rate (injuries per 100,000 person-years) (95% CI)															
ED visits	**21.1**	(5.2,	36.9)	**57.0**	(-1.7,	115.6)	**156.1**	(108.5,	203.8)	**331.7**	(211.8,	451.7)	**600.5**	(509.2,	691.8)
Hospitalizations	**2.6**	(-5.1,	10.3)	**7.4**	(-8.6,	23.3)	**23.4**	(8.2,	38.7)	**36.4**	(-1.1,	73.9)	**66.7**	(41.7,	91.7)
Deaths[1]	**0.0**	(0.0,	0.0)	**0.0**	(0.0,	0.0)	**0.7**	(-1.9,	3.2)	**1.2**	(-3.5,	6.0)	**5.0**	(-4.3,	14.3)
Total	**23.7**	(6.0,	41.3)	**64.4**	(3.6,	125.1)	**180.2**	(130.1,	230.3)	**369.4**	(243.6,	495.2)	**672.3**	(577.2,	767.4)

[1] Agricultural deaths may include virtually all machinery-related agricultural deaths but a part of non-machinery ones.

FN: First Nations, Farm-U: Farm in Urban areas, Farm-R: Farm in Rural areas

ED: Emergency department

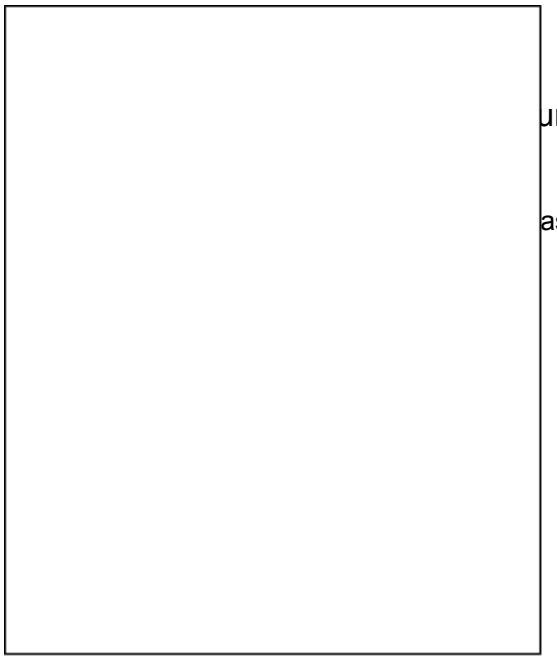
Table 4-3. Multivariate Cox proportional hazard model for agricultural injuries at the emergency department visit level and above combined

Variable	Hazard Ratio	SE	P	95% CI
Children's group				
Rural FN	2.68	0.64	<0.0001	1.68-4.28
Rural non-FN	8.21	1.34	<0.0001	5.97-11.31
Farm-U	16.63	2.79	<0.0001	11.97-23.10
Farm-R	26.91	4.17	<0.0001	19.86-36.46
Urban	Reference	-	-	-
Age, years				
15-17	2.65	0.59	<0.0001	1.72-4.09
10-14	2.07	0.43	<0.0001	1.39-3.09
5-9	1.43	0.29	0.077	0.96-2.13
1-4	1.09	0.22	0.685	0.73-1.62
<1	Reference	-	-	-
Sex				
Males	2.30	0.12	<0.0001	2.07-2.55
Females	Reference	-	-	-
Proxy SES				

Low status	1.44	0.07	<0.0001	1.30-1.59
No-subsidy	Reference	-	-	-

FN: First Nations, Farm-U: Farm in Urban areas, Farm-R: Farm in Rural areas

Proxy SES: Proxy socio-economic status based on subsidy status received for health care insurance premium



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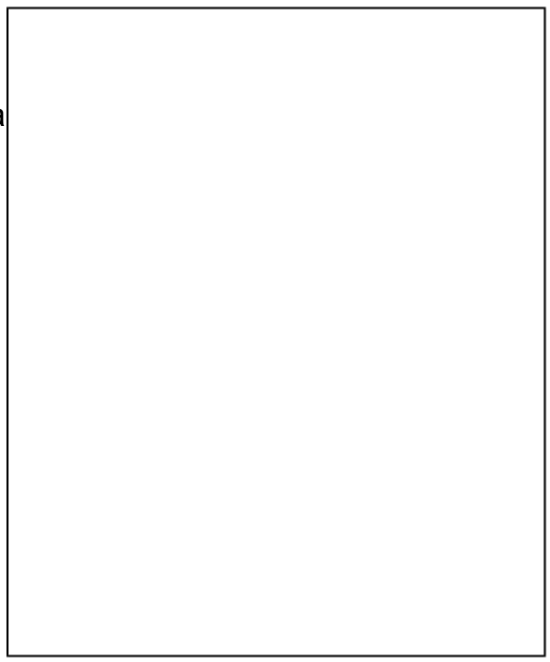

Table 4-4. Relative risks (95% CI) of agricultural injury for males to females

	Urban	Rural FN	Rural non-FN	Farm-U	Farm-R
ED visits	1.07 (0.87-1.27)	1.08 (0.77-1.38)	1.54 (1.49-1.60)	1.95 (1.86-2.04)	2.73 (2.71-2.76)
Hospitalizations	-	0.93 (0.89-2.76)	3.29 (2.46-4.11)	3.29 (1.64-4.94)	3.07 (2.85-3.30)
Deaths	-	-	-	-	4.68 (6.32-15.67)
Total	1.22 (1.00-1.43)	1.06 (0.80-1.32)	1.72 (1.67-1.77)	2.06 (1.98-2.15)	2.78 (2.76-2.80)

FN: First Nations, Farm-U: Farm in Urban areas, Farm-R: Farm in Rural areas

ED: Emergency department

Table 4-5. The leading causes of non-fatal agricultural injuries (crude incidence rates and rate ratios)

Mechanism	Urban	Rural FN	Rural non-FN	Farm-U	Farm-R	Rural FN			Rural non-FN			Farm-U			Farm-R		
	Rate (injuries per 100,000 person-years)					Rate ratio (95% CI), Reference: urban											
Natural	4.27	14.70	35.87	67.25	115.62	**3.44**	(2.48,	4.41)	**8.40**	(7.74,	9.07)	**15.75**	(15.06,	16.44)	**27.07**	(26.44,	27.70)
Machinery	1.71	6.30	23.92	67.25	105.32	**3.69**	(2.19,	5.18)	**14.00**	(12.98,	15.02)	**39.37**	(38.34,	40.39)	**61.65**	(60.66,	62.64)
Fall	2.14	10.50	26.63	51.24	80.98	**4.92**	(3.68,	6.16)	**12.47**	(11.55,	13.39)	**24.00**	(23.05,	24.94)	**37.92**	(37.03,	38.81)
Cut	0.85	8.40	22.29	28.82	66.00	**9.83**	(8.14,	11.53)	**26.09**	(24.67,	27.51)	**33.74**	(32.28,	35.21)	**77.27**	(75.88,	78.67)
Struck	1.28	2.10	12.50	44.83	57.11	**1.64**	(-0.62,	3.90)	**9.76**	(8.55,	10.96)	**34.99**	(33.80,	36.18)	**44.57**	(43.43,	45.72)
OLT	3.42	2.10	13.59	25.62	38.85	**0.61**	(-1.46,	2.69)	**3.98**	(3.18,	4.77)	**7.50**	(6.65,	8.35)	**11.37**	(10.65,	12.10)
Other SC	11.11	12.50	9.67	13.95	12.75	**1.13**	(0.23,	2.02)	**0.87**	(0.27,	1.47)	**1.26**	(0.49,	2.02)	**1.15**	(0.61,	1.68)
Overexertion	1.71	6.30	2.72	11.21	13.57	**3.69**	(2.19,	5.18)	**1.59**	(0.28,	2.91)	**6.56**	(5.33,	7.79)	**7.95**	(6.90,	8.99)

Poisoning	2.56	8.40	2.72	6.40	10.30	**3.28**	(2.01,	4.54)	**1.06**	(-0.13,	2.25)	**2.50**	(1.23,	3.76)	**4.02**	(3.12, 4.92)

FN: First Nations, Farm-U: Farm in Urban areas, Farm-R: Farm in Rural areas

OLT: Other Land Transport, Other SC: Other Specified, Classifiable

Natural/environmental: injuries related with animals, plant, lightning, excessive heat or cold, etc.

Rank	Urban	Rural FN	Rural non-FN	Farm-U	Farm-R
1	**Natural/ environmental**	**Natural/ environmental**	**Natural/ environmental**	**Natural/ environmental**	**Natural/ environmental**
	22.2%	21.9%	22.0%	19.5%	19.8%
2	**OLT**	**Fall**	**Fall**	**Machinery**	**Machinery**
	17.8%	15.6%	16.3%	19.5%	18.0%
3	**Poisoning**	**Cut**	**Machinery**	**Fall**	**Fall**
	13.3%	12.5%	14.7%	14.9%	13.9%
4	**Fall**	**Poisoning**	**Cut**	**Other SC**	**Other SC**
	11.1%	12.5%	13.7%	14.0%	12.8%
5	**Other SC**	**Other SC**	**Other SC**	**Struck**	**Cut**
	11.1%	12.5%	9.7%	13.0%	11.3%
6	**Machinery**	**Machinery**	**OLT**	**Cut**	**Struck by or against**
	8.9%	9.4%	8.3%	8.4%	9.8%
7	**Overexertion**	**Overexertion**	**Struck by or against**	**OLT**	**OLT**
	8.9%	9.4%	7.7%	7.4%	6.7%

Table 4-6. The leading causes of non-fatal agricultural injuries (proportions)

FN: First Nations, Farm-U: Farm in Urban areas, Farm-R: Farm in Rural areas

OLT: Other Land Transport, Other SC: Other Specified, Classifiable

Natural/environmental: injuries related with animals, plant, lightning, excessive heat or cold, etc.

Table 4-7. Mechanism and nature of injury for non-fatal agricultural vs. non-agricultural injuries

Rank	Agricultural injury		Rank	Non-agricultural injury	
	Mechanism of injury				
1	Natural/environmental	20.2%	1	Struck by or against	24.0 %
2	Machinery	17.3%	2	Fall	21.8 %
3	Fall	14.4%	3	Unspecified	9.4%
4	Other SC	12.3%	4	Overexertion	7.7%
5	Cut	11.2%	5	Cut	7.1%
6	Struck by or against	9.6%	6	Other SC	6.0%
7	OLT	7.2%	7	OLT	4.5%
8	Overexertion	2.6%	8	MVT	3.5%
9	Poisonings	2.2%	9	Natural/environmental	3.5%
10	Unspecified	1.7%	10	Pedal cyclist, other	2.7%
	Nature of injury				
1	Wound	32.0%	1	Dislocation	21.5 %
2	Contusion	20.9%	2	Contusion	20.4 %
3	Fracture	19.1%	3	Wound	19.8 %
4	Dislocation	9.4%	4	Fracture	16.6 %
5	Internal	4.4%	5	Internal	3.2%
6	Crush	3.1%	6	Foreign body	2.1%
7	Foreign body	2.1%	7	Burn	1.5%
8	Burn	2.0%	8	Other effects	1.5%
9	Toxic Exposure	1.9%	9	Toxic Exposure	1.3%

10	Amputation	1.6%	10	Crush	0.5%

Other SC: Other Specified, Classifiable, OLT: Other Land Transport, MVT: Motor Vehicle Traffic

Natural/environmental: injuries related with animals, plant, lightning, excessive heat or cold, etc.

Chapter 5. Differences in injury-related health care utilization for farm, rural, and urban children

5.1 Introduction

A review of health care utilization provides information on needs for medical services, patterns of services sought, and medical facilities frequently used by populations with different characteristics. In particular, episode-based utilization analysis has been used for the evaluation of the quality and efficiency of medical care provided as well as for appropriate planning and budgeting of health resources to meet the health needs of a defined population.[1] Injury-related health care utilization may mainly be determined by health care needs but also be influenced by social, economic, geographical, and cultural factors including accessibility to medical services, perceived quality of service, health care seeking behavior, etc.[2-5]

A substantial number of publications have demonstrated disparities in health care service provisions and utilization between rural and urban settings,

reporting greater pre-hospital deaths,[6-9] higher case fatality,[10-12] and more preventable deaths[13] among rural residents, possibly due to inferior access to adequate trauma care.[11,13-19] Although the rural pediatric population is composed of heterogonous groups, patterns of injury-involved health care uses between detailed subgroups, particularly between farm and other groups of children, have not been compared in North America.

Injury-related health care utilization for farm children might be expected to be similar to that for rural children as there is likely an exposure to similar health hazards (e.g., dangerous primary industries, traffic/road conditions, etc.)[19-22] and the prevailing medical environment in rural areas. On the other hand, differences might be introduced by distinct residential environments (i.e., a routine exposure to diverse agricultural hazards) for farm children [23,24] compared with the other rural children. A lack of information on health care use for farm children in previous research may possibly be attributed to difficulties in identifying farm families in administrative health databases. Only an approach that specifically identifies farm children and tracks down their health service use in administrative health databases will enable an examination of health care utilization for farm and non-farm children.

In Alberta, there was a unique opportunity to set up a farm population list in 1998, which an Alberta farm children list can be derived from. A farm children (i.e., children whose parents are farmers) list was linked to administrative health databases so that all injury records for identified farm children could be tracked down from 1999 to 2010. The linkage of multiple administrative health databases

captured nearly all injury records requiring medical care, providing a comprehensive picture of health care utilization for farm and non-farm children in Alberta.

The objective of this study was to examine differences in injury-related health care utilization between farm children and several groups of non-farm children under 18 years of age in Alberta. Findings from the present study could contribute to proper design and allocation of health care services for injuries specific to each group and identify groups with high demand.

5.2 Materials and methods

5.2.1 Study Design

A retrospective cohort study with a closed population was established. Different groups of children who met the inclusion criteria in the fiscal year of 1998 were selected and followed until they became 18 years of age within the study period (January 1, 1999 to December 31, 2010) to examine the incidence of all-cause injury. A population-based approach utilized linkage of multiple administrative health databases.

5.2.2 Study location

In 2006, Alberta's population consisted of an 82.1% urban and 17.9% rural dwellers where a quarter of those located rurally were farm families[25]. Alberta is

the third largest province in Canada with regard to the number of farms [26], which are mainly involved in cattle ranching and oilseed/grain farming.[27] Alberta has a social health care system where all medically necessary services are universally provided according to the Canada Health Act.[28]

5.2.3 Study participants

The study population consisted of farm children and three groups of non-farm children under 18 years of age who lived in Alberta in the fiscal year of 1998/99 and were not lost to follow up before January 1, 1999. As a closed population, there were no new entries into the study population after the first selection of subjects at the beginning of the study period. Subjects left the study due to death, migration or by becoming 18 years of age.

Farm children were identified from the all-ages Alberta farm population list that captured virtually all farm residents in Alberta. The all-ages farm population list was set up by probabilistically linking the Farm Fuel Tax subsidy list in 1998 and Health Care Insurance Plan Registry file in the same year to identify farm families. Two groups of non-farm children (rural and urban children) were extracted from two representative samples of all-ages non-farm rural and urban population that were randomly selected from the Alberta Health Care Insurance Plan registry with the equivalent sample size to the farm population, respectively. Classification of rural or urban residence was based on their postal code from the registry: A postal code with a "0" as the second character denotes a rural area where there are no letter carriers and residents go to the corner postal box or the

post office to pick up their mail.[29] Non-farm rural children were subdivided into First Nation (FN) and non-FN children based on health insurance premium status [30].

5.2.4 Data Sources

Outcome data (injury records) were obtained from four health databases that were maintained by Alberta Health, Government of Alberta. The four heath databases comprisedVital Statistics File, Hospital Discharge Abstract Database, the Ambulatory Care Classification System, and Physician Claim Billing file that contained data for mortality, hospital admissions, emergency department (ED) visits, and physician visits, respectively. The Physician Claim File consisted of services performed in hospital, ED, physician office, or diagnostic & therapeutic centers. Injury data for 12 calendar years (1999 to 2010) from each of the four databases were deterministically linked using scrambled personal health number (PHN) and also linked to the Health Care Insurance Plan Registry file being merged into a single file.

The Health Care Insurance Plan Registry file provided demographic information of subjects including age, sex, 3 digits of postal code, migration, health zone, and Alberta health insurance premium status. The insurance premium status was used as a proxy measure of socioeconomic status (SES) and categorized into high SES (i.e., no subsidy group) and low SES (i.e., FN treaty-status Aboriginals, full premium subsidy, and partial premium subsidy groups) in this study.

5.2.5 Injury identification

Injury-related health records included all medical records that contained the following International Classification of Disease (ICD) diagnostic codes or external causes (E-codes) for "injury and poisoning" in any of the diagnostic fields, including early complication or sequelae of trauma but removing complications of medical and surgical care and misadventures.

a. Diagnostic codes: 800-995 except 909(.3, .5) (ICD-9) or SOO-T98 except T80-T88 (ICD-10)

b. E-codes: E800-E869, E880-E929, E950-E999 (ICD-9) or V01-Y36, Y85-Y87, Y89 (ICD-10)

Injury records were classified by nature and body site injured into subcategories based on categorization tables, where detailed ICD diagnostic codes were assigned to each category for ICD 9th and ICD 10th revision coding system, respectively. The categorization tables followed previously published frameworks or matrices including Barell Injury Diagnosis Matrix and the Injury Mortality Diagnosis Matrix.[31,32] The categorization table also covered the injury data that were coded with ICD 9th revision Clinical Modification (ICD-9-CM) and ICD 10th revision Canada (ICD-10-CA) system, because sufficiently broad subcategories (8 body sites, 16 natures) were utilized to reduce the possibility of diagnostic categorization error occurrences due to different ICD versions.

5.2.6 Injury episode

Considering that one injury event may result in multiple medical services and visits, a definition of an episode of injury was created. Across the four databases, all injury-related medical records were classified into initial and subsequent visits of an injury episode. For each injury episode, only the record at the highest level of care was extracted and used in the analysis. This was used as a proxy measure for severity of an injury episode. If there were multiple records at the same highest level of care (e.g., two hospitalization records for a child), the first record was chosen.

To construct the injury episode, all injury data from multiple sources were merged together and sorted by the subject's id and medical service date. Beginning with the first injury record for each child, the immediate next injury record for the same child was determined, and the record was examined to identify if it represented a follow up visit of the previous injury or a new injury episode for the child based on criteria. The criteria used to identify follow up visits were built from detailed data examination and modification of the criteria used in previous publications,[33-35] while trying to be conservative in determining a record as a follow-up visit so as not to lose any incident cases.

To be determined as a follow-up visit of the previous injury record, the injury record was required to meet at least one of the following criteria compared with the previous injury record: the injury record (1) had ICD codes for sequelae or late effects of injury, (2) appeared on the same day, (3) occurred within 7 days in the same category of body region or the nature of injury, (4) occurred within 180 days in the same category of both body region and nature of injury, or (5)

occurred within 180 days with the exactly same diagnostic codes in all ten ICD diagnostic fields compared with the previous injury record. Episode identification for fatal cases was manually conducted, as the Vital Statistics database contains only a single E-code without any supporting diagnostic codes. An additional three years of injury records prior to 1999 were used to eliminate any incident injuries that occurred before 1999 and were treated after 1999.

5.2.7 Statistical analysis

Descriptive statistics for demographic variables (age, gender, proxy SES, and health service zone by residential area) and injury-related health services use (injury episode, services, nature, the length of stay in medical facility, etc.) were generated by children's group and data source (i.e., level of care) using frequencies, proportions, and ratios. Differences in demographic and outcome variables between children's groups were tested using one-way ANOVA and chi-square statistics. Injury pyramids for injury episodes and for all associated medical services were created by calculating the ratio of non-fatal injuries at each level of care to every injury death by children's group and sex.

The place of death in terms of the level of care received for each fatal injury (e.g., in-hospital deaths) was determined by manually checking all medical records for each fatal case. If there were no associated medical records for the fatal injury episode, a place of death was marked with "out of any health facility". If any medical record existed, the highest level of care facility was chosen for the place of death (e.g., hospital death, ED death, and practitioner's office death).

Hospitalization status (e.g., hospital admission category and length of hospital stay (LOS)) for all injury-related hospitalizations were examined by children's group using frequencies and proportions.

As an analytical analysis, multivariate logistic regression was carried out to examine the relationship between existence/absence of any injury service (outcome: 1, 0) and children's group adjusting for potential confounders (i.e., age, sex, and proxy SES). Also, multivariate regression was conducted to examine the relationship between a total number of injury service per subject and children's group adjusting for potential confounders (i.e., age, sex, and proxy SES). Data management and statistical analyses were conducted using SPSS® 18.0 and STATA® MP 12.1.

5.3 Results

From 12 years of follow-up (1999 to 2010) of 115,378 children under 18 years of age, there were a total of 672,805 medical services for 275,442 injury episodes documented. All physician visit-level episodes were claims from practitioner's offices. However, in terms of full injury-related records, physician claims consisted of claims from practitioner's office (58.0%), ED (38.7%), hospital (3.0%), and unknown sources (0.3%). The majority of farm children (77.4%) lived in rural areas, but 22.7% of farm children resided in urban areas. As there was homogeneity of injury patterns and rates between farm children living in rural and urban areas, data from the two farm groups were presented combinedly. Respective results for rural- and urban-living farm children for main outcomes

were presented in Appendix II.

Rural children comprised 83.0% of non-FN and 17.0% of FN children. FN children living in rural areas represented 87.2% of all FN children in the study population. The rest of FN children (1034 urban-living FN children, 12.8% of all FN) were classified into urban children comprising 3% of urban children.

5.3.1 Demographic Characteristics

Demographic characteristics of four groups of children are illustrated in Table 5-1. Rural FN children were younger (mean age: 8.9 years, $p<0.001$) and more likely to live in in the north health services zone of Alberta (53.6 %) than other groups of children. Farm and rural FN children received more health insurance premium subsidy (29.1 %, 100%, $p<0.001$) than the other groups (18.8 %, 17.9 %). Two groups of rural children (rural FN, rural non-FN) were more likely to be lost to follow-up before 18 years of age during the study period than other groups, mainly due to migration to urban areas (81.6 % of all losses for rural children), while farm children showed the most stable residency with the lowest loss to follow up (9.1 %).

5.3.2 Injury episodes and services

ED admission for all children's group except for urban children was the most common level of care for injury episodes. The proportions of ED visit-level injury episodes among all injury episodes was greatest for rural FN children (62.6%), followed by rural non-FN children (58.2 %), and farm children (54.1%). For

urban children, physician office visit-level injury episodes were the most common (54.6%). Regarding the full medical services received for the injury episodes, physician office visits were dominant across all children's groups comprising from 61.8% (FN) to 73.1% (urban children) of all services. Physician claims mainly consisted of physician office visits (21.0-48.8% of claims), ED services (22.3-36.8%), and in-patient services (1.4-3.8%). When considering all levels of injury records together, the ratios of services to episodes ranged from 2.1 (FN) to 2.6 (farm children). The ratio of services to episodes for physician office visits was considerably lower among rural FN children (1.3) than other groups (2.0-2.44).

A total of 68.2% of all subjects (78,747 out of 115,378 children) have ever received a medical service at any care level due to injury. As a result from multivariate logistic regression, adjusted odds ratios (ORs) of an experience of injury service for each children's group compared to urban group were not significant (adjusted ORs: 0.98-1.0, p-value: 06-0.8 by children's group) implying no significant relationship between an experience of injury service during the study period and children's group adjusting for age, sex, and proxy SES. Also, results from multivariate regression indicated that children's group alone or children's group, age, sex, and proxy SES taken together did not significantly predict the total number of injury service for a subject ($F(9, 115368)=1.81$, p-value=0.061).

5.3.3 Injury pyramid by children's groups and sex

Ratios of injuries at each level of care to deaths (i.e., injury pyramids) for injury episodes and for related full medical services varied by children's group and sex (Table 5-2, Figure 5-1). In terms of injury episodes, overall, rural FN children had the least hospitalizations, ED visits, and physician office visits per single death (18: 357: 195 per death) than any other children's groups indicating the greatest lethality of injuries for rural FN children. Farm children had the second greatest lethality, followed by rural non-FN and urban children in descending order with consistent rankings at every care level (Table 5-2). While male children showed similar trends as those for both sexes combined, for females, the second ranked group for lethality was rural, non-FN females next to rural FN ones both in episodes and full services. Urban females presented notably lower lethality than any other groups both in episodes and full services (Figure 5-1).

5.3.4 Place of deaths in terms of level of care

The proportion of in-hospital injury deaths of all injury deaths was greater among urban children (30%) than farm and rural children (6.3-17.5%) (Figure 5-2). Injury deaths occurred outside of any health facility were most common for rural FN children, followed by rural non-FN, farm, and urban children in descending order (84.4%, 62.5%, 53.5%, and 40.0%, respectively). The greatest proportion of deaths in EDs was documented from farm children (33.8%).

5.3.5 Hospitalization status

When considering all injury hospitalization records, in terms of an admission

category to a hospital, an urgent admission was the most common category across all children's groups and was more prevalent in rural FN (84.9% of all hospitalizations) and farm children (80.4%). The proportion of emergent admissions was greater in urban children than other groups.

5.3.6 Nature of injury

Dislocation, contusion, wound, fracture, and internal injuries were the most common natures of injury in physician office visit- and ED visit-level injury episodes across all children's groups, although rural FN children had less dislocations but more contusions and wounds than other groups (Table 5-4). In hospitalization-level episodes, fracture was the most prevalent nature of injury for all groups, followed by poisoning for rural FN children and internal injuries for the other three groups. For nature-specific injury rates, rural FN children had considerably higher rates for blood vessel injury, burns and toxic effects, while farm children had higher rates for crushing injury and amputations than the other groups of children.

When injury-related physician's claims, ED visits, and hospital admissions were combined, a ratio of services to episodes was greater for fracture and nerve injuries than other nature of injury across children's groups (2.85-6.35, 3.57-4.03) (Table 5-5). In particular, nerve injuries for rural FN children showed the greatest number of services per episode (6.35services/episode). Beyond these two natures of injury, amputations and internal injuries, especially among rural FN and farm children, were documented at about 3 services per episode.

5.4 Discussion

This study explored the injury-related health care utilization among four pediatric populations in Alberta using an individual-based linkage of all available administrative medical records from physician claims to deaths. A key finding of the present study was that farm and rural children, especially rural FN children, had greater utilization of higher levels of medical facilities, greater proportions of pre-hospital deaths, and fewer non-fatal injuries per death (i.e., a thinner "shape" of injury pyramid) than urban children, implying more serious and lethal injuries for farm and rural children.

Both in injury episodes and related medical services, it was found that proportions of ED visits and hospitalizations (higher levels of medical facilities) were the greatest for rural FN children, followed by rural non-FN, farm, and urban children in descending order. These results may be associated with two factors. Firstly, this trend may be mainly attributed to greater severity of injury for farm and rural children, particularly for rural FN children. Similar trends of injury severity were found from the shape of injury pyramids that presented the highest lethality of injury (i.e., the thinnest "shape" of pyramid) for rural FN children, followed by farm, rural, and urban children in descending order. These findings confirm the results of previous research that have reported higher rates of severe injuries for rural and remote rural children compared with urban counterparts.[36-40] Secondly, the results may be partly caused by less efficient capture of minor injuries for farm and rural children, particularly for rural FN children, as shown in

the low ratio of services to episodes for physician office visits for rural FN children, which may be associated with different medical environments[11,13,15,16] and health seeking culture/behaviors between groups.[2]

Unlike the apparent differences in health care utilization by the level of medical facilities between children's groups above, no significant differences between the children groups in an existence/absence of injury service/episode over the follow-up time or total number of injury services per child were found from the multivariate regression analysis. The results imply the analysis without an appropriate consideration of severity of injury and time at risk of injury would lead to misleading conclusions.

Regarding the place of deaths (i.e., level of treatment), it was noticeable that the majority of injury deaths occurred out of any medical facility for farm and rural children (53.3%-84.4%) unlike urban children (40.0%). Out of hospital deaths were 70-93.7% by children's group. Several prior research findings have reported considerable proportions of out-of-hospital injury deaths although the figures varied by study population and country. There have been reports of out-of-hospital injury deaths ranged between: 38.6% (the U.S., farm children);[41] 40% vs. 72% (urban vs. rural areas, the U.S., all ages);[9] 52% (Europe, all ages);[7] 85% (Sweden, <14 years);[6] and, 34% (the U.S., all ages).[8] A greater proportions of deaths at the scene (or before hospitalization) and less common in-hospital deaths for farm and rural children than urban children could be explained by a higher severity of injury in rural groups [36-40] as well as by poorer quality of medical services in rural areas including longer transport time to care,[11,13-16]

less-advanced pre-hospital care,[17] more difficult access to a trauma center,[18] and a lack of high-level trauma care centers for rural children.[12,19]

All these findings regarding utilization of higher-level injury services and an increased proportion of out-of-hospital deaths suggest the demands of high-level pediatric trauma care for severe injuries for farm and rural children are not being met. Given most high-level traumatic facilities are located in urban areas, the allocation and regionalization of advanced traumatic care facilities in rural areas (including FN resident locations and farming areas) should be an issue to be addressed. Given the common use of ED services and higher proportion of ED deaths than in-hospital deaths among farm and rural children, improved trauma care in the ED may be particularly effective in reducing the impact of injury in rural areas.

The findings of a high proportion of pre-hospital deaths across children's groups underline the importance of inclusion of vital statistics in research on fatal or severe injuries because the likelihood of there being considerable missing cases of death in hospital discharge or medical care databases. Prior studies also point out the substantial underestimation of fatal injuries in hospital data.[42,43] The use of limited information of deaths would lead to a significant underestimation of rates as well as a bias in the examination of prevalence and incidence of severe injuries considering different structures of places of deaths between children's groups.

Limitations of the present study include the possibility of misclassification of injuries due to errors in coding and charting of injury codes, which is an

inherent weakness of administrative databases. However, the misclassification is not likely to happen differentially between groups as the data came from a uniform health system. Our data had limited information on injury severity or detailed health care services given for each injury, although we were able to use level of care as a proxy measure of injury severity. There is a possibility of differential misclassifications of injury events and services if healthcare seeking behaviors or accessibility to health care services are different between children's groups. If populations living in rural areas are less likely to seek or get treatment from health care system possibly due to the longer distance to health care facilities,[19,44] their injury rates may be underestimated. Lastly, misclassification of a proxy of socio-economic status for FN children may occur. All FN treaty-status Aboriginals in the insurance premium status in Alberta were classified into children in a low SES status, but all FN children may not be in low SES status. However, children's SES status does not appeared to considerably affect the results as there were not much differences between adjusted and unadjusted results in regression.

One other thing to be aware of is that the results of this study are more likely to be influenced by older age groups as this study followed up a fixed study population over time without new entry of young children into the study population.

The main strength of this study was the full coverage of all injury-related health services that were recorded in any administrative health database from physician claims to vital certificates. Also, the medical records were classified

into an injury episode with initial and subsequent follow-up visits providing insight to the relationship between injury incidence and service use. The linkage of multiple databases and the identification of an injury episode across these databases made it possible to track and determine the location of deaths (i.e., the health facility where the last health service was received for the fatal injury or on-spot death without any health service recorded). This was a population-based study with a large sample size, which enhances the external validity of the results, and the use of administrative databases likely reduced bias (both selection bias and information bias). With these strengths, we were able to provide a comprehensive picture of frequency and patterns of injury-related medical services utilized by diverse pediatric populations, which has not been available from a substantial number of previous studies that have addressed urban-rural disparities of health services utilization.

5.5 Conclusions

This study followed farm and three groups of non-farm Albertan children (115,378 children) under 18 years of age from 1999 to 2010 to compare the injury-related health care utilization by linking administrative medical records from physician claims to death certificates. Various indicators including greater utilization of higher levels of medical facilities, thinner shapes of the injury pyramid, and greater proportions of pre-hospital deaths for rural FN children, followed by rural non-FN and farm children, compared with urban children

suggested a greater proportion of more serious injuries for farm and rural children. These findings emphasize the need for improved medical services, especially for efficient allocation and timely provision of advanced trauma care for serious injuries for rural areas including FN resident locales and farming areas. Findings regarding different patterns of health care utilization by children's group indicate the importance of targeted and strategic health services plans for specific pediatric populations.

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Table 5-1. Subject demographics

	Urban (N=34,386)	Farm (N=39,658)	Rural non-FN (N=34,288)	Rural FN (N=7,046)
Sex (male)*	50.7%	51.9%	51.2%	51.5%
Age (years, mean ± SD)**	9.6±4.9	9.9±4.9	9.7±4.9	8.9±4.8
Socio-economic status**				
Low status[1]	18.8%	29.1%	17.9%	100.0%
Health services zone				
Edmonton	38.4%	7.1%	7.6%	3.7%
Calgary	38.8%	10.4%	17.4%	10.7%
North	8.2%	28.4%	31.9%	53.6%
Central	8.4%	34.2%	28.8%	18.4%
South	6.3%	20.0%	14.2%	13.6%
Loss to follow up ** before 18 years of age	14.3%	9.1%	38.0%	26.3%
Person-years followed				
Males	118,604	143,021	94,898	24,654
Females	115,552	133,064	89,078	22,975
Total**	234,156	276,085	183,976	47,629

* $p<0.05$, ** $p<0.001$ regarding differences between groups

[1] Any subsidy received for health care insurance premium

FN: First Nations

Table 5-2. Episodes and services of any-cause injuries

	Urban		Farm		Rural non-FN		Rural FN	
Episodes (n, %)								
PO visits	43,412	54.6%	45,592	43.8%	29,364	39.9%	6,226	34.1%
ED visits	35,112	44.1%	56,315	54.1%	42,817	58.2%	11,412	62.6%
Hospitalizations	994	1.2%	2,112	2.0%	1,355	1.8%	568	3.1%
Deaths	20	0.0%	71	0.1%	40	0.1%	32	0.2%
Total	79,538	100.0 %	104,090	100.0 %	73,576	100.0 %	18,238	100.0 %
Full services (n, %)								
Physician claims	133,092	73.1%	191,837	70.4%	121,059	67.5%	24,047	61.8%
PO visits	88854	48.8%	111459	40.9%	64134	35.7%	8170	21.0%
ED Services	40656	22.3%	73527	27.0%	53213	29.7%	14300	36.8%
In-Patient Services	2616	1.4%	6494	2.4%	3500	2.0%	1482	3.8%
Diagnostic Serv. or unknown	966	0.5%	357	0.1%	212	0.1%	95	0.2%
ED visits	47,938	26.3%	78,193	28.7%	56,882	31.7%	14,229	36.6%
Hospitalizations	1,030	0.6%	2,259	0.8%	1,475	0.8%	601	1.5%
Total	182,060	100.0 %	272,289	100.0 %	179,416	100.0 %	38,877	99.9%
Services/1 episode	2.3		2.6		2.4		2.1	
Pyramid								
Episodes (Death: hospi.: ED: PO)	1: 50: 1756: 2171		1: 30 : 793: 642		1: 34 : 1070 : 734		1: 18: 357 : 195	
Full services (Death: hospi.: ED: PO)	1: 52: 2397: 6655		1: 32: 1101 : 2702		1: 37: 1422: 3026		1: 19: 445: 751	

FN: First Nations, PO: physician office, ED: emergency department

Table 5-3. Status of all hospitalizations by children's group

	Urban	Farm	Rural Non-FN	Rural FN
All hospitalizations (No.)	1,030	2,259	1,475	601
Admission category				
Emergency	199 (19.3%)	238 (10.5%)	215 (14.6%)	60 (10.0%)
Urgent	738 (71.7%)	1,816 (80.4%)	1,131 (76.7%)	510 (84.9%)
Elective	93 (9.0%)	205 (9.1%)	129 (8.7%)	31 (5.2%)
Length of stay (LOS)				
0-2days	729 (70.8%)	1,607 (71.1%)	1,079 (73.2%)	405 (67.4%)
3+ days	301 (29.2%)	652 (28.9%)	396 (26.8%)	196 (32.6%)
LOS (mean +_SD, days)	3.96+12.6	3.30+7.25	3.32+8.17	4.05+10.8
Special care unit (SCU)				
SCU (No. %)	105 (10.2%)	248 (11.0%)	150 (10.2%)	62 (10.3%)
SCU days (mean +_SD, days)	2.86 +4.56	4.21+8.66	3.08 +4.95	3.82+5.78

FN: First Nations

Table 5-4. The leading natures of injury episodes by children's group and the level of medical care

Rank	Urban		Farm		Rural non-FN		Rural FN	
PO visits (%)								
1	Dislocation	51.4	Dislocation	63.4	Dislocation	58.0	Dislocation	36.4
2	Contusion	18.5	Contusion	13.3	Contusion	17.1	Contusion	27.7
3	Wound	10.1	Wound	6.2	Wound	6.7	Wound	9.9
4	Facture	6.7	Facture	6.2	Facture	6.1	Facture	8.4
5	Internal	2.2	Internal	1.9	Internal	2.1	Internal	2.1
ED visits (%)								
1	Dislocation	23.5	Dislocation	22.1	Dislocation	22.2	Wound	25.7
2	Contusion	21.2	Wound	20.6	Contusion	21.1	Contusion	22.4
3	Facture	18.6	Contusion	19.9	Wound	20.9	Dislocation	15.9
4	Wound	17.2	Facture	15.3	Facture	13.6	Facture	13.7
5	Internal	3.2	Internal	2.9	Internal	2.7	Internal	1.9
Hospital admissions (%)								
1	Facture	56.1	Facture	52.8	Facture	49.7	Facture	39.6
2	Internal	12.9	Internal	19.1	Internal	15.6	Poisoning	18.5
3	poisoning	10.6	Dislocation	5.1	Wound	11.1	Wound	13.4

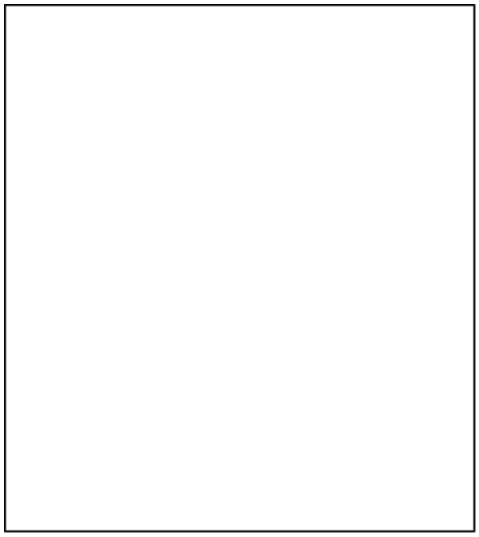
4	Wound	9.4	Poisoning	4.3	Contusion	10.3	Internal	10.2
5	Contusion	6.6	Burn	2.7	Poisoning	9.4	Contusion	10.4
6	Dislocation	4.2	Nerve	2.4	Dislocation	3.9	Toxic	4.9
7	Foreign body	3.2	Toxic	2.3	Burn	2.8	Burn	4.4

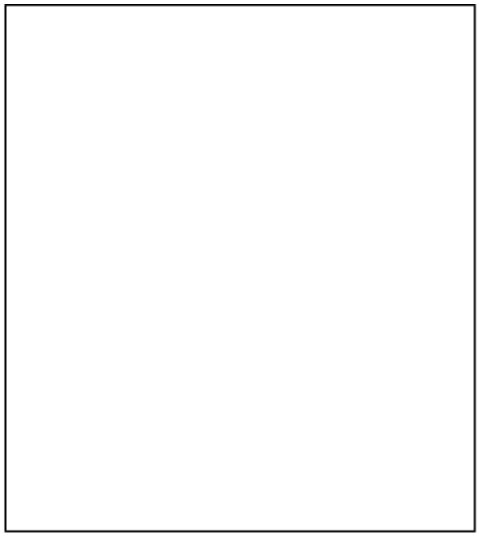
FN: First Nations, PO: physician office, ED: emergency department

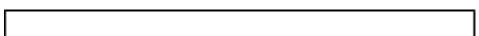
Table 5-5. An average number of services per an injury episode by nature of injury (From records of physician's claims, ED visits, and hospitalizations combined)

Nature of injury	Urban	Farm	Rural non-FN	Rural FN	Total
Nerve	6.35	4.15	4.52	2.85	5.05
Facture	3.64	4.03	3.96	3.57	3.86
Amputation	2.12	3.79	2.91	3.44	3.21
Internal	2.48	3.19	2.76	3.32	2.87
Dislocation	2.49	2.90	2.70	1.97	2.69
Burn	2.23	2.94	2.67	2.55	2.63
Poisoning	2.26	2.06	2.32	2.65	2.29
Blood	2.29	2.15	1.57	2.13	2.00
Wound	1.78	2.05	2.02	2.05	1.97
Crush	1.50	2.30	2.31	2.14	1.96
Foreign body	1.70	1.96	1.89	1.86	1.87
Contusion	1.53	1.79	1.77	1.72	1.70
Toxic	1.62	1.44	1.48	1.74	1.53
Other effects	1.27	1.28	1.39	1.52	1.34

FN: First Nations, ED: emergency department







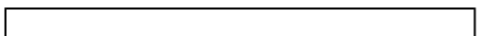
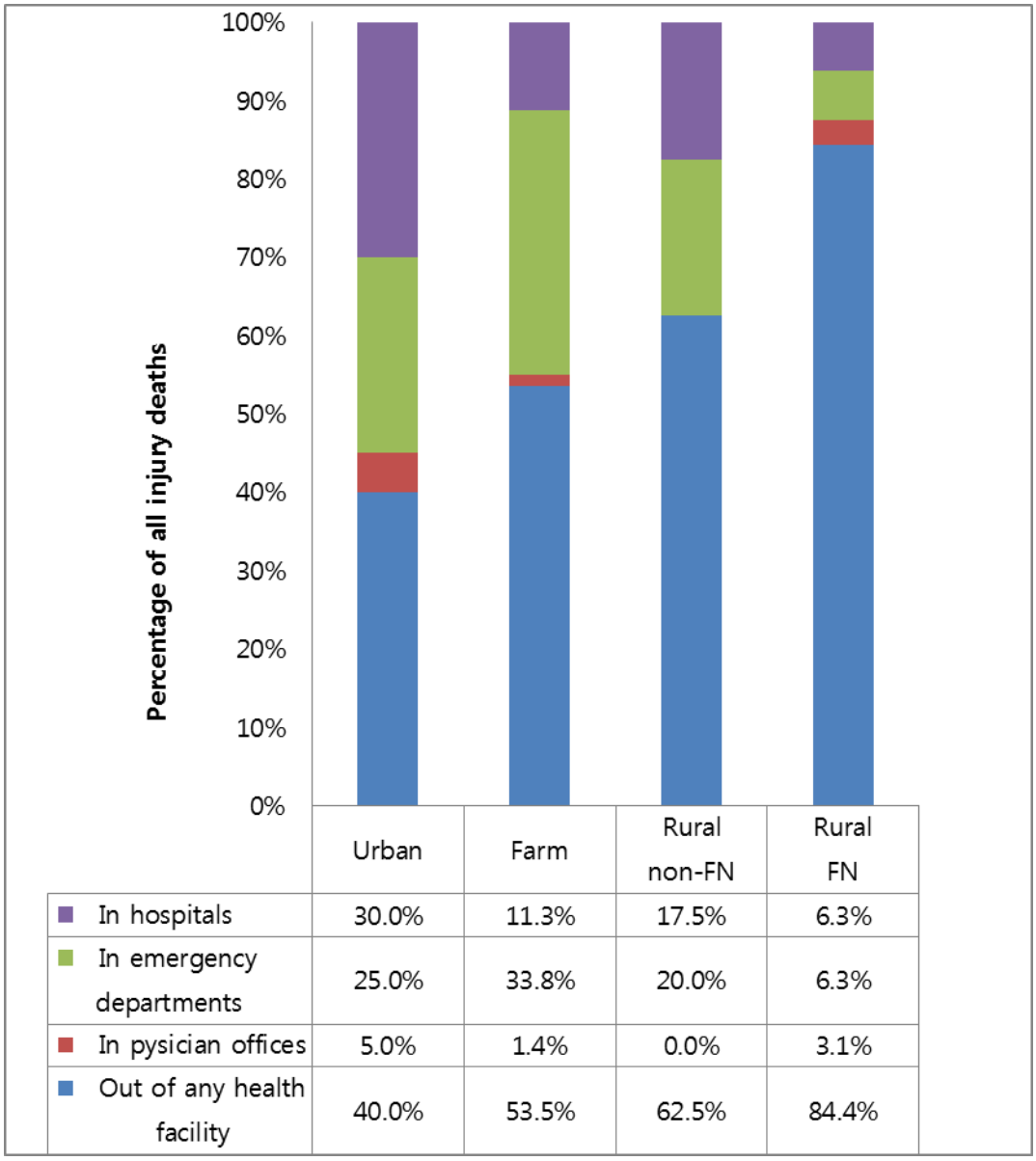


Figure 5-1. Injury pyramid by children ‘s group and sex

FN: First Nations, PO: physician office, ED: emergency department



	Urban	Farm	Rural non-FN	Rural FN
In hospitals	30.0%	11.3%	17.5%	6.3%
In emergency departments	25.0%	33.8%	20.0%	6.3%
In pysician offices	5.0%	1.4%	0.0%	3.1%
Out of any health facility	40.0%	53.5%	62.5%	84.4%

Figure 5-2. The place of deaths in terms of level of care

FN: First Nations, PO: physician office

Chapter 6. General discussion and conclusions

6.1 Overview of study objectives

There has been a lack of information on the overall and relative burden of injury for farm children compared to other groups of children. The objectives of this theses were 1) to systematically review available evidence regarding differences in injury incidence between rural and urban pediatric populations in Canada and the United States, and 2) to examine compare risk and patterns of all-cause incident injury (chapter 3), agricultural injury incidence (chapter 4), and injury-related health care utilization (chapter 5) for farm children compared to several groups of non-farm (rural, First nations, urban) children under 18 years of age in Alberta using an individual-based linkage of multiple administrative health databases from 1999 to 2010 from Alberta.

6.2 Summary and interpretations of the results

The systematic review of the literature revealed rural-urban differences in rates and patterns of injury in children. Rural children appeared to be at higher risk of overall injury, motor vehicle collision (MVC) injury, and suicide, whereas urban children in the U.S. experienced higher rates of firearm-related homicides. Greater rural-urban injury disparities were likely to be found between more extreme rural and urban areas, and children in remote rural areas were at increased risk of severe injuries than urban counterparts.

Regarding the risk of overall incidence of all-cause injury, rural FN children sustained the greatest burden of injury, followed by rural non-FN, farm, and urban children (in descending order), and the rank was largely consistent for most mechanisms of injury. Regarding the injury disparity by proxy severity of injury, urban children had higher rates of minor-severity injuries (physician office visits), but farm and rural children consistently had higher rates of injuries at emergency department (ED) visit level of severity and above with increased injury disparities for more severe injuries (a clearly linear relationship between injury disparity and injury severity). Farm children were at a higher risk of severe injuries (hospitalizations and deaths) than non-FN rural children. Considerably increased risk of other land transport (OLT), natural/environmental, and firearm-related injuries were noted for farm and rural children in common. Greater risk of farm hazard-related injuries (e.g., farm-animal and machinery-related injuries) were observed for farm and rural non-FN children, and markedly higher risk of unintentional firearm-related injuries and suicidal suffocation were of greater concern for rural FN children.

Agricultural injury comprised a small portion of overall injuries, but had more effect on serious injuries (e.g., about 10% of hospitalized and fatal injuries of all injuries for rural-living farm children) and on specific mechanisms/nature of injury events (e.g., 35.3% of all machinery-related injuries, 13.9% of all amputations and 7.2% of all crush injuries). Rural-living farm children appeared to have the highest rates of agricultural injuries, but considerable incidence rates were observed among urban-living farm children and non-FN rural children

indicating the impact of agricultural injuries on broader pediatric populations.

Similarly, by applying injury rates observed from this study and the size of each group's population in Alberta[1], it is assumed that approximately 50%, 30%, and 20% of agricultural injuries at the ED visit level of severity and above were sustained by farm, non-farm urban, and non-farm rural children, respectively as an actual burden of agricultural injury. It was found that agricultural injuries had distinct characteristics compared with non-agricultural injuries: more unintentional and lethal, more males and younger victims for serious injuries, and higher proportions of natural/environmental injuries, machinery, and falls for agricultural than non-agricultural injuries.

When examining injury-related health care utilization, it was found that higher levels of medical facilities (ED visits and hospitalizations) were more frequently used by rural FN children, followed by rural non-FN, farm, and urban children in descending order both in injury episodes and related medical services. Regarding the place of death in terms of level of care, it was noticeable that the majority of injury deaths occurred outside of any medical facility for farm and rural children (53.3%-84.4%), unlike urban children (40.0%). The greater proportion of more serious injuries for farm and rural children, especially rural FN children, than urban children was demonstrated by various indicators including greater utilization of higher levels of medical facilities, greater proportions of pre-hospital deaths, and fewer non-fatal injuries per death (i.e., a thinner "shape" of the injury pyramid) for farm and rural children, especially rural FN children.

6.3 Limitations and strengths

Limitations of the present study included the following: 1) this study has limited information on circumstances that led to injuries (e.g., occupational injury or not), changes in farming status over time, and various risk factors other than age, sex, and a proxy measure of socio-economic status. These are inherent weakness of administrative health records that are routinely collected for non-research purposes. Therefore, the potential for misclassification of participant demographic information and injury episode and residual confounding remained; 2) the possibility of misclassification of injuries exists from errors in coding and charting of injury code and diagnostic errors in administrative data. However, this misclassification is not likely to occur differentially between groups as we have data from a single health system; 3) some differential misclassification of injury events may occur if healthcare seeking behaviors or accessibility to health care services are different between farm and non-farm residents. If rural populations are less likely to seek or get treatment from the health care system possibly due to the longer distance to health care facilities,[2,3] their injury rates, especially for minor injuries,[4] may be underestimated; 4) the possibility of misclassification of a proxy of socio-economic status for FN children exists. All FN treaty-status Aboriginals in the insurance premium status in Alberta were classified into children in a low SES status in this study, but all FN children may not be in low SES status. However, children's SES status does not appeared to considerably affect the results as there were not much differences between adjusted and unadjusted hazard ratios of injury ; 5) agricultural injuries, especially agricultural

deaths, might be underestimated in this study, if E-codes for on-farm injuries were not recorded in any of medical databases per an episode, although this underestimation would be non-differential among comparison groups. One thing to be aware of is that the results of this study were more likely be influenced by older age groups as this study followed up the fixed study population over time without the addition of young children into the study population.

Nevertheless, the strengths of this study included: 1) increased external validity as a population-based study with a large sample size; 2) full coverage of all injury-related health services that have been recorded in any administrative health database from physician claims to vital certificates; 3) enhanced detection of agricultural injuries through manual supplementary work for the identification of potential agricultural injury records within an injury episode in the multiple databases linked; 4) provision of an accurate picture of incident injuries (i.e., injury episode) and subsequent follow-up visits by the level of a proxy severity of injury through valid assessment of incident injury and the determination of proxy severity of each episode (i.e., the highest level of care per an episode); 5) greater accuracy in calculating injury rates (i.e., the use of injury density rates by using person-time at risk of each individual and allowing multiple injury events per a child), and; 6) reduced selection bias for the sample and information bias (i.e., observer bias, recall bias) through the use of administrative data. Through these strengths, the present study was able to provide a broader picture of injury incidence for detailed, specified children's groups covering every cause and intent of injury.

6.4 Implications for research

With regard to methodology of injury risk assessment, the present study highlights several implications for future research. Firstly, future studies on non-fatal injuries are recommended to access incidence density rates with person-time denominators rather than incidence proportions because the use of incidence proportions can lead to a relatively greater underestimation of injury risk for populations with a greater tendency to move than other comparison populations: shorter follow-up time due to greater losses to follow-up leads to a reduced denominator in person-time rate resulting in increased incidence density rate than when using incidence proportions.

Secondly, concerns of underestimation of agricultural injuries in this study emphasize the need to incorporate external causes of injury codes (E-codes) for the place of injury occurrence in administrative health databases, especially in vital statistics death data. Also, continuous and extended operations of agriculture-specific injury surveillance[5] are required to complement the limitations of administrative databases.

Thirdly, the findings that high proportion of pre-hospital deaths occurred across all children's groups underlines the importance of the inclusion of vital statistics in research on fatal or severe injuries because of considerable missing cases of death in hospital discharge or any medical care databases. Prior studies also point out the substantial underestimation of fatal injuries in hospital data.[6,7]

The use of limited information of death cases would lead to a severe underestimation as well as a bias in the examination of prevalence and incidence of particularly severe injuries.

Fourthly, to be more rigorous for future systematic reviews, primary studies on this topic are recommended to use a standard rural-urban definition to reduce heterogeneity among studies, to report injury rates with proper denominators, to perform analytical statistics controlling for potential confounders, and to provide data with basic figures of variable-adjusted as well as variable-specific injury rates (e.g., injury rates for age subgroups).

Lastly, as for data sources for injury outcomes, future studies are recommended to use emergency department visit-level injury data and above without physician claims data. Although physician claims data are important to provide comprehensive picture of injury, physician claims data are at a lack of external code of injury and poisoning, more likely to capture minor injuries, more likely to be affected by health service accessibility and health seeking behavior, and might show different picture of injury incidence from data sources of higher care level. If physician claims data is used, the results should be carefully interpreted taking the severity of injury into account in analysis.

6.5 Implications for practice

In terms of future practice to prevent pediatric injuries, findings from this study clearly indicate a need for targeted and specialized injury prevention

strategies for higher-risk mechanisms in each group or combined groups such as unintentional firearm-related injuries and suicidal suffocation for rural FN children, farm hazard-related injuries for farm and rural non-FN children, and OLT, natural/environmental, and unintentional firearm-related injuries for farm and rural children in common. In addition to address specific cause of injury in each group, there is a need for attention for underlying risk factors among farm and rural pediatric populations that are consistently and universally associated with a greater risk of injury for those groups than urban counterparts. The underlying risk factors may include diverse physical hazards,[3,8]an inferior medical environment (i.e., availability and quality of health care services and programs),[3,9-11] lower SES (e.g., income, education, employment),[3,11,12] and higher levels of high risk behaviors.[13] Furthermore, FN children may be affected by social stressors such as cultural alienation, discrimination, and intergenerational effects of Indian Residential Schools.[3,14,15] For this generic and inter-related causes of injury in rural areas, new intervention strategies such as a community-based participatory approaches for rural populations,[3,16,17] multifaceted approaches for farm safety,[18,19] and cultural healing and restoring identity for FN,[20,21] along with common education approaches (e.g., workshops, booklets, awareness campaign, etc.) have recently been introduced and emphasized. Regarding the medical environment, the efficient allocation and regionalization for advanced traumatic care facilities, especially improved trauma care in the ED is emphasized for efficient and timely care in rural areas including FN resident locations and farming areas.

6.6 Conclusions

To examine differences in injury incidence between farm and non-farm children, a systematic review of the literature (41 studies) and three population-based cohort studies that followed farm and several groups of non-farm Albertan children (115,378 children) under 18 years of age from 1999 to 2010 were conducted. The systematic review of the literature revealed that rural children were at higher risk of overall injury, MVC injury, and suicide than urban children, and that children in remote rural areas were at increased risk of more severe injuries than urban counterparts. Similarly, the population-based cohort studies demonstrated that rural FN children, followed by rural non-FN and farm children in descending order, sustained a greater burden of overall injury, particularly for severe injury than urban children, which was evidenced by the higher incidence rates for overall injury as well as for most mechanism of injury (except for farm-hazard related injuries), and greater utilizations of higher levels of medical facilities (ED visits and hospitalizations). Farm and rural non-FN children were at a greater risk of agricultural injuries, particularly for farm-animal and machinery-related injuries than rural FN and urban children. Agricultural injuries appeared to be more unintentional and lethal, and farm children were at greater risk of severe injuries than rural non-FN children. Farm children were at a lowest risk for self-harm and violent injuries except suicidal death. Findings from this study clearly indicate a need for comprehensive intervention strategies for underlying and inter-related

causes of injury in rural areas, targeted and specialized injury prevention strategies for higher-risk mechanisms in each group, attention for agricultural injury controls to extended populations, and an improved medical environment (particularly for advanced pediatric trauma care for serious injuries the ED for efficient and timely care) in rural areas.

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Appendix I. MEDLINE (Ovid Version) search strategy

1. suburban health/ or urban health/

2. suburban population/ or urban population/

3. suburban health services/ or urban health services/

4. (urban or suburban or semi-urban or city or cities or metropolitan or suburb*).ti,ab.

5. 1 or 2 or 3 or 4

6. rural population/

7. Rural Health/

8. Rural Health Services/

9. (rural* or semi-rural* or non-urban or farm* or agricultur* or town* or village* or non-metropolitan or remote).ti,ab.

10. 6 or 7 or 8 or 9

11. "Catchment Area (Health)"/

12. (geographic or geography or jurisdiction or catchment).ti.

13. 11 or 12

14. exp "Wounds and Injuries"/

15. exp Accidents/

16. exp homicide/

17. exp Self-Injurious Behavior/

18. (trauma* or injur* or wound* or accident* or collision* or deaths* or fatal or drowning* or poisoning* or burn* or suicide* or homicide* or assault*). ti.

19. 14 or 15 or 16 or 17 or 18

20. 5 and 10 and 19

21. 13 and 19

22. 20 or 21

23. limit 22 to ("all child (0 to 18 years)" or "young adult (19 to 24 years)")

24. (child* or pe?diatric* or youth* or young adult* or juvenile* or adolecen* or teenag*).mp.

25. 22 and 24

26. 23 or 25

27. exp africa/ or exp caribbean region/ or exp central america/ or latin america/ or exp south america/ or exp antarctic regions/ or exp arctic regions/ or exp asia/ or exp atlantic islands/ or exp australia/ or berlin/ or london/ or moscow/ or paris/ or rome/ or tokyo/ or exp europe/ or exp historical geographic locations/ or exp indian ocean islands/ or exp oceania/ or exp "oceans and seas"/ or exp pacific islands/

28. 26 not 27

Appendix II. Health care utilization among five children's groups

	Urban		Farm in urban areas		Farm in rural areas		Rural non-FN		Rural FN	
Episodes (n, %)										
PO visits	43,412	54.6%	1,339	45.8%	4,253	43.2%	29,364	39.9%	6,226	34.1%
ED visits	35,112	44.1%	2,944	52.3%	3,371	54.7%	42,817	58.2%	11,412	62.6%
Hospitalizations	994	1.2%	444	1.8%	,668	2.1%	1,355	1.8%	568	3.1%
Deaths	20	0.0%	18	0.1%	53	0.1%	40	0.1%	32	0.2%
Total	79,538	100.0%	4,745	100.0%	9,345	100.0%	73,576	100.0%	18,238	100.0%
Full services (n, %)										
Physician claims	133,092	73.1%	8,107	72.2%	143,730	69.9%	121,059	67.5%	24,047	61.8%
ED visits	47,938	26.3%	8,008	27.1%	0,185	29.2%	56,882	31.7%	14,229	36.6%
Hospitalizations	1,030	0.6%	462	0.7%	,797	0.9%	1,475	0.8%	601	1.5%
Total	182,060	100.0%	6,577	100.0%	205,712	100.0%	179,416	100.0%	38,877	99.9%

Appendix II. (Continued)

	Urban		Farm in urban areas		Farm in rural areas		Rural non-FN		Rural FN	
Pyramid										
Episodes (Death: hospi.: ED: PO)	1: 50: 1756: 2171		1: 25: 719: 630		1: 31: 818: 646		1: 34 : 1070 : 734		1: 18: 357 : 195	
Full services (Death: hospi.: ED: PO)	1: 52: 2397: 6655		1: 26: 1000: 2673		1: 34: 1136: 2712		1: 37: 1422: 3026		1: 19: 445: 751	
Place of deaths										
Out of health facility	8	40.0%	8	44.4%	30	56.6%	25	62.5%	27	84.4%
In physician office	1	5.0%	0	0.0%	1	1.9%	0	0.0%	1	3.1%
In ED	5	25.0%	7	38.9%	17	32.1%	8	20.0%	2	6.3%
In hospital	6	30.0%	3	16.7%	5	9.4%	7	17.5%	2	6.3%
Total	20	100.0%	18	100.0%	53	100.0%	40	100.0%	32	100.0%