THE EPIDEMIOLOGY OF PEDIATRIC AMBULANCE TRANSPORT IN ONTARIO, CANADA

AMY BONNIE GALE COUPERTHWAITE

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Abstract

Background:

Trauma is one of the most frequent requests for ambulance services. However, little is known about the mechanism of injury sustained by pediatric patients seen by a paramedic. There are few studies comparing ambulance transport to private transport in pediatric patients and none within the Canadian context.

Methods:

This dissertation consists of three studies that describe the epidemiology of pediatric ambulance transport in Ontario, Canada. Study 1 focuses on creating a profile of children <19 years who were seen by Toronto Paramedic Services. Study 2 examines the difference in all-cause-mortality, hospitalization, ICU admission, and severe injury between ambulance transport and private transport to the emergency department [ED] in children in the province of Ontario. Study 3 examines differences in all-cause-mortality, hospitalization, ICU admission, and severe injury between ambulance transport and private transport in motor vehicle collisions for children in Ontario.

Results:

In Manuscript 1, the most common mechanism of injuries were falls, transport related injuries, assault/gunshot injuries, injuries involving choking or foreign bodies, and burn/scald injuries. In Manuscript 2, there were 1,872,519 patients who sustained an injury in Ontario with 129,577 (6.9%) transported to the ED via ambulance. The adjusted OR for all cause mortality was 154.88 (95% CI: 101.11-237.23), the adjusted OR for ICU admission was 19.17 (95% CI: 18.01-20.41), the adjusted OR for hospitalization was 13.27 (95% CI: 12.97-13.57) and the adjusted OR for severe injury was 1.88 (95% CI: 1.78-1.98). In Manuscript 3, There were 32,025 patients who sustained an injury in an MVC with 13,995 (43.7%) transported to the ED via ambulance. The adjusted OR for mortality in an MVC was 33.05 (95% CI: 8.05-135.79), the adjusted OR for ICU admission was 17.14 (95% CI: 11.57-25.39), the adjusted OR for hospitalization was 13.30 (95% CI: 11.05-16.01), and the adjusted OR for severe injury was 2.22 (95% CI: 1.45-3.39).

Conclusions:

The majority of injuries seen by TPS were fall related, transport-related, gunshots/assaults, choking/foreign body, and burn/scald injuries. Ambulance transport amongst pediatric patients

who sustained an injury and patients who were injured in an MVC in Ontario is associated with increased odds of mortality and morbidity outcomes.

Dedication

Optimism is the faith that leads to achievement; nothing can be done without hope

-Helen Keller

Some day I'll fly, some day I'll soar, some day I'll be so much more. 'Cause I'm bigger than my body gives me credit for

-John Mayer

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Table of Contents

List of Tables

List of Symbols, Abbreviations and Nomenclature

ACR: Ambulance Call Record

CI: Confidence Interval

CIHI: Canadian Institute for Health Information

DAD: Discharge Abstracts Database

ED: Emergency Department

EMS: Emergency Medical Services

ICD: International Classification of Diseases

ICU: Intensive Care Unit

ISS: Injury Severity Score

MBUN: Meaningless But Unique Number

MVC: Motor Vehicle Collision

NACRS: National Ambulatory Care Reporting System

OHIP: Ontario Health Insurance Program

OR: Odds Ratio

SRR: Survival Risk Ratio

TPS: Toronto Paramedic Services

Chapter One: **Introduction**

1.1 Impact of Injury and Pediatric Patients

Injury is one of the leading causes of hospitalization, death, and ICU admission in Canada for those under the age of 19 (1–4). In the province of Ontario in 2015, mortality due to injury for children less than 19 years of age was 6.3 (95% CI: 5.4-7.2) per 100,000 population, hospitalization due to injury was 345.5 (95% CI: 338.9-352.0) per 100,000 population, and emergency department [ED] visits were 13,149.9 (95% CI: 13,109.3-13,190.5) per 100,000 population (5–7).

Injuries cost the Canadian economy $29.4 billion in 2018, including $20.4 billion in direct healthcare costs and $9.5 billion of indirect costs to the Canadian economy (8). For those under the age of 19 in Canada: falls cost the economy $1.2 billion, transport related injuries $682 million, suicide/self-harm $475 million, violence related incidents $136 million, unintentional poisoning $133 million, and fire/burns $71 million (8). Falls and transport related incidents made up 47% of the cost to the Canadian economy. Falls were the biggest cost for those under the age of 14 and transport related injuries were the biggest cost for youth between 15 to 19. Injuries relating specifically to motor vehicle collisions cost the Canadian economy $280 million for those under the age of 19 over a one-year period (8).

1.2 Ambulance Transport and Pediatric Patients

There are few studies that investigate the severity of illness of those who were transported to hospital by ambulance, while even fewer examine the pediatric population. Previous research has suggested that pediatric patients may be less likely to utilize ambulance services compared to adults, which could lead to this gap in knowledge. Two studies conducted in the United States found that approximately 10% of the pediatric population utilized ambulance transport to an ED, even though they made up 30%-32% of the population seen in the ED (9,10).

In addition, a study conducted by Fifield et al. (1984) determined that pediatric patients were not being transported to the appropriate care facilities based on their presentation (11). A study conducted in 1995 examining high acuity patients found that 87% of pediatric patients arrived by private transport versus ambulance (12). Overall previous research has demonstrated that between 4% and 13% of pediatric patients are transported to the hospital via ambulance (9,10,13–16).

Kost et al. (2000) hypothesized that parents of pediatric patients may be more comfortable with transporting their children and believe that private transport may be faster than ambulance transport as a reason for this discrepancy (12). The child's physician may also have an impact as pediatricians tend to recommend private transport to the ED versus utilizing ambulance services (12,17). However, it has been noted that private transport of patients to EDs has been decreasing and the utilization of ambulances has increased since the 1980s (18).

The under-utilization of prehospital care, including ambulances, has been noted as problematic as there may be unintended consequences for patients who weren't seen sooner by a medical professional (12,19). There is also the additional concern that patients may go to an ED that is not equipped for their needs, especially for patients who sustained an injury (20). A preliminary inquiry in Northern Ireland found that patients who did not utilize an ambulance went to their nearest hospital rather than seek out a hospital with the appropriate resources. The study authors noted that patients cannot be expected to know which hospitals are appropriate for the nature of their injury and the decision is best left to medical professionals (20).

1.3 Ambulance Transport and Injury

Several studies examining ambulance utilization determined that trauma is the most common reason for use of ambulance services (9,11,12,21–23). A cross sectional study conducted in Australia found that trauma was a statistically significant predictor for demand of prehospital services [Relative Risk = 2.33; 95% Confidence Interval: 1.03–5.27] (24). However, it was not the most common predictor of demand of prehospital services in that study. This is in direct contrast to a study of 14 Emergency Medical Services [EMS] agencies across the United States (25). The authors found that 28% of pediatric ground and air ambulance transports were due to traumatic injury. Overall, 26% of ground transports and 74% of air ambulance transports were due to traumatic injury (25).

Seidel et al. (1984) found that the most common mechanisms of injury were gunshot wounds, incidents involving motor vehicles, and falls (10). However, they were unable to combine the data to give meaningful proportions due to drawing upon three different sources: a trauma registry, a mobile intensive care unit, and surveys distributed to paramedics. Kallsen and Tsai (1987) found that 54.5% of pediatric patients transported by ambulance had suffered from some sort of injury (9). Similarly Seidel et al., found that the most common mechanism of injury involved motor vehicles with 30.3% of patients sustaining an injury due to a motor vehicle (9,10). 14.3% of all patients seen by paramedics were an occupant of a motor vehicle, 3% were pedestrians struck by a motor vehicle, and 2.3% involved bicycles (9). Other injuries accounted for 22.7% of ambulance calls with 18.7% of patients suffering a blunt wound or fall, 3.4% suffering a penetrating wound, and 0.7% suffering from a gunshot wound (9). The most recent study conducted by Lin et al. (2017) in Singapore found that falls, burns, and motor vehicle collisions were the most common mechanism of injuries in pediatric patients (22). However, we note that this study was extremely limited in scope with only 21 patients seen by EMS.

1.4 Ambulance Transport in Ontario, Canada

Ambulance services in Ontario are governed under the Ambulance Act. The purpose of this Act is to ensure that ambulance transport, paramedic certification, and fees are standardized throughout the province of Ontario (26). Ambulance services in Ontario are funded through municipal partners and the Ontario Ministry of Health (27). Funding is provided through a 50/50 cost sharing agreement for ground ambulances between the Ministry and municipality whereas the Ministry provides 100% of funding for air ambulances, communication centres, and certified First Nations paramedic services (27,28). Fees for ambulance transport for residents of Ontario with a valid OHIP card is $45 (29,30). For those who are not residents of Ontario, do not have a valid OHIP card, or take a trip that is deemed medically unnecessary are charged $240 for an ambulance ride to the ED (29). Patients who decline transport to the ED via ambulance are not charged a fee (29).

Trauma systems within Ontario are accredited by the Trauma Association of Canada (31). There are five defined levels for adult hospital facilities and two defined levels for pediatric hospital facilities. Level I Pediatric Trauma Centres are expected to play a central role in regional and provincial trauma systems in all aspects of pediatric trauma care. They are expected to take on most of the caseload of injured pediatric patients in their region and all aspects of major trauma care must be on site with trauma surgeons and subspecialists providing bedside care within a timely manner. The idea behind Level I Pediatric Trauma Centres is that all trauma care for pediatric patients is consolidated within one centre for a particular area. Level II Pediatric Centres are required in areas that do not have a Level I Pediatric Centre or where the trauma caseload is too large for a single Level I Pediatric Centre. Whereas a Level I Pediatric Centre is required to be affiliated with an academic university, Level II Pediatric Centres are not required to be affiliated with one. Level II Pediatric Trauma Centres must admit at least 100 patients under the age of 16 per year to justify the dedicated trauma resources. Severe trauma is expected to be transported to a Level I Pediatric Centre if resources are available. Finally, paramedic services are considered a vital component of trauma centres and must demonstrate that they are highly functional and effective when transporting patients to the appropriate hospital (31). Decisions around transport on scene by paramedics is dependent on the ability of the patient or guardian to consent (32). The patient or guardian can consent to not being transported to the ED if the paramedic on scene is able to assert that the patient has the capacity to consent. The patient must not be experiencing severe suffering, not be high risk of experiencing suffering without treatment, must not require immediate treatment, or must not be at risk of sustaining severe bodily harm without medical care. Paramedics do have the ability to override the wishes of the patient and guardian for non-transport if the patient is in dire need of medical care. Patients who are obviously dead upon arrival require consultation with the physician at the base hospital before the decision around non-transport can be initiated (32). Paramedics are required to aim to prevent further injury, initiate resuscitation efforts where necessary, and provide timely transport to appropriate ED facilities. The paramedic on duty is required to know which is the most appropriate ED facility for hand-off based on the patient's needs and the facility's capabilities prior to initiating transport to the ED (31). If the paramedic on duty is unsure, they can consult the physician on call at any hospital to determine if transport to that ED is appropriate (31,32).

1.5 Ambulance Transport versus Private Transport

Several studies have examined if there was a difference in those who were transported by ambulance to hospital and those who were transported by private vehicle for traumatic injury. Demetriades et al. (1996) compared 4856 patients transported by ambulance to 926 patients who were privately transported (33). The relative risk for mortality for those transported by ambulance, after adjustment for injury severity score [ISS], was 1.60 (p=0.002). Those transported by ambulance had a much higher mortality rate (28.2%) than those who were not transported by ambulance (14.1%) (33). The study authors stated there was a need for larger studies in order to determine why there was a difference in mortality. Johnson et al. (2013) examined patients over a 5-year period from the Pennsylvania trauma registry. This was a retrospective cohort study with 91,132 patients retrieved from the trauma registry (34). 90.4% of patients were transported to the emergency department via ambulance and 9.6% were transported by private vehicle. Patients transported to the emergency department by ambulance were 1.9 times more likely to die than those who were transported by private vehicle (95% CI 1.5-2.4) (34). One of the major limitations to this study is that the information was gathered from a trauma registry and patients that suffered from less severe injuries may not have been captured.

One prospective study conducted in Los Angeles gathered information from a Level 1 trauma centre (18). Patients transported by ambulance were matched with those who were not according to age, ISS, head injury score, and mechanism of injury. There were no significant difference in mortality, length of hospital stay, days in the ICU, complications, or infections (18). This was in contrast to the findings by Demetraides. et. al (1996) and Johnson et. al (2013) who found statistically significant differences between the two groups (33,34). Limitations include that patients with an ISS score of 13 or greater were initially included in the matching process. The authors decided to include every 10^{th} patient transported by EMS with an ISS score lower than 12 in order to increase enrollment (18).

A study conducted by Lin et al. (2017) in Singapore was the only study to specifically examine pediatric patients (22). They only included those patients who suffered an unstable injury. These were defined as significant head injuries, spinal injuries, or proximal long bone injuries (22). As a result of this strict criteria, only 90 patients were included for analyses. The majority of patients were transported to hospital via private vehicle (n=69) while the minority were transported via ambulance (n=21). This differed from previous studies where the majority of the study population was transported to hospital via ambulance. There were statistically significant differences in injury mechanism and location of injury between the two groups ($p<0.0001$) (22). There were no statistically significant differences in mortality or ICU admission, although those patients who were transported by private vehicle had an overall shorter stay in hospital and ICU. As with previous studies, the limitations include that the data was obtained from a trauma registry and not all patients who suffered an injury may have been captured in the trauma registry. The strict criteria on what constituted an unstable injury also makes it difficult to generalize the conclusions. There were only two patients who died and 16 who were admitted to the ICU (22). A larger sample size would have been more useful in drawing conclusions regarding the difference between privately transported patients and those transported by ambulance.

Finally, a study conducted in St. Louis, Missouri over a one year period in 2001 compared adult ambulance transport against those who came by car, bus, or on foot to a Level 1 Trauma Centre (35). They stratified based on presenting complaint. Those who were injured in a motor vehicle collision were 7.1 times more likely to be transported by ambulance than other means (95% CI: 6.4-7.9). Those who sustained a gunshot or stab wound were 2.1 times more likely to be transported by ambulance than other means (95% CI: 1.5-2.8). Patients who sustained a fall less than ten feet were 2.0 times more likely to be transported by ambulance to the ED than other means (95% CI: 1.8-2.3). They did not find the same level of ambulance utilization for the medical complaints amongst adults with the exception of those who presenting with weakness/dizziness. Ruger et al. (2006) hypothesized that the high rate of ambulance utilization among those who sustain trauma due to motor vehicle collisions, gunshots, and stab wounds may be due to the presence of police and paramedics already on scene (35). They may make the decision to transport a patient to hospital. The study did not have access to the information on who made the decision to transport a patient to hospital. Moreover, the hospital in the study was a Level 1 Trauma Centre. Patients who sustain severe injuries may be more likely to be transported to a trauma centre versus those who sustain medical complaints.

There is a paucity of literature on ambulance utilization in injured pediatric patients. Much of the literature is out of date or examines trauma as a subset of their overall analyses. Most patient information is collected once the patient is in the emergency department. Patients who are not transported to hospital for various reasons are lost to follow up and not included in most of these studies. Previous research has found that between 15% and 46% of ambulance transport to the ED is due to trauma (10,13,14,36–38). MVCs specifically have been singled out as one of the main mechanisms of injury requiring transport to the ED versus private vehicle. An updated profile of injured pediatric patients is imperative for further understanding the severity, scope and mechanism of injuries paramedics are treating. It is also important to examine mortality and morbidity outcomes by transport method for injured pediatric patients due to the paucity of literature on this topic.

1.6 Objectives

This thesis is organized as three related manuscripts, each corresponding to a specific study to fill an important gap in the literature:

1. The first manuscript aims to describe the mechanism and location of injuries in children and youth who were seen by Toronto Paramedic Services in 2018 by age and sex.

2. The second manuscript compares differences in all-cause-mortality, hospitalization, ICU admission, and severe injury by ambulance transport and private transport to the emergency department in injured pediatric patients (<19 years) in the province of Ontario.
3. The third manuscript compares differences in all-cause-mortality, hospitalization, ICU admission, and severe injury by ambulance transport and private transport to the emergency department in pediatric patients (<19 years) injured in an MVC in the province of Ontario.

Chapter Two: **Manuscript 1**

The characteristics of pediatric injury patients treated by paramedics in Toronto, Canada

Amy B. Couperthwaite,[1] PhD Candidate, Michael Rotondi,[1] PhD, Stephen A. Gaetz,[2] PhD,

Alison K. Macpherson,[1] PhD

[1]School of Kinesiology and Health Science, York University, Toronto, Ontario

[2]Faculty of Education, Canadian Observatory on Homelessness, York University, Toronto, Ontario

Amy Couperthwaite
York University
School of Kinesiology and Health Science
Bethune College
4700 Keele Street
Toronto, Ontario, Canada
M3J 1P3

Abstract:

Background:

Trauma is one of the most frequent requests for ambulance services, however, there has not been a recent comprehensive profile of injured pediatric patients who were seen by a paramedic. The objective of this study is to describe the mechanism and location of injuries in children <19 years who were seen by Toronto Paramedic Services by age and sex.

Methods:

This is a retrospective descriptive study examining all injury related calls for patient records <19 years old who were seen by Toronto Paramedic Services in 2018. Mechanism of injury was categorized as falls, transport-related injuries, assaults/gunshot wounds, choking/foreign body, burns/scalds, and other. Location of injury was categorized as highway/street/sidewalk, residence, school, sports/recreation centre, retail establishment, and other. Age was divided into 5 categories: <1 year, 1-4 years, 5-9 years, 10-14 years, and 15-19 years.

Results:

There were 4,128 patient records. 2,413 (58.5%) were male and 1,715 (41.5%) were female. 157 (3.8%) were <1 year, 1,057 (25.6%) were 1-4 years, 692 (16.8%) were 5-9 years, 783 (19.0%) were 10-14 years, and 1,439 (34.9%) were 15-19 years. There were 1,313 (31.8%) fall-related injuries, 821 (19.9%) transport-related injuries, 510 (12.4%) assault and gunshot injuries, 225 (5.5%) injuries involving choking or foreign bodies, and 99 (2.4%) burn and scald injuries. 1684 injuries (40.8%) occurred in residences, 943 (22.8%) on highway/streets/sidewalk, 538 (13.0%) in school settings, 355 (8.6%) in sports/recreation centres, and 138 (3.3%) in retail establishments.

Conclusions:

The majority of injuries were fall related. Most injuries occurred in residential settings. Males sustained more injuries than females and those between 15-19 years sustained the highest proportion of ambulance attended injuries in Toronto in 2018.

2.1 Introduction:

Prehospital care is an essential part of healthcare. Paramedics not only transport patients to hospital but deliver treatment in emergency situations prior to the patient being seen by a physician (1–5). This is especially important in the treatment of pediatric patients as this age group has physiological differences compared to adults and respond differently to treatment (6–9). Injury is one of the leading causes of hospitalization and the leading cause of death for those between 1-19 years, thus understanding the types and frequencies of calls paramedics are responding to in this age group is critical, yet remains understudied (10–13).

Several studies examining ambulance utilization determined that trauma is frequently the most common complaint for ambulance services (3,14–19). A cross-sectional study conducted in Australia found that trauma was a statistically significant predictor for demand of prehospital services (20). A study of 14 EMS agencies across the United States found that 26% of ground transports and 74% of air ambulance transports were due to traumatic injury (21).

Seidel et al. (1984) reported that the most common mechanisms of injury were gunshot wounds, incidents involving motor vehicles, and falls (22). They were unable to combine the data to give meaningful proportions due to drawing upon three different sources. Tsai and Kallsen (1987) found that 54.5% of pediatric patients transported by ambulance had suffered from some sort of injury (14). The most common mechanism of injury involved motor vehicles with 30.3% of patients sustaining an injury (14,22). 14.3% of all patients seen by paramedics were an occupant of a motor vehicle, 3% were pedestrians struck by a motor vehicle, and 2.3% involved bicycles (14). Other injuries accounted for 22.7% of ambulance calls with 18.7% of patients suffering a blunt wound, 3.4% suffering a penetrating wound, and 0.7% suffering from a gunshot wound (14).

To our knowledge there has not been a recent comprehensive profile of injured pediatric patients who were seen by an ambulance. Patient health and demographic information is normally collected once the patient is seen in the emergency department versus on the scene. Patients who are not transported to hospital are generally lost to follow up and are rarely included because their information is not readily available. The objective of this study is to describe the mechanism of injuries and location of injuries in children and youth who were seen by Toronto Paramedic Services in 2018 by age and sex.

2.2 Methods:

We requested an anonymized database from Toronto Paramedic Services [TPS] for the time period between January 1st to December 31st, 2018 for all records under the age of 19 that were flagged as injury through the City of Toronto access to information process. TPS is Canada's largest paramedic service with over 1,100 paramedics, 45 ambulance stations, and 225 ambulances (23). TPS responded to 316,324 calls and transported 226,390 patients to the ED in 2019 (23).

Exclusion criteria included signs that no injury occurred, and some records that were flagged as duplicate records. If the original record was in the database by comparing incident month, sex of patient, and Canadian Triage and Acuity Scale, the record flagged as a duplicate was excluded. If the original record could not be found, the record listed as a duplicate was retained. All other records were assumed to be injury related.

The Ontario Ambulance Call Record [ACR] has pre-defined fields for mechanism of injury and location where the patient was seen by the paramedic (24). All patient records were coded for location, mechanism of injury, age, and sex once all records were excluded and the database was cleaned. As mechanism of injury has 17 fields in the ACR and location has 26 fields, we collapsed them into broader categories to better summarize the patient population. These decisions were based on similarities between each category in the ACR and number of injuries that occurred. Mechanism of injury was categorized into falls, transport-related injuries, assaults/gunshot wounds, choking/foreign body, burns/scalds, and other. Transport-related injuries included motorized and non-motorized injuries as well as pedestrian related incidents. Other included injuries such as drowning, suicide or attempted suicide, and sports-related injuries. Location of injury was categorized into highway/street/sidewalk, residence, school, sports/recreation centre, retail establishment, and other. Other consisted of places such as construction sites, factories, open water, and offices. Age was divided into 5 categories: <1 year old, 1-4 years old, 5-9 years old, and 15-19 years old. For cell counts less than 5, age categories were collapsed to prevent potential identification of patients. Data were not presented for location of injury if the cell count was less than 5. Descriptive statistics and chi square analyses were conducted using Stata 14 and all comparisons were performed at the 5% two-sided significance level (25). Missing data were addressed using case deletion. This study was approved by the Office of Research Ethics at York University (REB #: STU 2019-062).

2.3 Results

We received 4155 patient records that TPS identified as injury related for patients <19 years of age. 6 (0.1%) patient records were excluded for medical-related complaints and 21 (0.5%) patient records were excluded for being duplicate calls.

There were 4,128 patient records that met the inclusion criteria. Out of the 4,128 patients, 2,413 (58.5%) were male and 1,715 (41.5%) were female. 157 (3.8%) were <1 year old, 1,057 (25.6%) were between 1-4 years old, 692 (16.8%) were between 5-9 years old, 783 (19.0%) were between 10-14 years old, and 1,439 (34.9%) were between 15-19 years old.

The majority of injuries sustained during the study period were fall-related, with 1,313 (31.8%) sustaining a fall related injury. Of those 1,313 patients, 736 (56.1%) were male and 577 (43.9%) were female. There were 508 (38.7%) records where the patient was between 1-4 years old, and 278 (21.2%) patients were between 5-9 years old (Table 2-1). Falls were most common in residences with 655 (49.9%) patients sustaining a fall related injury in a residence, followed by schools with 231 (17.6%) injuries, and sports/recreation centres with 130 (9.9%) injuries (Table 2-2).

Transport-related injuries were the second leading mechanism of injury during the study period. There were 821 (19.9%) patients that sustained a transport-related injury. 421 (51.3%) were male and 400 (48.7%) were female. Those between 15-19 years old sustained the most transport-related injuries with 355 (43.2%) patients followed by those between 10-14 years old with 176 (21.4%) patients (Table 2-1). Transport-related injuries occurred most frequently on highways/streets/sidewalks with 680 (83.4%) injuries and in residences with 51 (6.3%) injuries (Table 2-2).

Assaults and gunshot wounds accounted for 510 injuries (12.4%). There were 314 (61.6%) males with assault/gunshot wounds and 196 (38.4%) females. 405 (79.4%) of these injuries occurred in those between 15-19 years old. The majority of assault/gunshot wounds were in males between 15-19 years old with 258 (50.6%) patients (Table 2-1). Assaults/gunshot wounds were most common in residences with 235 (46.1%) injuries, highways/streets/sidewalks with 93 (18.2%) injuries, and school settings with 72 (14.1%) injuries (Table 2-2).

There were 225 injuries that involved choking or foreign bodies with 113 (50.2%) being males and 112 (49.8%) being females. Choking/foreign body injuries were most common amongst those 1-4 years of age with 131 (58.2%) patients followed by those <1 year old with 36 patients (16%) (Table 2-1). Choking/foreign body injuries occurred frequently in residences with 180 (83.3%) injuries, school settings with 13 (6.0%) injuries, and retail establishments with 8 (3.7%) injuries (Table 2-2).

There were 99 (2.4%) burn/scald related injuries. There were 56 (56.6%) males and 43 (43.4%) females that sustained a burn/scald injury. Most burn/scald injuries occurred in those between 0-4 years with 61 (61.6%) patients. The remaining 38 (38.4%) were in patients between 5-19 years old (Table 2-1). 69 (74.2%) of the burn/scald injuries occurred in residences with 8 (8.6%) occurring in retail establishments and 5 (5.4%) occurring in schools (Table 2-2).

138 (3.3%) injuries did not fall into one of the five categories. There were 77 (55.8%) males and 61 (44.2%) females (Table 2-1). 74 (54.0%) of these injuries occurred in residences and 18 (13.1%) occurred in settings classified as "other" (Table 2-2). There were 1022 (24.8%) records that were missing the mechanism of injury. 696 (68.1%) of these records were male and 326 (31.9%) were female (Table 2-1). 420 (40.2%) of these injuries occurred in residences, 204 (19.5%) occurred in a school setting, and 194 (18.6%) occurred in a sports/recreation centre (Table 2-2).

2.4 Discussion

The five major mechanisms of injuries identified were falls, transport-related injuries, assaults/gunshot wounds, choking/foreign body, and burns/scalds. Falls are the leading cause of injury for those under 19 in Canada (26,27). Falls were the most common mechanism of pediatric injury seen by paramedics in Toronto in 2018. A survey of emergency department visits in the city of Toronto in 2015 found that falls were the most common mechanism of injury for children under 4 years of age (28). The age group in our study that had the highest proportion of fall related injuries were those between 1-4 years. Overall, fall related injuries are common in this age group and tend to decrease with age (26,29,30). Other studies that looked specifically at ambulance transport did not find falls as the main mechanism of injury. Seidel et al. (1984) found it as the second leading cause of injury, however, they only examined severe injuries that required ambulance transport and not all injuries that were seen by a paramedic (22). Diggs et al. (2016) examined patients who were seen by Basic Life Support paramedics in the United States and also found it as the second leading cause of injury in their study (3).

Transport-related injuries, assaults/gunshot wounds, choking/foreign body injuries, and burns/scalds are also leading causes of injury across Canada (27). Transport related injuries were the second most common mechanism of injury seen during the study period. This differs from findings by Seidel et al. (1984), Kallsen and Tsai, (1987) and Diggs et al. (2016) where motor vehicle collisions were the most common trauma complaint seen by paramedics (3,14,22). Those between 15 to 19 years of age were most frequently seen for transport related injuries. Kallsen and Tsai (1987) found that adolescents between 13 and 18 years were most likely to be seen for motor vehicle injuries.(14) Previous literature has shown that as children's age increases, the number of transport related injuries increases (14,26,30).

Assault/gunshot wounds were the third leading mechanism of injury over the study period. Gunshot wounds were one of the main mechanisms of injury seen by paramedics in two studies conducted in the United States (14,22). In our study 15-19 year disproportionally sustained more assault and gunshot wounds than those under the age of 15. There were more assault/gunshot wound injuries than any of the other mechanisms of injuries for this age group. Males between 15-19 years sustained over half the gunshot and assault injuries overall which aligns with previous studies that found gunshot wounds in pediatric patients are predominantly found in older, male adolescents (31,32). Most research on gunshot and assaults is conducted in the United States and is difficult to generalize to a Canadian context (33).

Choking/foreign body were the fourth leading mechanism of injury. Children between 1-4 years of age made up of 58.2% of all choking/foreign body injuries. A previous study in London, England found that the vast majority of choking injuries seen by a paramedic were sustained by those between 0-4 years old (34). More females than males under the age of 4 sustained a choking injury in our study, which is consistent with the study by Pavitt et al. (2017) (34).

The fifth leading cause of injury were burns and scalds. Children between 0-4 years of age sustained more burns and scalds than children between 5-19 years. This is consistent with previous research on burns and scalds within the pediatric population (28,35–38). However, in the study by Kallsen and Tsai (1987) the majority of burn injuries seen by paramedics occurred in those between 1 and 6 years and those between 13 to 18 years (14). We did not find a large amount of burn and scald injuries in the older age groups.

The most common locations where patients were seen were residences, highway/streets/sidewalks, schools, sports/recreation centres, and retail establishments. Studies by Diggs et al. (2016) and Richard et al. (2006) did not stratify trauma patients by the location, however, their findings were similar to ours in the overall pediatric population (2,3). It is established that the majority of pediatric unintentional injuries occur in residences (39,40). With transport-related injuries being the second leading mechanism of injury in this study, it was expected that highway/streets/sidewalks were the second most common location.

One of the major limitations of this study was the amount of missing data for mechanism of injury and location. Missing information is common with injured patients and ambulance data (3,41–44). As this was a retrospective study and it could not be linked to hospital databases, we could not determine the mechanism of injury or location if it was missing. There was also the possibility of misclassification or data entry errors for the mechanism of injury and location by the paramedics. There may have been some subjectivity in collapsing the mechanism of injury and location categories. We minimized this by having two people review the data and discussing which categories made sense based on both the mechanism of injury and location of injury that best represented the population of patients seen by paramedics. Finally, there is the possibility that the search did not identify all pediatric injury records, as previously stated, missing information is common with injured patients and those patients may not have been flagged as an injury within the ACR.

This is the first study looking at pediatric patients who sustained an injury and were seen by a paramedic in a Canadian setting. This study is novel for several reasons. Most literature on pediatric ambulance transport, specifically looking at mechanism of injury, is over 20 years old. There has been no updated comprehensive profile examining pediatric injury in the recent literature to our knowledge. Additionally, we examined a population that has access to heavily subsidized ambulance transport that is universally available to all residents. Other studies examined systems that were privatized or mixed public-private systems which likely had higher costs for ambulance transport compared to the population in our study. Of particular strength, many previous studies examined trauma as a subset of their analyses rather than as the primary focus, which limits generalizability of results. Moreover, we were able to obtain a large sample size over a 12-month period to account for seasonal variation in injury. Different types of injuries occur over different seasons in Canada and a shorter timeframe may not be reflective of all mechanisms of injury. Other studies took place over a limited span of time and may not have accounted for this effect. We were also able to collect data directly from Toronto Paramedic Services' database whereas other studies had to rely on hospitalization or trauma databases for information, which may have led to missing patients who were not transported to hospital. In conclusion, our findings present the largest and most comprehensive summary of pediatric patients who were seen by a paramedic in Canada.

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Table 2-1: Number of patients <19 years of age that were seen by Toronto Paramedic Services for an injury in the city of Toronto in 2018 by age and sex.

Mechanism of Injury					
	Age	Male	Female	Total	p value
Falls					p=0.001
	<1 year	29 (46.0%)	34 (54.0%)	63	
	1-4 years old	259 (51.0%)	249 (49.0%)	508	
	5-9 years old	173 (62.2%)	105 (37.8%)	278	
	10-14 years old	152 (64.1%)	85 (35.9%)	237	
	15-19 years old	123 (54.2%)	104 (45.8%)	227	
	Total	736 (56.1%)	577 (43.9%)	1,313	
Transport Related					p=0.86
	<1 year	15 (45.5%)	18 (54.5%)	33	
	1-4 years old	59 (48.0%)	64 (52.0%)	123	
	5-9 years old	70 (52.2%)	64 (47.8%)	134	
	10-14 years old	90 (51.1%)	86 (48.9%)	176	
	15-19 years old	187 (52.7%)	168 (47.3%)	355	
	Total	421 (51.3%)	400 (48.7%)	821	
Assault/Gunshot Wound					p=0.15
	0-9 years	20 (54.1%)	17 (45.9%)	37	
	10-14 years old	36 (52.9%)	32 (47.1%)	68	
	15-19 years old	258 (63.7%)	147 (36.3%)	405	
	Total	314 (61.6%)	196 (38.4%)	510	
Choking/Foreign Body					p=0.22
	<1 year	17 (47.2%)	19 (52.8%)	36	
	1-4 years old	60 (45.8%)	71 (54.2%)	131	
	5-9 years old	22 (62.9%)	13 (37.1%)	35	
	10-19 years old	14 (60.9%)	9 (39.1%)	23	
	Total	113 (50.2%)	112 (49.8%)	225	
Burns/Scalds					p=0.53

	0-4 years	36 (59.0%)	25 (41.0%)	61	
	5-19 years	20 (52.6%)	18 (47.4%)	38	
	Total	56 (56.6%)	43 (43.4%)	99	
Other					p=0.65
	0-4 years old	19 (59.4%)	13 (40.6%)	32	
	5-9 years old	12 (46.2%)	14 (53.8%)	26	
	10-14 years old	16 (66.7%)	8 (33.3%)	24	
	15-19 years old	30 (53.6%)	26 (46.4%)	56	
	Total	77 (55.8%)	61 (44.2%)	138	
Missing					p=0.81
	0-4 years old	137 (65.2%)	73 (34.8%)	210	
	5-9 years old	126 (67.4%)	61 (32.6%)	187	
	10-14 years old	173 (68.7%)	79 (31.3%)	252	
	15-19 years old	260 (69.7%)	113 (30.3%)	373	
	Total	696 (68.1%)	326 (31.9%)	1,022	

Table 2-2 Number of patients <19 years of age seen by Toronto Paramedic Services in 2018 by location of injury and mechanism of injury

	Residence	Highway/ Street/ Sidewalk	School	Sports/ Recreation Centre	Retail Establishment	Other	Missing	Total
Falls	655 (49.9%)	96 (7.3%)	231 (17.6%)	130 (9.9%)	56 (4.3%)	68 (5.2%)	77 (5.9%)	1313
Transport	51 (6.3%)	680 (83.4%)	*	*	6 (0.7%)	23 (2.9%)	55 (6.7%)	815⁺
Assault/ Gunshot	235 (46.1%)	93 (18.2%)	72 (14.1%)	18 (3.5%)	35 (6.9%)	36 (7.1%)	21 (4.1%)	510
Choking/ Foreign Body	180 (83.3%)	*	13 (6.0%)	*	8 (3.7%)	*	15 (6.9%)	216⁺
Burns/ Scalds	69 (74.2%)	*	5 (5.4%)	*	8 (8.6%)	6 (6.5%)	5 (5.4%)	93⁺
Other	74 (54.0%)	10 (7.3%)	13 (9.5%)	13 (9.5%)	*	18 (13.1%)	*	137⁺
Missing/ Small Cell Count	420 (40.2%)	64 (6.1%)	204 (19.5%)	194 (18.6%)	25 (2.4%)	76 (7.3%)	61 (5.8%)	1044⁺
Total	1684 (40.8%)	943 (22.8%)	538 (13.0%)	355 (8.6%)	138 (3.3%)	227 (5.5%)	252 (6.1%)	4128

* Cell counts less than 5 are noted with an asterisk to avoid potential patient identification and are considered small cell count

⁺ Totals differ from those in Table 1 due to cells with counts less than 5 being included in missing/small cell count

Chapter Three:

Manuscript 2: Ambulance transport versus private transport for injured pediatric patients in Ontario, Canada. A retrospective cohort study

Amy B. Couperthwaite,[1] PhD Candidate, Michael Rotondi,[1] PhD, Stephen A. Gaetz,[2] PhD, Alison K. Macpherson,[1] PhD

[1]School of Kinesiology and Health Science, York University, Toronto, Ontario

[2]Faculty of Education, Canadian Observatory on Homelessness, York University, Toronto, Ontario

Amy Couperthwaite
York University
School of Kinesiology and Health Science
Bethune College
4700 Keele Street
Toronto, Ontario, Canada
M3J 1P3

Abstract

Background:

Previous research has shown that between 4% and 13% of pediatric patients are transported to the hospital via ambulance with 15% to 46% of these transports due to trauma. However, there is a paucity of research in pediatric ambulance utilization. The objective of this study was to compare differences in all-cause-mortality, hospitalization, ICU admission, and severe injury by ambulance transport and private transport to the emergency department in injured pediatric patients (<19 years) in the province of Ontario.

Methods:

This was a retrospective cohort study over a 5-year period utilizing the National Ambulatory Care Reporting System database and Discharge Abstract Database. The study population was all patients <19 years who presented to an ED with an injury in the province of Ontario between 2012 and 2017. The exposure variable was transport to the ED by an ambulance. There were four outcomes: all-cause mortality upon discharge, admission to hospital, admission to ICU, and injury severity. Odds ratios were calculated using logistic regression with 95% confidence intervals and adjusted for age and sex.

Results:

There were 1,872,519 patients who sustained an injury with 129,577 (6.9%) transported to the ED via ambulance. 303 patients died with 280 (92.4%) transported by ambulance (adjusted OR 154.88; 95% CI: 101.11-237.23). 4,234 patients were admitted to the ICU with 2,521 (59.5%) transported via ambulance (adjusted OR 19.17; 95% CI: 18.01-20.41). 32,448 patients were hospitalized with 15,313 (47.2%) transported via ambulance (adjusted OR 13.27; 95% CI: 12.97-

13.57). 10,398 patients that met the criteria for severity and 5,514 (53.0%) were transported by ambulance. (Adjusted OR 1.88; 95% CI: 1.78-1.98).

Conclusion:

Ambulance transport to the ED is associated with higher odds of all-cause mortality, ICU admission, hospital admission, and severity for pediatric patients <19 years who sustained an injury.

3.1 Introduction:

There is debate around the usage of pediatric ambulance transport. Some studies have deemed the majority of transports unnecessary, and patients would be better served by private transport to the emergency department [ED] (1,2). Contrasting this, other studies have concluded that pediatric patients are under-served by ambulance treatment and transport (3–5). A study examining moderate to severely injured pediatric patients in the United States found that those who arrived to a hospital via ambulance were less likely to be transferred to a trauma centre than those who arrived by other means (6). However, one study examining pediatric patients in Singapore found that there was no difference in mortality or intensive care unit (ICU) admission between mode of transport (7). In the adult population, two studies found that adult patients transported by ambulance had a statistically significant higher mortality rate than those who were transported by private vehicle (8,9). Another study conducted at an adult level 1 trauma centre found that there was no significant difference in mortality, length of hospital stay, days in the ICU, complications, or infections (10).

Previous research has demonstrated that between 4% and 13% of pediatric patients are transported to the hospital via ambulance (3,11–15). Further research has found that between 15% to 46% of transports are due to trauma (3,12,13,16–18). Yet a large proportion of injured pediatric patients are transported to the emergency department via private vehicle (4,7,19). While ambulance transport has been well studied in adults, there is a paucity of research in pediatric patients (12). As injury is the leading cause of death and one of the leading causes of hospitalization for those between 1 and 19 years in Canada, it is imperative to assess the impact of ambulance transport on mortality and morbidity outcomes (20).

The objective of this study is to compare differences in all-cause-mortality, hospitalization, ICU admission, and severe injury by ambulance transport and private transport to the emergency department in injured pediatric patients (<19 years) in the province of Ontario.

3.2 Methods:

This was a retrospective cohort study utilizing health administrative data obtained from the Canadian Institute for Health Information (CIHI). The study population were all pediatric (<19 years) patients whose primary presenting complaint was an injury in an ED within the province of Ontario between April 1st, 2012 to March 31st, 2017. This study utilized two databases: National Ambulatory Care Reporting System (NACRS), and Discharge Abstract Database (DAD). NACRS contains information on ED visits while DAD contains information on hospital visits.

Injury was defined as the acute exposure to physical agents such as mechanical energy, heat, electricity, chemicals, and ionizing radiation interacting with the body in amounts or at rates that exceed the threshold of human tolerance (21–23). Records were extracted from NACRS and DAD based on ICD-10 diagnosis codes S00 to T78.9.

Patients who did not have their sex recorded within the dataset were excluded. Patients who were seen in the ED to be admitted for day surgery, admitted to a hospital clinic, or as an inter-facility transfer were also excluded. Finally, patients whose main diagnosis in NACRS did not correspond to an injury despite having injury as a secondary diagnosis were excluded.

CIHI assigns a Meaningless But Unique Number (MBUN) to each patient record which allows for linkage between NACRS and DAD. Patient records that did not have an MBUN in DAD required manual examination within NACRS to find the corresponding record by matching age, admission date and time to hospital, postal code, and sex. We note that participants remained anonymous and were not at risk of identification. If there were no corresponding patient record in NACRS, the patient record in DAD was excluded. If there was no corresponding record in DAD for a patient who was admitted to hospital or ICU according to NACRS, the patient record was retained and noted as admitted to hospital or ICU in the analyses. Some records in NACRS had the same MBUN but were not the same patient. To facilitate linkage between NACRS and DAD utilizing the MBUN, all records listed as admitted to the hospital or ICU in NACRS were extracted into a separate database. This database was linked to DAD. This database was then merged with the non-hospitalized patient records in NACRS. All patient records in DAD that were not linked to NACRS were subsequently excluded.

The exposure of interest was transport to the ED by an ambulance while the control cohort was defined as those who were transported to the ED by other means such as private vehicle. There were four outcomes: all-cause mortality upon discharge, admission to hospital, admission to ICU, and injury severity. All-cause mortality was defined as death occurring within the ED or hospital. Severe injury was defined as in Pike et al. (2017) where the injury was classified as severe or not severe (24). Severe was only analyzed for those who were admitted to hospital. The denominator for all-cause mortality and severe injury included all patients in the sample whereas the denominator for the other two outcomes excluded patients who died upon arrival to hospital or in the emergency department. As ambulance transport was our exposure variable, it was important that the records matched in NACRS and DAD. If a record in DAD stated that the patient was transported by ambulance with date and time recorded, but it did not state it in NACRS, the patient was assumed to have been transported by ambulance. Descriptive statistics were presented for all mortality and morbidity outcomes as well as stratified by age and sex.

Odds ratios were calculated using logistic regression with 95% confidence intervals. Covariates such as age and sex were examined to determine whether the odds ratios should be adjusted. All statistical tests were considered significant at the 0.05 (two-sided) level and performed in SPSS version 27 (25). As not all DAD records could be linked to NACRS, a sensitivity analysis for severe injury was performed to determine if there were any differences between the linked patients and non-linked patient records. This was important as the severe injury indicator only includes patients who were admitted to hospital or ICU (24). We needed to determine that the records that were unable to be linked to NACRS from DAD did not affect the direction or significance of severe injury. Missing data were handled by case deletion. This study was approved by the Office of Research Ethics at York University (REB #: STU 2019-062)

3.3 Results:

3.3.1 Sample Characteristics

There were 1,907,837 patients <19 years of age who sustained an injury and were seen in an ED in the province of Ontario in the NACRS database between April 1st, 2012 and March 31st, 2017. There were 32,428 patients <19 years of age who were recorded as hospitalized in DAD during the same period.

117 patients did not have sex listed in NACRS and were therefore excluded. 4,346 patients were seen in the ED for purposes of admission to day surgery, hospital clinic, or interfacility transfer and were also excluded. After examining the primary NACRS diagnosis code, 30,855 patients did not have injury as the primary reason for their visit to the ED and were excluded. The final sample consisted of 1,872,519 patients.

Out of the 32,428 patients in DAD, 26,673 (82.3%) had injury as the primary diagnosis. Overall, 24,677 patients (92.5%) were able to be linked to NACRS from DAD using the described linkage strategy. 1,996 patients in the DAD database were excluded from further analyses as they could not be linked to NACRS. Due to discrepancies within NACRS and DAD, 7,771 patients in NACRS who were admitted to hospital or the ICU did not have a corresponding record in DAD. Those patient records were retained in the analyses.

3.3.2 Demographics:

Out of 1,872,519 patients, 129,577 (6.9%) were transported to emergency department via ambulance. Females accounted for 801,019 (42.8%) of patients while males accounted for 1,071,287 patients (57.2%). Those between the ages of 0-4 years accounted for 453,168 (24.2%) of patients. 382,162 (20.4%) were between 5-9 years of age. 544,264 (29.1%) were between 10-14 years and 492,712 (26.3%) were between 15-19 years (Table 3-1).

3.3.3 Ambulance Transport Analyses:

The adjusted ORs are presented as there were significant differences between age and sex when examining both variables. Age was divided into 4 categories: 0-4 years, 5-9 years, 10-14 years, and 15-19 years. There were 303 (0.02%) patients who died during the study period, 280 (92.4%) were transported by ambulance to the ED and 23 (7.6%) were transported by other means (Table 3-1). The crude OR was 164.10 (95% CI: 107.27-251.06). The adjusted OR for all-cause mortality for those that were transported to ED via ambulance was 154.88 (95% CI: 101.11-237.23) (Table 3-2).

Overall, 4,234 (0.2%) patients were admitted to the ICU after being seen in the ED. 2,521 (59.5%) were transported via ambulance and 1,713 (40.5%) were not (Table 3-1). The crude OR was 20.20 (95% CI: 18.99-21.48). The adjusted OR for ICU admission for those who were transported to the ED via ambulance was 19.17 (95% CI: 18.01-20.41). (Table 3-2)

A total of 32,448 (1.7%) patients were hospitalized after being seen in the ED. 15,313 (47.2%) were transported via ambulance and 17,135 (52.8%) were not (Table 3-1). The crude OR was 13.52 (95% CI: 13.22-13.83). The adjusted OR for hospitalization for those who were transported to the ED via ambulance was 13.27 (95% CI: 12.97-13.57) (Table 3-2).

There were 10,398 (0.6%) patients that met the criteria for severe injury. Out of the 10,398 patients, 5,514 (53.0%) were transported to ED by ambulance and 4,884 (47.0%) were not. (Table 3-1) The crude OR was 1.51 (95% CI: 1.44-1.59). The adjusted OR for severe injury for patients who were transported to the ED via ambulance was 1.88 (95% CI: 1.78-1.98) (Table 3-2).

3.3.4 <u>Sensitivity Analysis:</u>

There were 26,673 patients in DAD who met the injury criteria but not all the records were able to be linked. Overall, 24,677 (92.5%) DAD records were able to be linked to NACRS. 10,738 (40.3%) met the criteria for severe injury. 5,670 (52.8%) were transported to the ED by ambulance and 5,068 (47.2%) were not. The adjusted OR for severe injury in the sensitivity analysis for patients who were transported to the emergency department via ambulance was 1.91 (95% CI: 1.81-2.01). The sensitivity analysis examining all patient records in DAD for severity had an OR that was statistically significant, thus there is no evidence to suggest that the unlinked DAD records would have changed the direction or significance of the OR for severity.

3.4 <u>Discussion:</u>

Ambulance utilization is associated with higher odds of all-cause mortality, ICU admission, hospital admission, and severe injury for pediatric patients who sustained an injury.

The majority of patients were transported to hospital via private vehicle rather than ambulance. However, most patients who died or were admitted to the ICU were transported to hospital via ambulance rather than private vehicle.

Patients between the ages of 15 to 19 had the highest proportion of ambulance transport with 10.2% of patients transported to the ED via ambulance. They also had the highest odds of dying, being admitted to the ICU, or being admitted to hospital compared to the other three age groups. Those between 15 and 19 tend to be navigating modes of transportation independent of their parents or guardians (26,27). They are also more likely to drive or be passengers in vehicles with peers of the same age (26,28). This may be a contributing factor in ambulance utilization among those 15 to 19.

Ambulance utilization within this study was 6.9% among pediatric patients. This is in line with previous research that found 4% to 13% of pediatric patients were transported to an emergency department via ambulance (3,11–15). Previous studies comparing adults transported by ambulance have shown different results. Demetriades et al. (1996) and Johnson et al. (2013) found that adults transported by ambulance to trauma centres had a higher mortality rate than those who were transported by private vehicle (8,9). Demetriades et al. (1996) concluded that patients with severe trauma transported by private vehicle had better outcomes than those transported by ambulance (9). They concluded the patients transported by ambulance had worse outcomes overall, but further studies needed to be done to explain this discrepancy (9). They were limited to ambulance transports to a single level 1 trauma centre in California. Johnson et al. (2013) examined patients over a 5-year period in the Pennsylvania trauma registry who were transported to several trauma centres across the state. They also found that mortality was higher in patients transported by ambulance than those transported by private vehicle, but the association was not as strong as previous studies (8). They were limited to patients who were captured by the trauma registries. This aligns with the results from our study. Both studies had 84% and 90.6% of patients transported to hospital via ambulance, which is a much higher rate than other studies (8,9). This is likely because they focused only on severely injured patients and not all injured patients. A follow up study conducted by Cornwell et al. (2000) conducted in Los Angeles County found that there was no statistically significant difference in mortality between those transported to hospital via private vehicle and those transported by ambulance (10). Their cohort study only enrolled 103 patients and did not state the number of patients that died over the 10 month study period.

Two studies specifically examined pediatric patients: one in the United States and one in Singapore. Corrado et al. examined all patients under the age of 15 who had an injury severity score (ISS) greater than 15 and were captured within the National Trauma Bank in the United States over a five year period (6). They found that ground and air ambulance usage was associated with higher mortality than those who were transported by private vehicle. In this study 45.8% of patients were transported to hospital via ambulance, but this was likely due to the strict inclusion criteria. This was in contradiction to the study conducted by Lin et al. (2017) where the majority of pediatric patients were transported by private vehicle (7). 74% of patients were transported by private vehicle and 26% of patients were transported by ambulance. They concluded that there was no difference in mortality or ICU admissions between the two groups. However, this study was small with only 90 patients were enrolled in the study and 2 deaths.

This study had several strengths. It was a large, population-based study examining data over 5 years. It was also focused on the pediatric population who have sustained an injury. There is a paucity of literature regarding pediatric ambulance transport, especially for those who sustained an injury. To our knowledge, this is the first study that has specifically looked at ambulance utilization among all pediatric patients who have sustained an injury. This was also the first study of its kind to examine pediatric patients in a public system with affordable access to ambulance services. Patients are only required to pay $45 for ambulance transport if they are covered under the Ontario Health Insurance Program as an Ontario resident.

NACRS and DAD are known to be robust and comprehensive databases. Additionally, CIHI routinely examines NACRS and DAD to ensure that the data is of high quality and accurate (29–32). A detailed and thorough linkage strategy was used to ensure that as many patient records between NACRS and DAD could be linked.

Finally, a more accurate definition of severity was utilized within this study. ISS and survival rate ratio (SSR) underestimate the number of severe injuries within the pediatric population (24,33,34). The severe injury indicator developed by Pike et al. (2017) captures more severe injuries than the ISS and SSR and is a more thorough method to assess severe injuries in this population (24).

One of the major limitations to this study is within NACRS and DAD it is difficult to ascertain the circumstances of transport. We had to rely on the initial diagnosis within NACRS and assume that the patient was transported via ambulance or private vehicle due to an injury and not for any other medical complaint. There was the possibility for misclassification bias, but this is low. As previously stated, CIHI routinely examines variables for robustness and at the time of this study the ambulance indicator variable in NACRS was robust.

Another limitation was that there were only 303 patients who died over the 5-year study period. This lead to large 95% CI for all-cause mortality. The ORs for mortality may be unstable estimates of all-cause mortality due to the low amount of deaths during the study period.

3.5 Conclusion:

Ambulance transport among pediatric patients in Ontario is associated with increased odds of mortality and morbidity outcomes.

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Table 3-1: Number of patients <19 years of age with a primary diagnosis of injury and mode of transport to the emergency department in Ontario between 2012 and 2017 by outcome, sex, and age.

			Transported by Ambulance Number, (%)			
			Yes n=129,577 (6.9%)	No n=1,742,942 (93.1%)	Total n=1,872,519	
Outcome						p-value
	All-cause mortality		280 (92.4%)	23 (7.6%)	303	p <0.001
	ICU admission		2,521 (59.5%)	1,713 (40.5%)	4,234	
	Hospitalization		15,313 (47.2%)	17,135 (52.8%)	32,448	
	Severity		5,514 (53.0%)	4,884 (47.0%)	10,398	
Sex						
	Overall					p <0.001
		Female	56,336 (7.0%)	744,762 (93.0%)	801,098	
		Male	73,241 (6.8%)	998,108 (93.2%)	1,071,421	
	All-cause mortality					p=0.23
		Female	99 (90.0%)	11 (10.0%)	110	
		Male	181 (93.8%)	12 (6.2%)	191	
	ICU admission					p <0.001
		Female	970 (55.5%)	779 (44.5%)	1,749	
		Male	1,551 (62.4%)	934 (37.6%)	2,485	
	Hospitalization					p <0.001
		Female	6,991 (45.7%)	8,303 (54.3%)	15,294	
		Male	8,322 (48.5%)	8,832 (51.5%)	17,154	

	Severity					p <0.001
		Female	1,859 (47.1%)	2,088 (52.9%)	3,947	
		Male	3,655 (56.7%)	2,796 (43.3%)	6,451	
Age						
	Overall					p <0.001
		0-4 years	28,349 (6.3%)	424,872 (93.7%)	453,221	
		5-9 years	18,963 (5.0%)	363,222 (95.0%)	382,185	
		10-14 years	32,167 (5.9%)	512,149 (94.1%)	544,316	
		15-19 years	50,098 (10.2%)	442,699 (89.8%)	492,797	
	All-cause mortality+					p=0.76
		0-9 years	89 (91.8%)	8 (8.2%)	97	
		10-14 years	60 (90.9%)	6 (9.1%)	66	
		15-19 years	131 (93.6%)	9 (6.4%)	140	
	ICU admission					p <0.001
		0-4 years	348 (48.8%)	365 (51.2%)	713	
		5-9 years	376 (43.9%)	481 (56.1%)	857	
		10-14 years	452 (56.9%)	342 (43.1%)	794	
		15-19 years	1,345 (71.9%)	525 (28.1%)	1,870	
	Hospitalization					p <0.001
		0-4 years	3,004 (38.8%)	4,735 (61.2%)	7,739	
		5-9 years	2,260 (35.4%)	4,116 (64.6%)	6,376	
		10-14 years	3,325 (48.5%)	3,531 (51.5%)	6,856	
		15-19 years	6,724 (58.6%)	4,753 (41.4%)	11,477	

	Severity					p <0.001
		0-4 years	1,366 (45.2%)	1,656 (54.8%)	3,022	
		5-9 years	1,343 (39.5%)	2,060 (60.5%)	3,403	
		10-14 years	1,034 (60.3%)	680 (39.7%)	1,714	
		15-19 years	1,771 (78.4%)	488 (21.6%)	2,259	

+due to counts less than 5, data were presented for those between 0-9 years rather than those between 0-4 years and 5-9 years

Table 3-2 Adjusted odds ratios of transport to the emergency department for patients <19 years of age in Ontario between 2012 and 2017 by outcome, age, and sex

	Mortality OR (95% CI)	ICU admission OR (95% CI)	Hospitalization OR (95% CI)	Severe Injury OR (95% CI)
Outcome				
Transported by ambulance (yes vs. no)	154.88 (101.11-237.23)	19.17 (18.01-20.41)	13.27 (12.97-13.57)	1.88 (1.78-1.98)
Sex (male vs female)	1.38 (1.09-1.75)	1.09 (1.03-1.16)	0.84 (0.82-0.86)	1.29 (1.23-1.36)
Age				
0-4 years	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)
5-9 years	0.61 (0.40-0.95)	1.60 (1.45-1.77)	1.07 (1.04-1.11)	1.80 (1.68-1.94)
10-14 years	0.85 (0.60-1.19)	0.95 (0.86-1.06)	0.75 (0.72-0.77)	0.55 (0.51-0.60)
15-19 years	1.23 (0.92-1.64)	1.83 (1.68-2.00)	1.10 (1.07-1.13)	0.50 (0.46-0.53)

All odds ratios were adjusted for age and sex

Chapter Four: **Manuscript 3**

Ambulance transport versus private transport for pediatric patients injured in a motor vehicle collision in Ontario, Canada. A retrospective cohort study

Amy B. Couperthwaite,[1] PhD Candidate, Michael Rotondi,[1] PhD, Stephen A. Gaetz,[2] PhD, Alison K. Macpherson,[1] PhD

[1]School of Kinesiology and Health Science, York University, Toronto, Ontario

[2]Faculty of Education, Canadian Observatory on Homelessness, York University, Toronto, Ontario

Amy Couperthwaite
York University
School of Kinesiology and Health Science
Bethune College
4700 Keele Street
Toronto, Ontario, Canada
M3J 1P3

Abstract

Background:

Injuries due to motor vehicle collisions (MVCs) are one of the leading causes of death, admission to ICU, and hospitalization. Injuries due to MVCs may be more severe than other injuries and require prompt medical intervention. There is limited research regarding ambulance utilization and pediatric patients who sustain an injury in an MVC. The objective of this study is to examine differences in all-cause-mortality, hospitalization, ICU admission, and severe injury in pediatric patients (< 19 years) who are transported by ambulance or private transportation to the emergency department after an MVC in the province of Ontario.

Methods:

This retrospective cohort study used the National Ambulatory Care Reporting System database (NACRS) and Discharge Abstract Database (DAD). The study population was all children <19 years who presented to an ED with an injury due to an MVC in the province of Ontario. The primary exposure variable was transport to the ED by ambulance. There were four outcomes: all-cause mortality upon discharge, admission to hospital, admission to ICU, and injury severity. Odds ratios were calculated using logistic regression with 95% confidence intervals and adjusted for age and sex.

Results:

There were 32,025 patients who presented to the ED with an MVC related injury with 13,995 (43.7%) transported to the ED via ambulance. Among the ambulance-transported group, 54 patients died (adjusted OR 33.05; 95% CI: 8.05-135.79). We were unable to report the number of patients transported by ambulance or private vehicle due to small cell counts. Regarding ICU admission, 366 patients were admitted to the ICU with 339 (92.6%) transported via ambulance.

(adjusted OR 17.14; 95% CI: 11.57-25.39). 1,292 patients were hospitalized with 1,166 (90.2%) transported via ambulance. (adjusted OR 13.30; 95% CI: 11.05-16.01). 820 patients met the criteria for severe injury and 767 (93.5%) were transported by ambulance. (adjusted OR 2.22; 95% CI: 1.45-3.39).

Conclusion:

Ambulance transport is associated with higher odds of all-cause mortality, ICU admission, hospital admission, and severe injury for pediatric patients <19 years who sustained an injury due to an MVC.

4.1 Introduction:

Injuries due to motor vehicle collisions (MVCs) are one of the leading causes of death, hospitalization, and emergency department (ED) visits in Canada for those under the age of 19 (1–4). These injuries may be more severe than other injuries and require transport to the ED by ambulance. Whether ambulance transport for pediatric patients is necessary has been extensively debated. Some studies have concluded the majority of pediatric patients would be best served by private transport to the ED, while others have argued that pediatric patients are under-served by ambulance transport (5–9). Injuries due to MVCs have been singled out as necessary for ambulance transport to the ED (5).

MVCs are one of the most common reasons for ambulance presentation in pediatric patients. A recent study conducted in Toronto, Ontario found that 19.9% of all injured pediatric patients sustained a transport related injury, second only to falls (10). Other studies have found that MVCs are one of the main mechanisms of injury sustained by pediatric patients (7,11–13). Kallsen and Tsai (1987) found that 30.3% of patients sustained an injury due to a MVC with 14.3% of patients being an occupant of the vehicle (11). Seidel et al. (1984) found that ambulance use due to motor vehicles were the most common reason for ambulance presentation for pediatric patients in three separate surveys (7). In their study, 23% of pediatric ambulance presentations were admitted to a mobile intensive care unit and 25% of pediatric ambulance presentations were admitted to hospital (7). A study of basic life support calls in the United States in 2007 found that MVCs were the most common complaint for injury-related presentations with 32.3% of all injury presentations being MVC-related (13).

Previous research has shown that between 4% and 13% of pediatric patients are transported to the hospital via ambulance (7,11,14–17). A previous study found that adult patients injured in an MVC were 7.1 times more likely to arrive to the ED by ambulance than by other means of transportation (18). Another study found that 50.9% of pediatric patients who sustained an injury due to an MVC were transported by ground ambulance to the ED (19). With MVC-related injuries being one of the leading causes of death, hospitalization, and intensive care unit (ICU) utilization in Canada for those under 19 years of age, it is crucial to assess the impact of ambulance transport on mortality and morbidity outcomes in this population (1–4).

The objective of this study is to compare differences in all-cause-mortality, hospitalization, ICU admission, and severe injury by ambulance transport and private transport to the emergency department in pediatric patients injured in an MVC under the age of 19 in the province of Ontario.

4.2 Methods:

This was a retrospective cohort study utilizing health administrative data obtained from the Canadian Institute for Health Information (CIHI). The study population was all pediatric (<19 years) patients whose primary presenting complaint was an injury resulting from a MVC in an emergency department within the province of Ontario between April 1st, 2012 to March 31st, 2017. This study utilized two databases: National Ambulatory Care Reporting System (NACRS), and Discharge Abstracts Database (DAD). NACRS contains information on emergency department visits while DAD contains information on hospital visits.

Records were initially extracted from NACRS and DAD based on ICD-10 diagnosis codes S00 to T78.9. Patients who did not have their sex recorded within the databases were excluded as were those who were seen in the emergency department for day surgery, admission to hospital clinic, or inter-facility transfer. Patients whose primary diagnosis in NACRS was not injury related were also excluded. The NACRS and DAD databases were then linked based on the Meaningless But Unique Number assigned by CIHI to each record. After linkage patient records were extracted from NACRS based on the ICD-10 codes V20.0 to V79.9, which correspond to injuries sustained in motorcycle collisions, motor vehicle collisions, heavy transport vehicle collisions, and passenger bus collisions. Other MVCs including cyclists and pedestrians were excluded. Each record was examined to ensure that primary mechanism of injury was an ICD code between V20.0 to V79.9. If it was not listed as the primary mechanism of injury, it was excluded from the primary analyses.

The primary exposure of interest was transport to the emergency department by an ambulance after sustaining an injury in a MVC while the reference group was defined as those who were transported to the emergency department by other means such as private vehicle. The secondary exposure of interest were patients who sustained an injury in an MVC while the reference group was those who were injured but not in an MVC. We did a further analysis comparing those who were injured in an MVC to all pediatric patients in order to determine if MVC patients had different mortality and morbidity outcomes compared to all injuries.

There were four outcomes: all-cause mortality upon discharge, admission to hospital, admission to ICU, and those who sustained a severe injury. All-cause mortality was defined as death occurring within the ED or hospital. Severe injury was defined as in Pike et al. (2017) where the injury was classified as severe or not severe (21). Severe injury was only analyzed for those who were admitted to hospital. The denominator for all-cause mortality and severe injury included all patients in the sample whereas the denominator for the other two outcomes excluded patients who died upon arrival to hospital or in the ED.

Odds ratios were calculated using logistic regression with 95% confidence intervals. Covariates such as age and sex were examined to determine whether the odds ratios should be adjusted. Age was divided into four categories: 0-4 years, 5-9 years, 10-14 years, and 15-19 years. All statistical tests were considered significant at the 0.05 level and performed in SPSS version 27 (22). This study was approved by the Office of Research Ethics at York University (REB #: STU 2019-062).

4.3 Results:

4.3.1 Sample Characteristics:

There were 1,872,519 patients <19 years of age who sustained an injury and were seen in an emergency department in the province of Ontario in the NACRS database between April 1st, 2012 and March 31st, 2017. 32,025 (1.7%) of those patients sustained an injury due to an MVC.

4.3.2 Demographics:

Out of 32,025 patients, 13,995 (43.7%) were transported to emergency department via ambulance. Females accounted for 16,656 (52.0%) of patients while males accounted for 15,369 patients (48.0%). Those between the ages of 0-4 years accounted for 2,899 (9.1%) of patients, 4,759 (14.9%) were between 5-9 years of age, 6,448 (20.1%) were between 10-14 years and 17,919 (56.0%) were between 15-19 years.

4.3.3 Ambulance Transport Analyses:

The adjusted ORs are presented as there were significant differences related to age and sex in this study population. There were 54 (0.2%) patients who died during the study period (Table 4-1). Due to cell counts less than 5, exact numbers for transport could not be reported. Patients transported to the hospital had a significantly increased odds of mortality [Adjusted OR: 33.05 (95% CI: 8.05-135.79)] (Table 4-2).

Overall, 366 (1.1%) patients were admitted to the ICU. 339 (92.6%) were transported via ambulance and 27 (7.4%) were not. A total of 1,292 (4%) patients were hospitalized. 1,166 (90.2%) were transported via ambulance and 126 (9.8%) were not. There were 820 patients that met the criteria for severe injury. Out of the 820 (2.6%) patients, 767 (93.5%) were transported to emergency department by ambulance and 53 (6.5%) were not (Table 4-1).

The adjusted OR for ICU admission for those who were transported to the emergency department via ambulance was 17.14 (95% CI: 11.57-25.39). The adjusted OR for hospitalization for those who were transported to the emergency department via ambulance was 13.30 (95% CI: 11.05-16.01). The adjusted OR for severe injury for patients who were transported to the emergency department via ambulance was 2.22 (95% CI: 1.45-3.39) (Table 4-2).

4.3.4 Motor Vehicle Collisions Compared to Other Injuries:

There were 303 deaths from all injuries in Ontario with 54 (17.8%) deaths being due to an MVC. The adjusted OR for death for all-cause mortality for patients in an MVC was 10.67 (95% CI: 7.88-14.49) (Table 4-3).

There were 4,234 patients admitted to the ICU for injuries and 366 (8.6%) were due to an MVC. The adjusted OR for ICU admission for patients admitted to the ICU with an MVC related injury was 4.42 (95% CI: 3.96-4.93) (Table 4-3).

There were 32,448 patients hospitalized for injuries with 1,292 (4%) due to MVCs. The adjusted OR for hospitalization with an MVC related injury was 2.13 (95% CI: 2.02-2.26) (Table 4-3).

There were 10,398 patients that met the criteria for severe injury with 820 (7.9%) due to MVCs. The adjusted OR for severe injury due to an MVC was 5.10 (95% CI: 4.45-5.83) (Table 4-3).

4.4 Discussion:

Ambulance utilization is associated with higher odds of all-cause mortality, ICU admission, hospital admission, and severe injury for pediatric patients who sustained an injury in an MVC. Overall, 43.7% of patients were transported to hospital via ambulance compared to 56.3% of patients who were transported via other means. However, over 90% of patients who died, were admitted to the ICU, admitted to the hospital, or met the criteria for severe injury were transported to hospital via ambulance.

MVCs can lead to serious outcomes (23–25). While MVCs only consisted of 1.7% of all pediatric injuries seen in the emergency department between April 1st, 2012 to March 31st, 2017, they accounted for 17.8% of deaths, 8.6% of ICU admissions, 4% of hospital admissions, and 7.9% of injuries classified as severe. Pediatric patients who were injured in an MVC during this 5-year span were 10.67 times more likely to die, 4.42 times more likely to be admitted to the ICU, 2.13 times more likely to be hospitalized and 5.10 times more likely to sustain a severe injury. MVCs had a disproportionate burden on the healthcare system compared to other injuries. Previous research on pediatric ambulance utilization has focused on the impact of MVC relative to other mechanisms of injuries (7,11–13). A study of ambulance utilization in injured adults in Perth, Australia found those who were injured in an MVC had the highest percentage of deaths on scene and deaths within 24 hours (26). Another study conducted in Los Angeles County found that 23% of pediatric patients seen by an ambulance were admitted to ICU and 25% were admitted to hospital due to an MVC. MVC related injuries were the second most common reason for admission to hospital and ICU after medical complaints (7).

Previous research has shown between 4% and 13% of pediatric patients are transported to the hospital via ambulance (7,11,14–17). As previously stated, 43.7% of patients who sustained an injury due to an MVC were transported to the hospital via ambulance and over 90% of patients who died, were admitted to the ICU, admitted to the hospital, or met the criteria for severe injury were transported to hospital via ambulance. MVCs are disproportionately represented in pediatric ambulance calls. Our findings are much higher than other studies. A study in Ontario over the same 5-year span found that 6.9% of patients who sustained an injury were transported by ambulance (27). Our findings are similar to a study conducted in the United States utilizing the National Trauma Data Bank. Corrado et al. (2017) analyzed ambulance usage amongst injured pediatric patients under the age of 16 who had an injury severity score [ISS] greater than 15 (19). They found that 50.9% of patients who sustained an MVC related injury were transported to hospital by ground ambulance. The study was restricted to moderately to severely injured patients and not all patients who sustained an MVC related injury (19).

23% of patients were between the ages of 15 to 19 years old and transported to hospital via ambulance. Those between the ages of 15 and 19 had the highest odds of being admitted to the ICU, hospital, or sustaining a severe injury compared to other age groups. Recent statistics from Transport Canada show that those between 15 to 19 years of age had the highest number of fatalities, serious injuries and overall injuries due to MVCs in 2020 out of all pediatric patient groups (28). Those between the ages of 15 and 19 are more likely to be driving or passengers of vehicles of peers of the same age (29,30). They are also learning how to operate motor vehicles as the minimum age to obtain a driver's licence in Ontario is 16 (31). Drivers in this age group are more likely to be in an MVC as they are inexperienced, and still developing the cognitive functions required to safely operate a motor vehicle (32). Many of the cognitive functions needed to operate a motor vehicle are not fully developed until well into adulthood (33).

More females than males were injured in MVCs over the study period. One study utilizing self-reported data from the Canadian National Population Health Survey found that more females were injured in MVCs than males (34). The vast majority of studies have found that more males were injured in MVCs than females (4,35–38). Yet more males died, were hospitalized, admitted to the ICU or severely injured than females despite there being more females injured overall. This is consistent with previous research regarding males and MVC related injuries (4,35–38). The reason for the discrepancy may be because females are more likely to seek out medical care than males (39,40).

When examining the adjusted ORs for comparing patients injured in an MVC to all other injuries, there was a difference in the age groups ORs (Table 4-3). Those between 15 and 19 years of age were more likely to die, be admitted to the ICU, or be hospitalized for an MVC injury compared to all other injuries (Table 4-3). Patients between the ages of 5 and 9 years were 1.72 times more likely to sustain a severe injury in an MVC compared to other injuries (95% CI: 1.60-1.85). Patients between the ages of 5 and 9 were 1.40 times more likely to be admitted to the ICU for an injury sustained in an MVC (95% CI: 1.27-1.54). The ORs for ICU admission and severe injury for those between 5 and 9 years old were notable and merited further examination into previous literature.

Several observational studies found that there was high improper restraint usage for children under the age of 11 (41–44). One study conducted in Australia found a high rate of inappropriate restraint usage for children between 5 and 8 years old who sustained an injury in an MVC (45). They found 68% of children between 5 to 6 years and 94% of children between 7 to 8 years were wearing adult seat belts rather than dedicated child restraints at the time of the MVC. The children who were improperly restrained sustained more severe injuries than those who were properly restrained. Due to the limited number of children who were in dedicated child restraints, they were not able to calculate if there was statistical significant differences between the two groups (45). Improper child restraint usage may be a contributing factor for those between 5 and 9 years of age sustaining higher odds of ICU admission and sustaining a severe injury compared to the rest of the population.

This study had several strengths. It was a large, population-based study examining data over 5 years. It was also focused on the pediatric population who have sustained an injury due to an MVC. This is the first study to our knowledge that has specifically looked at ambulance utilization among all pediatric patients who were injured in an MVC rather than examining it as a subset of analyses. It also was the first study to our knowledge that examined mortality and other morbidity outcomes and ambulance transport in pediatric patients who were injured in an MVC.

NACRS and DAD are known to be robust and comprehensive databases. Administrative databases have been thoroughly studied and found to be a great to excellent proxy for medical chart review (46). Additionally, CIHI routinely examines NACRS and DAD to ensure that the data is of high quality and accurate.

Finally, a more accurate indicator of severe injury was utilized within this study. ISS and survival rate ratio (SRR) underestimate the number of severe injuries within the pediatric population (21,47,48). The severe injury indicator developed by Pike et al. (2017) captures more severe injuries than the ISS and SSR and is overall a more thorough method to assess severe injuries in this population (21).

One of the major limitations to this study is within NACRS and DAD it is difficult to ascertain the circumstances of transport. We had to rely on the initial diagnosis within NACRS and assume that the patient was transported via ambulance or private vehicle due to an injury sustained while in an MVC. Additionally, we had to rely on the first mechanism of injury being the correct one if there were multiple mechanisms listed for a patient. There was the possibility for misclassification bias, but this is low. As previously stated, CIHI routinely examines variables for robustness and at the time of this study the ambulance indicator variable in NACRS was robust (49–52).

Another limitation was that there were only 54 patients who died in an MVC over the 5-year study period. This lead to large 95% CI for all-cause mortality. The ORs for mortality may be unstable estimates of all-cause mortality for patients who were injured in an MVC due to the low deaths over the study period.

4.5 Conclusion:

Ambulance transport among pediatric patients who sustain an injury in an MVC in Ontario is associated with increased odds of mortality and morbidity outcomes.

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Table 4-1: Number of patients <19 years of age who sustained an injury due to a motor vehicle collision and mode of transport to the emergency department in Ontario between 2012 and 2017 by outcome, sex, and age.

			Transported by Ambulance Number, (%) of row total*			
			Yes n=13,995 (43.7%)	No n=18,030 (56.3%)	Total n=32,025	
						p value
Outcome						
	All-cause mortality		*	*	54+	p <0.001
	ICU admission		339 (92.6%)	27 (7.4%)	366	
	Hospitalization		1,166 (90.2%)	126 (9.8%)	1,292	
	Severity		767 (93.5%)	53 (6.5%)	820	
Sex						
	Overall					p<0.001
		Female	7,502 (45.0%)	9,154 (55.0%)	16,656	
		Male	6,493 (42.2%)	8,876 (57.8%)	15,369	
	All-cause mortality					p=0.05
		Female	*	*	19+	
		Male	*	*	35+	
	ICU admission					p=0.07
		Female	122 (96.1%)	5 (3.9%)	127	
		Male	217 (90.8%)	22 (9.2%)	239	
	Hospitalization					p=0.004
		Female	478 (93.2%)	35 (6.8%)	513	
		Male	688 (88.3%)	91 (11.7%)	779	

	Severity					p=0.03
		Female	323 (95.8%)	14 (4.2%)	337	
		Male	444 (91.9%)	39 (8.1%)	483	
Age						
	Overall					p<0.001
		0-4 years	1,393 (48.1%)	1,506 (51.9%)	2,899	
		5-9 years	2,219 (46.6%)	2,540 (53.4%)	4,759	
		10-14 years	2,649 (41.1%)	3,799 (58.9%)	6,448	
		15-19 years	7,734 (43.2%)	10,185 (56.8%)	17,919	
	All-cause mortality					p=0.04
		0-4 years	*	*	15[+]	
		5-9 years	*	*	6[+]	
		10-14 years	*	*	5[+]	
		15-19 years	*	*	28[+]	
	ICU admission					p=0.06
		0-9 years	55 (91.7%)	5 (8.3%)	60[^]	
		10-14 years	38 (84.4%)	7 (15.6%)	45	
		15-19 years	246 (94.3%)	15 (5.7%)	261	
						p=0.12
	Hospitalization	0-4 years	110 (88.0%)	15 (12.0%)	125	
		5-9 years	143 (89.4%)	17 (10.6%)	160	
		10-14 years	182 (86.7%)	28 (13.3%)	210	
		15-19 years	731 (91.7%)	66 (8.3%)	797	
						p=0.50

	Severe Injury	0-4 years	57 (89.1%)	7 (10.9%)	64	
		5-9 years	86 (94.5%)	5 (5.5%)	91	
		10-14 years	106 (93.8%)	7 (6.2%)	113	
		15-19 years	518 (93.8%)	34 (6.2%)	552	

[+]due to cell counts less than 5, only overall data was presented for all-cause mortality for age and sex

[^]due to cell counts less than 5 for ICU admissions for those between 0-4 and 5-9 years, data was presented for those 0-9 years of age

Table 4-2: Adjusted odds ratios of transport to the emergency department for patients injured in motor vehicle collisions <19 years of age in Ontario between 2012 and 2017 by outcome, age, and sex

	Mortality OR (95% CI)	ICU admission OR (95% CI)	Hospitalization OR (95% CI)	Severe Injury OR (95% CI)
Outcome				
Transported by ambulance (yes vs. no)	33.05 (8.05-135.79)	17.14 (11.57-25.39)	13.30 (11.05-16.01)	2.22 (1.45-3.39)
Sex (male vs female)	2.04 (1.17-3.58)	2.24 (1.80-2.79)	1.83 (1.63-2.06)	0.80 (0.61-1.05)
Age				
0-4 years	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)
5-9 years	0.25 (0.10-0.66)	0.68 (0.41-1.13)	0.80 (0.63-1.02)	1.06 (0.62-1.80)
10-14 years	0.18 (0.07-0.50)	0.83 (0.52-1.33)	0.88 (0.70-1.11)	0.99 (0.60-1.63)
15-19 years	0.35 (0.19-0.65)	1.70 (1.15-2.51)	1.18 (0.97-1.44)	1.99 (1.28-3.09)

All odds ratios were adjusted for age and sex

Table 4-3: Adjusted odds ratios for injury due to motor vehicle collisions compared to all injuries for patients <19 years of age in Ontario between 2012 and 2017 by outcome, age, and sex

	Mortality OR (95% CI)	ICU admission OR (95% CI)	Hospitalization OR (95% CI)	Severe Injury OR (95% CI)
Outcome				
Motor Vehicle	10.67 (7.88-14.49)	4.42 (3.96-4.93)	2.13 (2.02-2.26)	5.10 (4.45-5.83)
Sex (male vs female)	1.39 (1.10-1.76)	1.08 (1.02-1.15)	0.84 (0.82-0.86)	1.33 (1.26-1.40)
Age				
0-4 years	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)
5-9 years	0.48 (0.31-0.74)	1.40 (1.27-1.54)	0.97 (0.94-1.00)	1.72 (1.60-1.85)
10-14 years	0.77 (0.55-1.08)	0.91 (0.82-1.01)	0.73 (0.71-0.76)	0.57 (0.53-0.62)
15-19 years	1.49 (1.11-2.01)	2.20 (2.01-2.40)	1.33 (1.30-1.37)	0.49 (0.46-0.53)

All odds ratios were adjusted for age and sex

Chapter Five: **Conclusion**

5.1 Overview of Thesis

The aim of this dissertation was to describe the epidemiology of pediatric ambulance transport and injury in the province of Ontario, Canada along with the implications of mortality and morbidity outcomes. The first study described the mechanism of injury and location of injury in pediatric patients seen by TPS, including those who were not transported to the ED. The second study expanded to examine mortality and morbidity outcomes by ambulance transport to the ED for injured pediatric patients in the province of Ontario. The final study examined the specific subset of pediatric patients who sustained an injury in an MVC and were transported to the ED by ambulance, including their demographic characteristics, mortality and morbidity outcomes.

Pediatric patients were seen by paramedics for various mechanisms of injuries and at different kinds of locations. The most common mechanism of injury in the first study were falls and transport-related injuries. The most common locations were residences and highway/street/sidewalk. This information will be reported to TPS and may be used to inform future paramedic operations and education. This information will also be useful to emergency room physicians and hospital administrators to plan for capacity and staffing in the emergency departments. Other specialties may be interested due to the number of patients admitted to hospital and ICU in the second and third studies. In the second and third studies, ambulance transport to the ED was associated with higher levels of all-cause mortality, morbidity outcomes, and severe injury. This suggests that ambulance transport to the ED is being utilized appropriately by patients who are most at risk. Together, all three studies provide decision makers and stakeholders in Toronto and Ontario with information on ambulance utilization among pediatric patients who sustained an injury.

5.2 Overall Demographic Trends and Emerging Themes in Pediatric Ambulance Transport

5.2.1 Sex

Out of the 4,128 patients that were seen by TPS in 2018, 58.5% were male and 41.5% were female. In the second study examining all patients who were seen in an Ontario ED for an injury over a five-year period, 57.2% were male and 42.8% were female. When examining those only transported by ambulance, 56.5% were male and 43.5% were female. These findings are consistent with previous research regarding injury. Male pediatric patients are more likely to sustain an injury than female pediatric patients (39,40).

In the third study examining pediatric patients that sustained an injury in an MVC, 48% were male and 52% were female. When examining those only transported by ambulance, 46.4% were male and 53.6% were female. This contrasts the first two studies where the majority injured were male. One study utilizing self-reported data from the Canadian National Population Health Survey found that more females were injured in MVCs than males (41). The vast majority of studies have found that more males are injured in MVCs than females (42–46). When we stratified by mortality and morbidity outcomes: 64.8% of those who died, 65.3% of those admitted to the ICU, 60.3% of those hospitalized, and 58.9% of those who sustained a severe injury were male. One possible explanation for the disparity in the overall numbers for sex versus mortality and morbidity outcomes may be that females are more likely to seek medical attention for medical complaints than males (47,48). We cannot be certain that this was the case in the third study as we cannot ascertain the reasons and circumstances around seeking treatment in the ED.

5.2.2 Age

In the first study: 3.8% of patients were <1 year, 25.6% of patients were between 1 and 4 years old, 16.8% of patients were between 5 and 9 years old, 19.0% of patients were between 10 and 14 years old, and 34.9% of patients were between 15 and 19 years old. In the second study: 24.2% of patients were between 0 and 4 years old, 20.4% of patients were between 5 and 9 years old, 29.1% of patients were between 10 and 14 years old, and 26.3% of patients were between 15 and 19 years old. The nature of injury is heterogeneous and certain types of mechanisms of injury affect different age groups disproportionately. For the first study we examined the different mechanism of injuries by age groups and found that falls were most common in those between 1 and 4 years old and those between 5 and 9 years old. Fall related injuries are common in pediatric patients under the age of 4 and tend to decrease as children get older (49–51). Transport-related injuries were most common in those between 15 and 19 years old and those between 10 and 14 years old. The majority of assault and gunshot injuries were sustained in those between 15 and 19 years old. Patients between the ages of 15 and 19 are more likely to sustain severe injuries. Previous literature has shown that as children's age increases, the number of transport related injuries increases (9,49,51). Transport related injuries, gunshot wounds, and assault injuries were most frequently sustained in those between 15 and 19 years of age. These types of injuries tend to be far more severe and require immediate attention. This may explain why those between 15 and 19 years of age made up a larger proportion of those seen by a paramedic in the first study. It is difficult to ascertain other reasons for why those between 15 and 19 may be seen by paramedics more than their younger counterparts. It has been hypothesized that higher rates of ambulance transport for adults who sustained an injury due to an MVC or gunshot wound was due to police or ambulance presence already on scene (35). We do not have information on other on-scene factors that may have influenced ambulance transport amongst those between the ages of 15 to 19.

In the third study: 9.1% of patients were between 0 and 4 years old, 14.9% of patients were between 5 and 9 years old, 20.1% of patients were between 10 and 14 years old, and 56% of patients were between 15 and 19 years old. Pediatric patients between the ages of 15 and 19 are navigating vehicular transport on their own independent of a guardian (52–54). New drivers may also have younger siblings or similar aged peers as passengers in a vehicle (52,55). The minimum age to obtain a driver's licence in the province of Ontario is 16 (56). Drivers under the age of 19 are restricted in how many passengers they can have in the vehicle until they obtain a full driver's licence. They may have no more passengers than working seatbelts and are restricted to the number of non-family member passengers under the age of 19 between midnight and 5 am (56). Drivers in this age group are more likely to be in an MVC as they are inexperienced in addition to developing the cognitive functions required to safely operate a motor vehicle (57).

5.3 Mechanism of Injury and Location of Injury Seen by Paramedics

The Ontario ACR has 17 fields for mechanism of injury if the patient sustained an injury (58). We ended up collapsing the 17 fields into 6 categories: falls, transport-related, gunshot and assault, choking and foreign body injuries, burns and scalds, and other. The ACR has 26 fields for location of where the patient was seen by the paramedic (58). We collapsed the 26 fields into 6 categories: residences, highway/street/sidewalk, school settings, sports/recreation centres, retail settings, and other. Falls were the leading cause of injury for all pediatric patients under the age of 19 seen by TPS in 2018. This aligns with general injury prevention research that suggests falls are the leading cause of injury (49,59). Yet research examining only ambulance transport found that transport related injuries such as MVCs, bicycle related injuries, and pedestrian incidents were the leading cause of injury rather than falls (10,38). This may be due to the design of the studies where only severely injured patients were captured. We sought to examine all injuries regardless of severity and captured patients that were low acuity whereas other studies sought to examine patients who sustained high acuity injuries.

There is a paucity of research on the location where a patient sustained an injury in ambulance research. The first study is novel in that we were able to identify where patients were seen by a paramedic. This is not commonly studied. The majority of injuries occurred in residences, which aligns with general injury research that injuries are more likely to occur in the home (60,61). The second most common location for injuries was highway/street/sidewalk. This was to be expected as the second most common mechanism of injury seen by a paramedic was transport-related.

5.4 Ambulance Transport Versus Private Transport

Out of the 1,872,519 patients seen in the ED for an injury, 129,577 were transported by ambulance. Our finding of 6.9% transport is in line with previous findings that ranged from 4% to 13% in previous studies for general pediatric ambulance transport usage (9,10,13–16). When examining mortality and morbidity outcomes, the percentage of patients transported for general injuries was even higher. 92.4% of patients who died, 59.5% of patients admitted to the ICU 47.2% patients who were hospitalized and 53.0% of patients who met the criteria for severe injury were transported to the ED by ambulance. Previous research examining high acuity trauma cases found that patients who sustained a fall from less than 10 feet were 2.0 times more likely to be transported to hospital by ambulance, patients who sustained a gunshot or stab wound were 2.1 times more likely to transported to hospital by ambulance, and patients injured in an MVC were 7.1 times more likely to be transported to hospital by ambulance (35). Studies examining patients with severe injuries have found ambulance transport rates between 54.5% to 90.4% (9,33,34). While our measures of morbidity were defined differently, our percentage of ambulance transports to hospital are comparable.

In the third study, there were 32,025 patients who were injured in an MVC. Out of the 32,025 patients, 13,995 (43.6%) were transported to the hospital by ambulance. There was only one study that explicitly mentioned MVC injuries and ambulance transport. As previously mentioned, they found that those injured in MVCs were 7.1 times more likely to be transported to hospital via ambulance (35). We were unable to do an analysis comparing ambulance transport in regard to MVCs and the general population. However, ambulance utilization for MVCs was high in the third study compared to overall injuries in the second study. The overall ambulance transport to the ED for MVCs was 43.6%, which is below the range of 54.5% to 90.4% reported by other studies for severe injuries (9,33,34). We took into account all MVCs that were seen in the ED and not all MVC injuries were severe, which may explain this disparity. Examining the morbidity outcomes: 92.6% of ICU patients, 90.2% of hospitalized patients, and 93.5% of patients who sustained a severe injury were transported to the ED by ambulance. The ambulance utilization by ICU patients and patients who sustained a severe injury is higher than what has been reported in previous literature.

5.5 Ambulance Transport Conclusions

Ambulance transport to the hospital or ED for pediatric patients has been a conflicting topic in the scientific literature. Many studies have deemed it unnecessary, with one study going as far as calling ambulances for pediatric patients a "medical taxi" (62,63). Other studies have specified trauma as a priority for ambulance transport to the ED or hospital (10,64,65). Overall, in the second study the percentage of patients transported by ambulance to the ED was 6.9%. As mentioned previously, this was in line with previous studies (9,10,13–16). When we looked at mortality and morbidity outcomes for overall injury, transport percentages were higher. 92.4% of patients who died, 59.5% who were admitted to the ICU, 47.2% who were hospitalized, and 53.0% who sustained a severe injury were transported by ambulance to the ED. Once we adjusted the ORs for age and sex: the OR for mortality was 154.88 (95% CI: 101.11-237.23), the OR for admission to the ICU was 19.17 (95% CI: 18.01-20.41), the OR for hospitalization was 13.27 (95% CI: 12.97-13.57), and the OR for severe injury was 1.88 (95% CI: 1.78-1.98). This is a strong indication that ambulance transport to the ED is being utilized appropriately for pediatric patients who sustain an injury.

When further examining pediatric patients who sustained an injury due to an MVC, 43.6% were transported to the ED via ambulance. This is lower than transport for severe trauma but higher than general pediatric trauma in the scientific literature (9,34). When examining morbidity outcomes: 92.6% of patients who were admitted to the ICU, 90.2% of patients who were hospitalized, and 93.5% of patients who sustained a severe injury were transported to the ED by ambulance. Examining the ORs after adjustment for age and sex for patients who sustained an injury in an MVC and were transported to hospital by ambulance: the OR for mortality was 33.05 (95% CI: 0.85-135.79), the OR for admission to ICU was 17.14 (95% CI: 11.57-25.39), the OR for hospitalization was 13.30 (95% CI: 11.05-16.01), and the OR for severe injury was 2.22 (95% CI: 1.45-3.39). This is a strong indication that ambulances and paramedic services are being utilized appropriately for pediatric patients who sustained an MVC related injury.

5.6 Strengths and Limitations

5.6.1 Strengths

This dissertation has many strengths. The first study of this dissertation was able to utilize the Ontario Ambulance Call Record. It is important to note that not all patients seen by a paramedic are transported to hospital. Patients who are dead upon arrival or die while being treated on scene generally are not transported to hospital and patients or their parents have the right to refuse transport to hospital via ambulance. In utilizing the ACR, we were able to capture all patients who were seen by an ambulance under the age of 19 in the city of Toronto over a one year period, regardless of whether they were transported to hospital or not. The majority of studies only take into account patients who were transported to hospital or captured within a trauma registry. Being able to access all the paramedic records provides a full picture of the mechanism of injuries that paramedics are attending to and the location of the incidents.

The second and third studies of this dissertation examined private transport versus ambulance transport in a Canadian context with regards to pediatric injury. There is a paucity of trauma related research in regard to ambulance utilization overall, and even fewer studies that address pediatric ambulance utilization specifically (13). The majority of studies examining ambulance transport took place in other countries. While some of their findings could be generalized to a Canadian context, there are some differences in how medical services are delivered in Canada. Ontario services are delivered under a public healthcare system whereas other countries had a mix of private and public healthcare systems. The different healthcare systems do make it difficult to generalize findings to a Canadian context. Our studies took place in a public healthcare system with affordable access to ambulance services. Patients are only required to pay $45 for ambulance services under the OHIP program as Ontario residents (29). Other studies did not discuss the cost of ambulance services.

All three studies had relatively large sample sizes. The first study examined 4,128 patients over a one-year period in the City of Toronto. Examining the patients over a one-year period allowed us to account for any seasonal variation in injury. The second and third studies took place over a five-year period. As mentioned previously, the second study had 1,872,519 patients and the third study had 32,025 patients. This large dataset allowed us to gather and present more information about mortality, ICU admissions, hospitalizations, and severity in detail for both the second and third studies.

Additionally, all studies were examining trauma. As this is a population that paramedic services attend to frequently, it's important to understand the nature of trauma they are encountering. It is also important to determine the utilization of ambulances for trauma calls versus private vehicles. As MVCs have a disproportionate burden on mortality and morbidity outcomes, it is imperative to examine them separately. Many studies examine MVCs as a subset rather than a stand-alone study. This only gives a partial picture of ambulance transport and MVCs. They have also been singled out in previous studies as a gap in the literature, as to our knowledge, there has been no studies examining method of transport to the ED following MVC-related injuries. The second and third studies were unique in examining pediatric injuries and transport to the ED.

Finally, the usage of the severe injury indicator developed by Pike et al. (2017) rather than ISS to measure injury severity in the second and third studies was one of the major strengths of these two manuscripts (66). ISS was developed as a means to measure injury severity on a scale from 0 to 75. ISS is not the most reliable indicator of injury severity and has been revised several times to try and capture more severe injuries. Pike et al. (2017) developed an indicator for severe injuries that was a much more comprehensive indicator for severity (66). It is also simpler as it classifies an injury as severe or not severe rather than having to make distinctions on severity based on a scale from 0 to 75. ISS and SSR underestimate the number of severe injuries within the pediatric population (66–68). The distinction of severe or not severe made it easier to calculate a results for severe injuries.

5.6.2 Limitations

With administrative data, it's difficult to ascertain the circumstances of transport to the ED. Ruger (2006) hypothesized that the higher rate of transport for adults who sustained injuries in MVCs and assaults may have been due to the presence of police or paramedics on scene already (35). It has been hypothesized that parents may be more comfortable with transporting their child to hospital versus leaving them in the care of a paramedic (12). Additionally, pediatricians may have an influence as pediatricians tend to recommend private transport to the ED versus ambulance transport (12,17). To our knowledge, no study has examined the factors that influence the decision to call for a paramedic in pediatric patients. As we do not have the background information on the calls themselves, we cannot discern why the method of transport to the ED was chosen at the time. We can only rely on the information present in NACRS and DAD that the patient was transported to the ED.

There were also challenges with missing data. In the first study, 1,022 (24.8%) of records were missing the mechanism of injury and 252 (6.1%) of records were missing the location of injury. For the second study, 117 patients did not have their sex reported and were excluded from analyses. Missing data is common with injured patients and ambulance data (38,69–72). Treating injuries is complex and may be time sensitive (71). Paramedics and other healthcare providers may not have the time to adequately chart during treatment and may not recall certain details when going back to chart. The nature of paramedic services does not allow for many pauses for paramedics to catch up on charting as they need to attend to the next patient; as a result, charts may be incomplete and missing information. Imputation has been suggested as a method of dealing with missing data in medical sets but to be done with extreme caution (71). This would not have been applicable to our study as we were describing the mechanism of injury and location of injury of pediatric patients in Toronto rather than doing advanced analyses. We accepted the data was missing and reported it as such.

In the second and third study we assumed that our exposure variable, transport method to the hospital, was coded properly in NACRS and DAD. In order for something to be captured in NACRS and DAD, it must be recorded within the patient chart. If it was not indicated within the patient's chart that they were transported by ambulance, it was not recorded in the corresponding patient record within NACRS and/or DAD. There was the possibility for misclassification bias. Only 138 patients were classified as seen by an ambulance in DAD but were not classified as seen by an ambulance in NACRS. CIHI routinely examines variables for robustness and at the time of this study the ambulance indicator variable in NACRS was robust.

5.7 Conclusions

The majority of injuries seen by TPS were fall related, transport-related, gunshots/assaults, choking/foreign body, and burn/scald injuries. Patients most frequently sustained injuries in residences, on highway/streets/sidewalks, school settings, sports/recreation centres, and retail establishments. Overall, ambulance transport amongst pediatric patients in Ontario is associated with increased odds of mortality and morbidity outcomes. When examining specifically pediatric patients who were injured in an MVC, ambulance transport is also associated with increased odds of mortality and morbidity outcomes. The increased mortality and morbidity outcomes amongst injured pediatric patients transported to the ED by ambulance indicates that ambulance transport is necessary and appropriate-used within this population. The findings from the three studies within this dissertation can be used by paramedic services and health policy-makers to plan and anticipate the needs of the pediatric population for emergency care and within the hospital system.

Chapter Six: **Bibliography**

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