SOCIOECONOMIC STATUS, ED VISITS AND HOSPITALIZATIONS FOR PEDIATRIC CONCUSSION

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Abstract:

In Ontario, the number of Emergency Department visits for concussion is rising, but little is known about the association between concussion and socio-economic status. The objective of this study was to examine the association between SES and ED visits for concussions in Ontario, Canada. This longitudinal population-based study using routinely-collected administrative data from the Institute for Clinical Evaluative Sciences included data from all ED visits and hospitalizations. The rate per 100000 children was calculated from 2008 to 2015. There were 5,889 concussions reported at an ED in 2008, and 14,906 in 2015. The rates of concussions among all socioeconomic quintiles were either stable or increasing. The results of this study suggest that rates of reporting concussions are increasing. However, children in higher income quintiles consistently visited EDs for concussion more than the lower income quintiles. These results suggest that policies related to concussion awareness and identification need to be considered.

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Chapter 1 - Introduction

Pediatric Concussions

Concussions, otherwise known as mild traumatic brain injuries, are a common injury in children and adolescents typically identified by a loss of consciousness, amnesia, or a change in mental status following a direct or indirect blow to the head.[1] A study by Zemek[2], found that by the age of 10 years old, 16% of children will have suffered a head injury that subsequently required medical attention. There are many concerns when suffering a concussion, especially in a population with cognitive maturation still taking place that may potentially lead to more devastating effects.[3] Many questions arise following a concussion diagnosis that may include: the effects on future academic success, the risk or likelihood of further sustaining concussions and the point it is acceptable to return to physical activity or sports participation.

The rise of concussions and the seriousness of them is not going unnoticed in Canada and among its lawmakers. In March of 2014, the Ministry of Education of Ontario passed the Policy/Program Memorandum # 158 that mandates school boards develop and implement a concussion policy.[4] More recently, in 2016, Ontario became the first province in Canada to pass a concussion policy (Rowan's Law), which is intended to provide guidelines on the prevention, diagnosis, treatment and surveillance of head injuries among children and youth.[5] In addition, there are organizations such as Parachute Canada that continue to provide educational materials to parents, educators in schools and coaches on sports team about the recognition and management of concussions.[6] There are also easily accessible tools such as the Concussion Recognition Tool 5 (CRT5) and Concussion Awareness Training Tool (CATT) supported by the Olympics, FIFA and IIHF to name a few, that help in the identification of a concussion in persons of all ages. Due to the high number of pediatric concussions suffered from sports and recreational play, during the recovery period of a sustained concussion, there is a lot of emphasis

put on the “return to play”. Return to play requires giving the brain a rest, this includes initially restricting activities that elevate blood pressure or heart rate, and reducing cognitive stress such as video games, computers and reading.[7]

With the ever growing information and education coming forward with regards to pediatric concussion, there still remains research areas that are less explored. Return to play is a term regularly discussed within the concussion realm, perhaps because much of the concussion awareness stems from professional sports where their primary goal is to return to work, which evidently is return to play.[8] A study by Carson[9] states that students returning to school without physician approval or a return to learn strategy risk the returning of their symptoms or a prolonged recovery period. Baker[10] found that there is limited data that exists addressing the academic effects of a concussion and the optimal process for returning to school. As previously mentioned, the concussion discussion largely stems from professional sports where the athletes must return to their work, thus the advancement in return to sport knowledge. However, for the continuously developing pediatric population, their work is their academic studies. This should highlight the equal, if not, greater importance of concussion recovery with regards to returning to learn as there is with returning to play.

Evidence of Injuries within Socioeconomic Status

The usage of Emergency Departments (ED) continue to rise in North America. In Canada specifically, where health insurance is universal, theoretically the use of respective EDs should not vary by socioeconomic status (SES).[11] Lower SES is commonly associated with poorer health status, which may lead to an increased usage of the health care system.[12] With an often

discussed shortage of family physicians, those of lower SES may be less likely to acquire care from a family physician, thus, turning to an ED for their primary source of care.[11]

The literature on SES and its association with sustaining injuries continues to find mixed results. A possible explanation for these discrepancies in the research findings is that SES may be differentially related to injuries according to cause.[13] There is evidence that higher SES may be positively related to sports and recreation injuries within the pediatric population, while conversely, lower SES sees an association with some types of traffic injuries and intentional injuries.[14-16] In fact, there are many determinants that factor into the association between SES and injuries among the pediatric population such as parental care and supervision, the living environment and neighborhood and individual behaviours.[17-19] These characteristics likely relate differently to injury risk and it is plausible there are several layers to these relations. For example, physical activity behaviors may be related to sports and recreation injuries and higher SES may be provided with more of these opportunities. Neighborhood environment and individual behaviors may be related to traffic injuries. In a study conducted by Stewart[20], they found that 81% of patients presenting to an ED live in an urban setting, compared to the rural 19% in Southwestern Ontario, Canada. However, it was found that the rural setting had more than double the incidence rate per 1000 (3.0-1.4).

The inconsistent research findings with regards to SES and injuries can also be related to the inconsistencies in defining social class or SES at an international level. Some nations have viewed social stratification in terms of occupational class, while North American research has placed more emphasis on occupational status with regards to income and education.[13,21] Even within North American research however, inconsistencies exist as some researchers will put emphasis solely on a family's income, for example. With more consistency in defining such

terms internationally and nationally, the body of research highlighting the relationship between SES and pediatric injuries can grow stronger leading to a greater understanding of this relationship and the consequent actions that can be taken to address this matter.

Emergency Department Visits and Reporting

With the growing knowledge of concussion awareness among parents, schools, sports team coaches and other members of the community; there exists a growing opportunity for individuals to recognize the signs and symptoms of when a child or adolescent may have suffered a concussion. According to recent research from the Canadian Institute for Health Information (CIHI), almost 95% of all emergency department (ED) visits for sport-related brain injuries in 2014-2015 were concussion related.[22] In a study conducted by Fridman[23], they observed the annual trends of concussions from 2003-2013 and found that 7126 pediatric concussions were evaluated in year one of the study compared to 21 681 visits for concussion in 2013. Data from from the United States shows that sports-related concussions effect as many as 0.5-1.1 million Americans each year between the ages of 5-19, with the majority of them going to the ED.[24]

One of the issues in assessing trends in concussions is underreporting and under-diagnosis.[25] One US based analysis shows that nearly half (44.9%) of former collegiate athletes reported sustaining undiagnosed sport-related concussions.[26] It appears Ontario also suffers from underreporting concussions; data routinely gathered by the Ontario School Boards' Insurance Exchange (OSBIE), in 2011 saw 634 reports of concussions out of 84,706 general incidence reports, therefore, concussions occurring at a 0.7% rate of all incident reports, that number of reported concussions is drastically lower than reported in most other studies suggesting

underreporting of concussions in Ontario schools.[27] Additionally, according to Fridman[23], the rate of follow-up care for concussions nearly tripled in both EDs and physician's offices from 2003-2013. Despite this significant rise in seeking a health professional's care, two-thirds of all children and adolescents still do not receive the minimum standard of care and that concussions remain underreported.[23] Although it is clear that concussion rates and reporting are rising dramatically, it remains clear that the underreporting of concussions still exists and the actual number of concussion occurrence is much greater.

Hospitalizations

It can be generally accepted that if an ED visit leads to being admitted and hospitalized, then the injury is more serious in nature and further testing/evaluation will be conducted. Since head injuries can have a more devastating outcome on a child's brain compared to an adult's brain, the full effect of an injury to a child's brain can only be seen over time as the brain fails to mature with the child's physical growth and development.[28] In the United States in 2000, an estimated 50,658 traumatic brain injuries (TBI) associated hospitalization occurred in children 17 years of age and younger.[29] The hospitalization rate was 70 cases per 100,000 children and these pediatric hospitalizations totaled more than $1 billion in medical bills.[29] The rise in ED visits for brain injuries seemingly every year is noteworthy, however, a study found that from 2001-2010 the rates of hospitalization also increased by 11%.[30] Taylor[31] found that in 2013, there were 282,000 TBI related hospitalizations. Among those, the highest rates per 100,000 belonged to the 0-4 years (1,541.1 per 100,000) and 15-24 years (1,001.9 per 100,000). A study in British Columbia, Canada found that 9.7% of head injury hospitalizations from 2001-2010 were due to

concussions.[32] Among those, 39% were among children and youth aged 0-19 years of age and rates were highest among the 10-14 years (19.8 per 100,000).[32]

With the continuous rise in head injuries, there are areas that are making progress in diminishing the number of head injuries and concussions that are occurring. The literature displays mixed results with regards to concussion-related hospitalizations. A study from British Columbia and Atlantic Canada (New Brunswick, Prince Edward Island, Nova Scotia & Newfoundland) have found a decline in concussion hospitalization from 2001-2014 and 2004-2013 respectively.[34-35] There is significantly more research highlighting concussions and ED visits or physician office visits than hospitalizations. The limited research that have studied concussion-related hospitalizations seem to be finding mixed results. There is undeniably a rise in overall concussions rates, presumably one would expect the total number of hospitalizations to climb as the total number of concussions increase.

Variability in Injury Rates by Age

It is not until adulthood that our brains are fully developed.[3] Therefore, an undeveloped brain, and, in some cases of younger children, a still developing body will inevitably be more susceptible to injuries and such injury may require less force than it would take for their older counterparts. Additionally, experts believe young children who are still developing essential skills may be at increased risk for developmental delays and they are more likely to report "second impact syndrome" in which brainstem herniation occurs while a patient is still symptomatic from a previous concussion.[36-37] Studied related to the incidence of concussions in the pediatric population have found varying results, with one study reporting a peak in concussions at approximately 10 years of age followed by a decline, while other studies have

reported that children >10 years of age were at an increased risk of head injury.[38-39] The type of common injury leading to concussions also varies by age. Falls have repeatedly been found as the most common injury in younger children, whereas adolescents have been found to be more susceptible to concussions through sports-related injuries.[37,40]

Macpherson[41] was the first study to include both ED and physician office visits for concussions and found that the number of visits for concussions increased until 15 years of age, then subsequently decreased until 18 years of age. Fridman[42], separated their study by sex, however, they found that females aged 5-9 and males aged 10-14 were the most likely to have suffered a concussion, respectively. Taylor[31] found that in 2013 in the United States that after the elderly population (>75 years) that the group with the highest rates of TBI-related ED visits belonged to the 0-4 years (1,541.1 per 100,000).

It is clear that there is no consensus around which age group is more susceptible to concussions and there may be many reasons for this. As mentioned above, the cause of injury seems to differ by age, as a young child it appears concussions are predominantly fall related and as children age into adolescence, they are more likely to suffer their injury through sport.

Summary

While there has been an increase in research related to concussions, there remains very clear areas where a lack of clarity within the literature still exists. A distinct area of confusion within its definition is defining pediatric. Studies within the literature fail to consistently establish the age group for the pediatric population, thus, making direct comparisons more difficult. Another area within the literature with very minimal evidence is with concussion hospitalizations. Perhaps this is due in large part because individuals being hospitalized due to

concussions are presumably being admitted having suffered another substantial head injury with a more concrete diagnoses such as skull fractures or neck/vertebrae injuries. These other severe injuries could potentially be getting documented and treated rather than documenting a concussion, which in most severe head trauma cases would have also occurred.

Concussion education is undoubtedly spreading and new research continues to further educate the population. With this better understanding of the effects of concussions and recognizing their signs and symptoms, health and medical facilities will likely continue to see a rise in concussions, thus, further highlighting the importance of understanding the effects of concussions and the proper rehabilitation needed to ensure a safe return to play/learn without hindering pediatric physical and brain development.

Objectives

The primary objectives of this study is to:

1. Determine if the rate of admission to an emergency department with a concussion differs between level of socioeconomic status among the pediatric population in Ontario
2. Determine if the risk of hospitalization with a concussion differs between level of socioeconomic status among the pediatric population in Ontario

Chapter 2 - Manuscript

Socioeconomic Status and ED Visits for Pediatric Concussion

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Abstract:

Background: Concussion has been a topic of concern in Ontario, and new research and guidelines are emerging around the world. In Ontario, the number of Emergency Department (ED) visits for concussion is rising, but little is known about the association between concussion and socio-economic status.

Objective: The objective of this study was to examine the association between socio-economic status and ED visits for concussions in Ontario, Canada.

Methods: This is a longitudinal population-based study using routinely-collected administrative data from the Institute for Clinical Evaluative Sciences. Data from all Emergency Department visits and hospitalizations are included. For the purposes of this study, all injuries coded using the ICD-10 CA code associated with concussion (S060) were included. The denominator used for this study was the number of children residing in Ontario in each age group. The rate per 100000 children was calculated from 2008 to 2015.

Results: There were 5,889 concussions reported at an emergency department in 2008, and 14,906 in 2015. The rate among the lowest socioeconomic class quintile was 5.23 per 100000 person years in 2008, and 7.12 for the highest socioeconomic class quintile. By comparison, the lowest and highest quintiles recorded 8.64 and 11.07 respectively in 2015. The rates of concussions among all socioeconomic quintiles were either stable or increasing.

Conclusions: The results of this study suggest that rates of concussions are increasing among children. However, children in a higher income quintile consistently visited EDs for concussion more than children from lower income quintiles. This may be due to the increased opportunity wealthier children have to engage in organized sports such as hockey as well as the overall greater availability of these families to respond to symptomatic children. These results suggest

that further policies related to awareness and identification of concussions need to be considered for all children.

Introduction

Concussion has been a topic of interest, new research and knowledge transfer with regards to concussion knowledge and education are emerging around the world.[1] In Ontario, the number of Emergency Department (ED) visits for concussion is rising, but little is known about the association between concussion and socio-economic status. A concussion occurs after a blow to the head, face, neck or elsewhere on the body with an impulsive force transmitted to the head, resulting in rapid onset of short-lived impairment of neurological function.[2] The impairment of neurological function caused by the blow is referred to as a concussion. The pediatric population are continuously surrounded by the possibility of head injuries through common daily activities such as sports and outdoor recreational play.

A factor to be considered when discussing concussions in the pediatric population is their socioeconomic status (SES). Socioeconomic status is defined as individual factors relating to social position or economic situation such as income, occupation, and educational attainment, or area level factors such as average neighborhood income and neighborhood deprivation indexes.[3] When looking at different SES across Ontario, the children may be subject to different environments and lifestyles depending on their place of residence and their family income. The literature has shown that SES is an important variable to research as it demonstrates a multitude of factors such as health outcomes among different populations, prevention strategies across these different populations, and the different rates of trauma. Previous literature has found that high SES and high physical activity are associated with better self-rated health and better quality of life.[4]

The pediatric population is a vulnerable group as suffering a concussion can impact their mental, physical and academic performance and social encounters.[5] Recognizing the signs of a

concussion (headaches, fatigue, difficulties with attention, memory and concentration) and equally prescribing sufficient rest before returning to school and play is pivotal.[6] Returning to school or other activities too quickly can lead to a worsening of symptoms, prolonged recovery and the risk of reinjury.[7]

There has been an increase in the focus on concussion research and education over the past several years both in professional sports and generally.[8] Children and adolescents are at a greater risk of concussion compared to adults and they often have longer recovery periods.[9] A previous population-based study with a decade worth of concussion related visits to EDs in Ontario, beginning in 2003, found that reported concussion rates have quadrupled per 100,000 children.[10]

There has been no previous research examining the relationship between pediatric concussion and SES. It is important to identify vulnerable populations in order to develop evidence based prevention policies to mitigate the overall impact of concussion occurrences. The primary objective of this study is to examine the association between Emergency Department visits and hospitalizations for concussion and socioeconomic status in Ontario pediatric population.

Methods

Study design and overview

A retrospective cohort study was conducted using Ontario emergency department (ED) data from the fiscal years 2008-2015 obtained from the Institute of Clinical Evaluative Sciences (ICES). The ICES data is subject to an agreement with Sunnybrook's Research Ethics Board (REB). The study population included Ontario children and adolescents aged 1-19 years old. The

National Ambulatory Care Reporting System (NACRS) captured ED visits of all children who presented to the ED having suffered a concussion, including those who are hospitalized from the ED and those who were discharged directly from the ED. Population information on children and youth in Ontario was obtained from the OHIP eligible Registered Population Database. Household income quintiles were determined using the Statistics Canada Postal Code Conversion File 2011, with Quintile 1 representing the lowest income quintile and Quintile 5 representing the highest income quintile.[11]

The primary outcome variable was the diagnosis of concussion. A concussion was defined using the S060 code in the ICD-10. This is based on the diagnosis in the ED by a healthcare professional. Hospitalization, a secondary outcome measurement, reflects the severity of the incident or perhaps other mitigating factors that lead to the hospital admission. All concussed individuals that were admitted to the hospital from the ED were considered severe as they required further treatment. Admission to the hospital is a proxy measure of severity as there may have been other underlying reasons for admission.

The primary objective was to evaluate the association between SES and pediatric concussions. This study evaluated the change in concussion incidence over an eight-year period (2008-2015). Descriptive statistics on rates in each income quintile, as well as rates over time were conducted. Rates over time were also investigated for age groups and sex.

Results

There were a total of 80,642 children treated for pediatric concussions in Ontario EDs between 2008 and 2015. Figure 1 includes the standardized rates of ED visits by income quintiles per 100,000 children. The results also show that the higher the income quintile, the

more likely the study population are to seek treatment in an ED for a concussion. During the study period, the lowest income quintile (IQ1) saw a 3.4 fold increase in rates per 100,000 rising from 114.52 in 2008 to 400.50 in 2015. Comparatively, the highest income quintile (IQ5) exhibited a 2.84 fold increase in rates per 100,000 rising from 201.52 in 2008 to 572.81 in 2015, respectively.

Figure 2 displays the age standardized rates of hospitalizations by income quintile per 100,000. There is a greater variation by income quintiles for hospitalization compared to ED visits. The highest income quintile continues to have higher rates of concussions that lead to hospitalization than the lowest income quintile. The increasing rates among income quintiles are more varied and it should be noted that there are some outliers that exist. In 2012, IQ2 had the highest rate of hospitalization, meanwhile, in 2015 it was IQ3 that saw the greatest number of hospitalizations for concussions.

Figure 3 illustrates the standardized rates by age group per 100,000 children. There was an increase in all age groups over the study's eight year period. The increase was greatest in the 10-14 and 15-19 age groups which saw an increase in ED visits for a concussion rise by 209% and 206%, respectively over the study's eight years.

Lastly, Figure 4 displays the standardized rates by sex per 100,000 children. There was an increase in both sexes over the study's eight year period. Males incurred 61% of the total number of concussions. In addition, females saw a 3.4 fold increase in pediatric concussion from 2008-2015 in comparison to males which saw a 2.1 fold increase, respectively.

Discussion

This study found an increase in ED visits for concussions among all income quintiles, however, in the higher income quintiles the rates of ED visits are consistently the highest among

all groups. However, these results did not translate with regards to the hospitalizations by income quintiles. It was found that the three highest income quintiles were subject to noticeably higher rates of hospitalizations than the two lowest income quintiles, however, among the three highest there was some interchanging across the study's eight year period. Perhaps the most noticeable results of the study are the ED visit rates for concussion by age group. All age groups were subject to a rise in concussion rates from 2008 to 2015, however, the 10-14 and 15-19 age groups saw the greatest increases rising from 2082 and 2491 reported concussions in 2008 to 5622 and 6184 reported concussions in 2015, respectively.

There are several reasons why this increasing trend in reported concussions through ED visits might be occurring. Firstly, participation in sports have previously been found to have a high incidence of concussions, whether it be through contact or simply the fast pace of play which accompany sports such as hockey and football/flag football.[12,13] The price of equipment and registration for these sports is costly, thus, potentially giving higher income children greater opportunity to participate in such sports. Secondly, the NACRS data stems from all over Ontario where higher income families may live in proximity to more hospitals with greater access to emergency departments than their lower income counterparts who may be situated more in rural areas of the province or simply lack the possibility of transportation.[14] There also exists the possibility that a difference in recognition among the income quintiles exist where the parents in lower SES neighborhoods may have less access to information about concussions or because of other pressures such as language barriers or cultural norms. Additionally, it is possible that lower SES children are living in single parent homes where the parent has competing interests such as working long hours or salary loss from missing work, thus lacks the time and availability to get

their child's symptoms examined.[15] Contrarily, higher SES homes often have a non-working or part-time working parent where this barrier to seeking treatment is less likely.

Although this study does not include the location or cause of concussion data, previous studies researching pediatric concussions have included how concussions occurred. Zemek[5] researched the annual trends of pediatric concussion ambulatory visits in Ontario between 2003-2013 and found that sports (30.7%), falls (21.4%), exposure to force (18.3%), school (8.8%), and motor/nonmotor vehicle (7.4%) were the biggest causes of pediatric concussion**.** Additionally, Macpherson[16] found when researching specific causes of pediatric concussions from 2003-2010 that the large majority of concussions stemmed from sport participation. Specifically, hockey had the large majority of concussions with just under 8000 ED visits followed by motor vehicle accidents which incurred less than 3000 ED visits, respectively. Their study found that seven of the ten highest specific causes of pediatric concussion were sport related.

An increase in the number of ED visits for concussion injuries across the variables also saw an increase in concussion hospitalizations over the study period. The severity of suffering a concussion as a continually developing child/adolescent is cause for concern considering the potential damages that may be sustained such as cognitive maturation and increased likelihood of recurrence.[17] Observing the findings that hospitalization rates are also increasing among the study population highlights the significance of some of these injuries being suffered leading to head trauma. The slower rise in hospitalization compared to ED visits suggests perhaps that the education and knowledge of suffering a concussion is growing and the public is learning to recognize the signs and symptoms. Nonetheless, hospitalizations are most likely occurring alongside more obvious symptoms such as a loss of consciousness or seizing.

The notable rise in concussions among the 10-14 and 15-19 age groups in comparison to their younger counterparts was expected. As children age into adolescence and are more than likely encouraged to be participating in sports/physical activity through the influence from many sources such as their peers, parents or the schools, this is also a time where a large difference in body size exists among teammates and opponents, in large part due to puberty.[18] It is likely in sports for a child to be competing alongside someone who could be up to twice their size. Considering the high participation of children and adolescents in fast-paced and contact sports such as hockey and football, a significant difference in size among players can presumably lead to an increase in the rate of sustaining injuries.

The concussion data and trends by sex was expected and further establishes some of the more recent findings in the literature. The literature suggests that the number of females participating in sports is increasing and so are the number of reported concussions.[19] There is also a growing literature that females are reporting a greater number of symptoms associated with concussions, ultimately leading to greater reporting and seeking care from EDs.[20,21]

The concussion data used in this study were gathered within the context of the healthcare system. All of the individuals in our study were treated at a hospital emergency department. The differences noted in this study may be due to detection, access to health care, or differences in rates of concussion. The advantage of NACRS data is that the diagnoses and injury mechanisms are recorded very reliably, and the advantage of emergency department data is that the injuries included are of sufficient severity to be worth preventing. Additionally, routinely collected health care data minimize the possibility for bias resulting from self-reported concussion injuries.

Strengths and limitations

The main strength of this study is the large sample size in part that NACRS collects data from all emergency departments across Ontario, therefore, the data is able to capture in large part all of the testing variables. The primary limitation of this study is that it may be subject to underreporting. The NACRS data stems from emergency department visits, therefore, any youth individuals presenting themselves to a family physician, other health care provider or simply did not seek medical attention for a concussion will not be represented in this study. Additionally, this study does not include Ontario residents who suffered their concussion outside of the province. Secondly, hospitalization is not a direct measure of concussion as their admission into the hospital may be a result of another injury or co-morbid condition in addition to the concussion. Lastly, we could not control for the possibility that children and youth may have suffered several concussions throughout the study's eight year period, thus, they may account for more than one incident.

Conclusions

In conclusion, the higher the income quintile, the more likely a child is to present themselves in an emergency department having suffered a concussion and to be hospitalized from such injury. As the income quintiles decrease so does the risk of suffering a concussion among that population. Other variables leading to an increase in the likelihood of suffering a concussion are being a male and being between the ages of 10-19. Specific injury location data could further explain and could potentially provide greater insight as to why these rates of concussions are occurring amongst income quintiles. Future research should further evaluate the cause of concussion injuries among income quintiles to further investigate if the source of injury differs among the populations.

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Chapter 3: Extended Results

Extended Results

Additional results displayed in Table 1 illustrate that there is a noticeable increase in emergency department visits as the age groups increase. The likelihood of suffering a concussion drastically increases among the 10-14 and 15-19 age groups compared to their younger counterparts. There is also an obvious increase in ED visits for concussions across all age groups from 2008-2015. Males are more likely to seek care for a concussion in an ED than females. However, throughout the course of the study period, both males and females have seen a rise in the rates of suffering a concussion with every passing year.

There was an increase in pediatric concussion hospitalization in all age groups from the beginning of the study in 2008 until the end of 2015, as per Table 2. Similarly to the results from Table 1, males also are more likely to be hospitalized from a concussion than females. However, it should be noted that the rates of hospitalization among females nearly doubled throughout the study's eight year period. It should also be highlighted that in the year 2012 there was a spike in the rate of hospitalizations among all age groups and sexes from previous years before falling anew the following year.

Chapter 4: General Discussion

General Discussion

There were a total of 80,642 children treated for pediatric concussions in Ontario EDs between 2008 and 2015. This study found an increase in ED visits for concussions among all income quintiles, which highlights that concussions are on the rise among the entire population. However, it should be noted that the highest income quintiles are the groups that are presenting themselves to EDs with a concussion at the highest rates. The hospitalizations among income quintiles differ slightly from the aforementioned results. There is more interchanging with regards to the hospitalization results among the income quintiles over the study's eight year period. As found in Figure 2, the three highest income quintiles were among the greatest rates of hospitalization throughout the study with some changes among these income quintiles throughout the years.

Perhaps the most noticeable results of the study are the ED visit rates for concussion by age group. All of the age groups saw a rise in concussion rates from 2008 to 2015. These results are highlighted by the 10-14 and 15-19 age groups which saw a rise from 2082 and 2491 reported concussions in EDs in 2008 to 5622 and 6184 reported in 2015, respectively. These increases among the 10-14 and 15-19 age groups from 2008 to 2015 are an increase of 209% and 206%, respectively over the study's eight year period. The results from Table 2 highlight similar results with regards to hospitalizations among age groups. The 10-14 and 15-19 age groups display much higher rates of hospitalization throughout the study than the 1-4 and 5-9 age groups. The two older age groups while remaining the highest rates among all age groups, saw some interchanging among these hospitalization rates throughout the study.

The results from this study regarding ED visits for pediatric concussion among sex support the overall literature findings. Males consistently displayed higher rates of ED visits for

concussion every year throughout the study. However, females saw a greater rise in concussion rates (110.84 – 455.32) from 2008-2015 than their male counterparts (223.02 – 538.45). The hospitalizations for concussions among sex yielded similar results. Males were consistently and often found to be hospitalized for concussions at twice the rates of females throughout the 8 year study period, as seen in Table 2.

Previous research has found results similar to those displayed in Table 1. Late in childhood and early adolescence is when there seems to be a drastic rise in the number of concussions being suffered.[37] A reason for this sudden rise in concussion rates compared to when in infancy and early childhood may be the children gaining some independence and freedom from the previous constant supervision of their parents or other authority figures. This is also the age period where children begin to develop physically growing in height and weight and the numbers begin to grow in sports registration.[14,16] Some studies suggest that the rise in concussions in these age groups are due to the rise in sports activities becoming available, the increasing competitiveness in youth sports and the increasing intensity of practicing and playing times.[37]

The results displayed for concussion rates among the two sexes also supports the literature. Males are still often found to suffer a greater number of concussions than females, however, female enrollment in sports has been steadily increasing and so are the number of concussions.[43] There seems to be mixed evidence which may suggest when controlling for participation rates in sports that women are at a higher risk for concussion than men.[44] It should also be noted that there is growing literature suggesting that females may be reporting a higher number of symptoms and experiencing greater neurocognitive problems than males following a concussion which may inevitably lead to a greater number in reporting and seeking care.[45-47]

The pediatric concussion hospitalization results from this study are unique in that there exists very little literature on pediatric concussion hospitalization and relatively none stemming from Canada. This seemingly lack of concussion hospitalization research may be because the knowledge regarding concussions and its short-term and long-term effects are continuously growing and being researched. It may also suggest that if hospitalization is occurring there could potentially be an overlap with a more severe pathologic traumatic brain injury or mimic other medical conditions in addition to the concussion itself.[48] Pediatric concussion hospitalization data should be further researched as this can serve as a proxy measure of concussion severity and additional data in the literature could better serve to understand where these severe concussions are occurring and what population may be at a greater risk.

There exists numerous guidelines for the management of concussion from specialty groups which include: sports medicine, neurology, pediatrics and large medical associations and there is a collective agreement across all guidelines that the initial management should include removal from play, physical and cognitive rest and a gradual return to normal activities.[49-51] Zemek[48], state that the incidence of concussions has increased by over 50% in the past decade in Canada and the United States see approximately 250,000 ED visits annually. This demonstrates a vital growing issue that is still seeking a common practice variation among pediatric emergency medicine physicians in the application of physical and cognitive rest recommendations.[48] A barrier to this solution may be the lack of concussion specialists that exist in Canada. A study by Zemek[48] that reported on pediatric emergency medicine physicians from across Canada found that only 18% of physicians were frequently or always referring their patients to concussion specialists (sports medicine specialists and neurologists) and that some physicians never refer their patients due to a lack of concussion specialists in their region.

As with all studies some limitations exist. The current study collected data from emergency departments all across Ontario through NACRS, however, not all ED visits were reported correctly therefore there is some data that was excluded from the study as the income quintile for some individuals throughout the eight year study period were missing. The literature surrounding pediatric concussion suggests that the commonplace of injury occurs through sport participation, however, future research should include the location of injury to further evaluate high risk areas of pediatric concussion.

In conclusion, the results of this study may lend to present a lack of data with regards to income quintiles and pediatric concussion. It may also serve as additional data for the pediatric concussion literature with regards to age group and gender differences. As the first known study to evaluate pediatric concussion among income quintiles, this current study should allow future research to further evaluate the differences among income quintiles and the factors these differences may have on the incidence of concussions or injuries in general.

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Figure 1: ED Visit Rates for Pediatric Concussion by Income Quintile in Ontario, 2008-2015

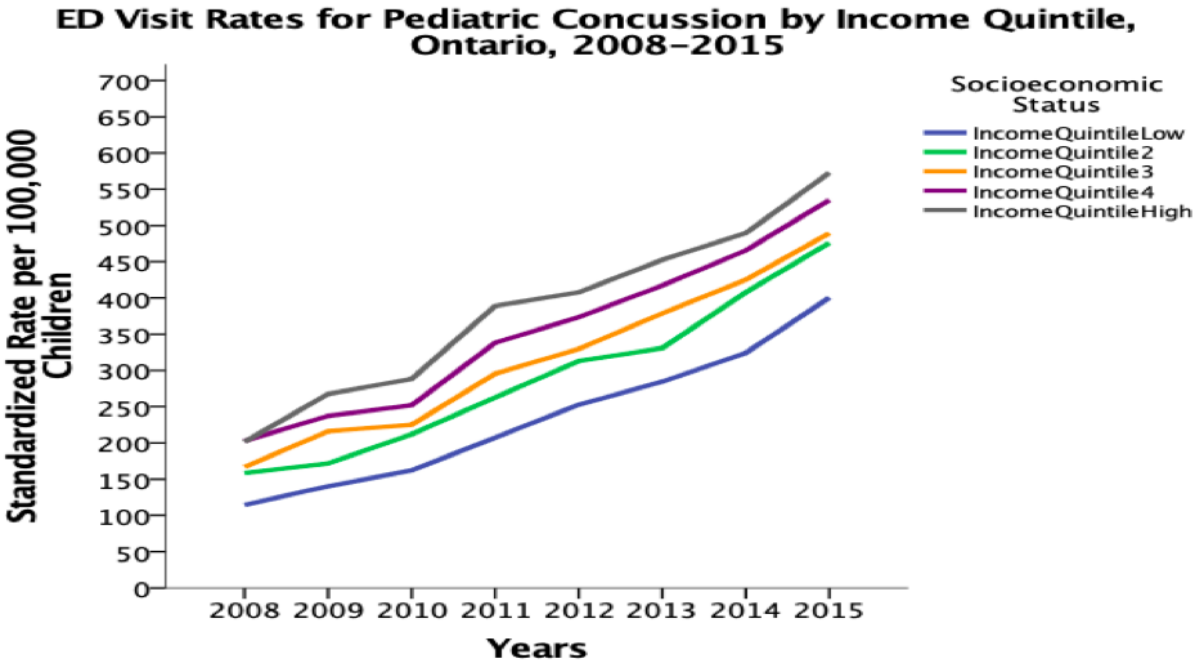

Figure 2: Hospitalization Rates for Pediatric Concussions by Income Quintile in Ontario, 2008-2015

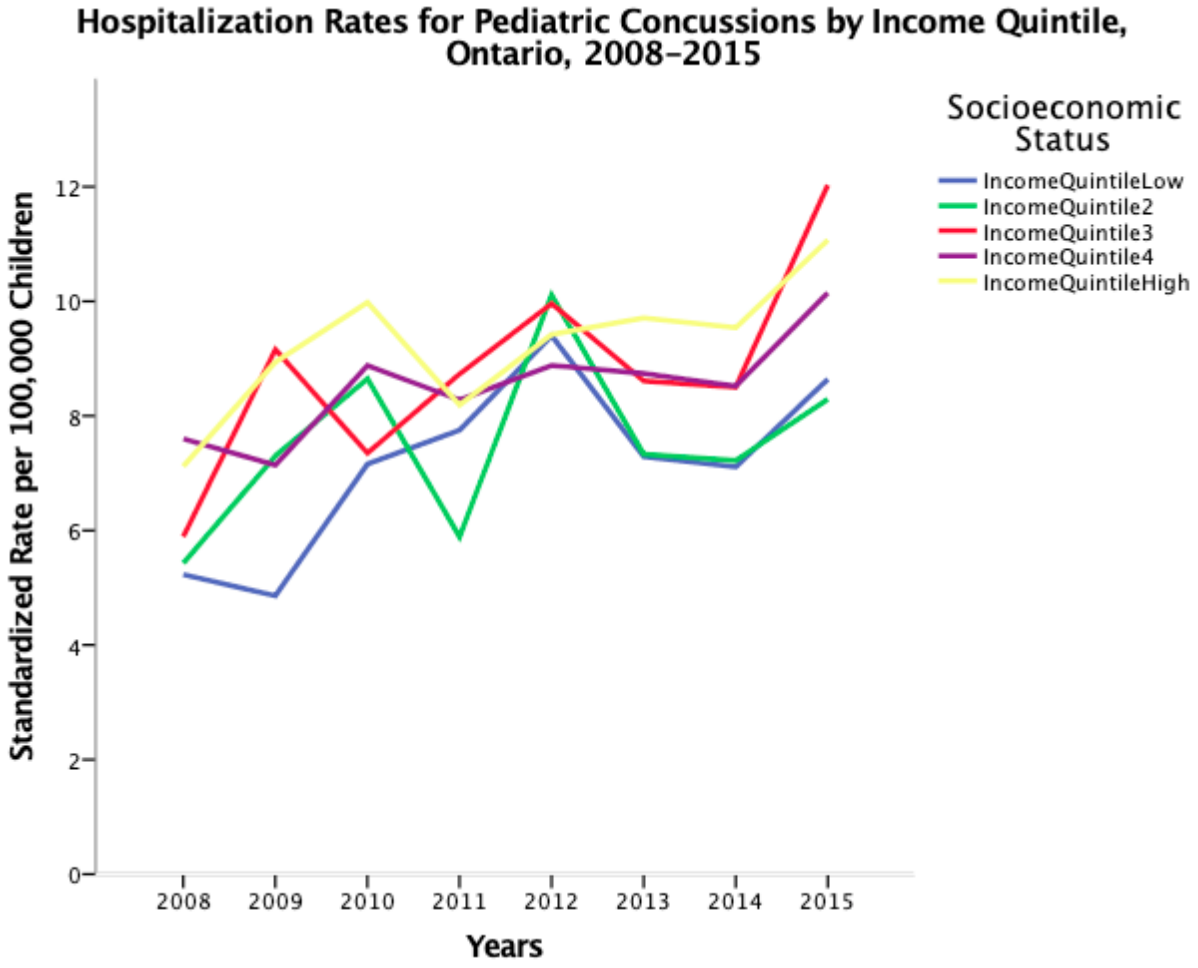

Figure 3: ED Visit Rates for Pediatric Concussion by Age in Ontario, 2008-2015

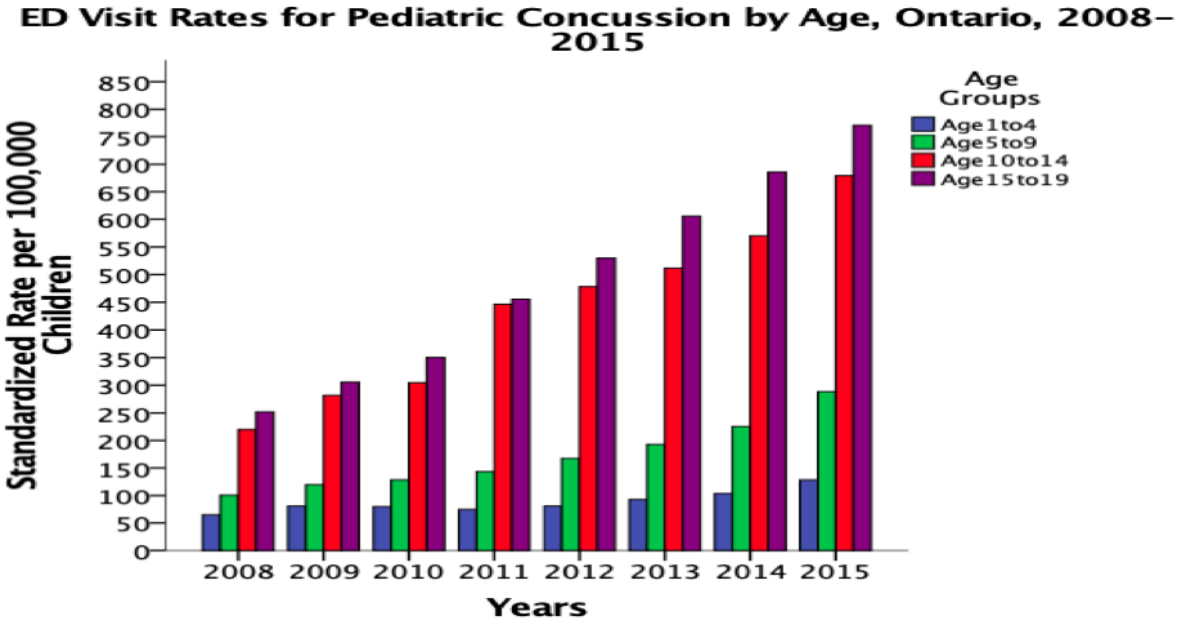

Figure 4: ED visit rates for Pediatric Concussion by sex in Ontario, 2008-2015

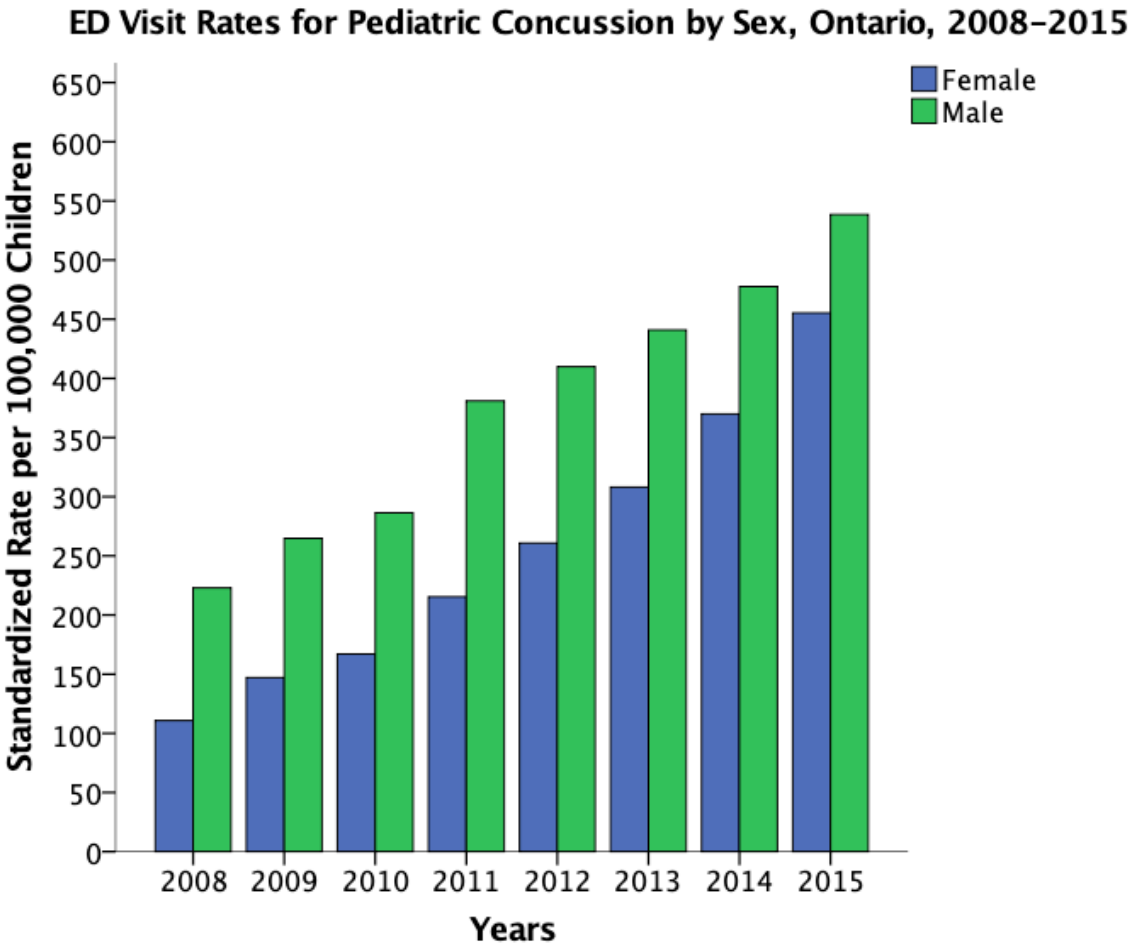

Table 1

Standardized rates of emergency department visits for pediatric concussion in Ontario per 100,000 (annual average) years 2008-2015

	Rates per 100000							
	2008	2009	2010	2011	2012	2013	2014	2015
Age Group								
1-4	64.98	80.63	79.29	74.33	80.69	94.42	103.42	128.32
5-9	100.67	119.59	128.33	143.05	167.44	192.90	225.18	288.54
10-14	219.81	281.62	304.56	446.47	478.09	511.61	570.18	679.10
15-19	251.84	305.44	349.98	455.53	529.63	605.66	686.07	771.06
Sex								
Male	223.02	264.81	286.43	380.97	409.90	440.92	477.68	538.45
Female	110.84	147.03	167.11	215.45	260.81	308.19	369.87	455.32

Table 2

Standardized rates of hospitalizations for pediatric concussion in Ontario per 100,000 (annual average) years 2008-2015

	Rates per 100000							
	2008	2009	2010	2011	2012	2013	2014	2015
Age Group								
1-4	6.15	8.09	7.94	5.58	8.42	6.88	8.49	8.74
5-9	6.29	6.82	4.70	5.32	8.21	6.13	5.66	9.67
10-14	7.18	8.79	10.16	9.63	11.82	10.24	9.83	11.35
15-19	6.38	6.72	10.61	9.97	10.14	9.93	9.02	11.03
Sex								
Male	8.54	9.80	10.99	10.18	12.37	10.29	10.47	12.80
Female	3.99	5.04	5.72	5.31	6.64	6.41	5.98	7.42