PHYSICAL FIGHTING AND FIGHTING-RELATED INJURIES IN CANADIAN ADOLESCENTS: A DEMOGRAPHIC ANALYSIS AND ASSESSMENT OF THE EFFECTS OF FAMILY AFFLUENCE

by

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Abstract

Background: Physical fighting is a concerning behaviour among adolescents and can lead to injury. Family affluence can influence adolescent injury, but its impact on injury has not been extensively explored in a fighting context.

Objectives:1) To describe the prevalence and trends of physical fighting and fighting-related injury in Canadian adolescents over time, 2) to examine the association between family affluence and the outcomes of physical fighting and fighting-related injury.

Methods: *Manuscript 1*. Canadian data from cycles 2-6 of the Health Behaviour in School-aged Children (HBSC) Study were used (N=61,465 grade 6-10 students). Cross-tabulations were used to calculate proportions and risk estimates by sex, grade, and self-perceived affluence. A trend analysis was conducted across time cycles.

Manuscript 2. HBSC data from 2009/2010 were used (N=26,078). Poisson regression was performed to compare the risk of physical fighting and fighting-related injury at different affluence levels. Three affluence indicators were used: self-perceived affluence, family affluence scale (FAS), and area-level average household income.

Results: *Manuscript 1*. A significant change was observed over time for physical fighting (P_{trend}=0.015) and fighting-related injury overall (P_{trend}<0.001). Although for fighting especially, more time-points are necessary to confidently determine the extent and direction of trend. Males were twice as likely to report both outcomes compared to females (p=0.001-0.044). There was a decreased risk of fight involvement from lower to higher grades (p_{trend}<0.001), but an increased risk for fighting-related injury with increasing grades (p_{trend}=0.001-0.261). Decreased affluence was associated with a higher risk of both outcomes (p_{trend}=0.001-0.913).

Manuscript 2. Patterns were generally similar in all three measurements, although the gradient strength varied for each measure. Self-perceived affluence showed a stronger inverse gradient in girls than boys. FAS showed a similar inverse gradient within females, and low FAS greatly

influenced both outcomes in males. Area-level income only presented a significantly higher likelihood for fighting in females (low RR=1.26, 95% CI: 1.08-1.46), and insignificant associations with fighting-related injury.

Conclusion: Physical fighting and fighting-related injury have changed over time. Specific subgroups, especially those of lower affluence, are at higher risk for both outcomes. The strength of the association varied depending on which affluence measurement was used.

Co-Authorship

This thesis presents the work of Maya Djerboua done in collaboration with supervisors Dr. Colleen Davison and Dr. Bingshu Chen. The idea of assessing physical fighting and injuries related to fighting among Canadian adolescents and the use of multiple family affluence indicators was developed collaboratively by Dr. Davison and Maya Djerboua.

The data used in thesis came from the Canadian Health Behaviour in School-aged Children (HBSC) Study. The HBSC data is coordinated by Matthew King of the Social Program Evaluation Group at Queen's University. The principal investigators of the Canadian study were Dr. William Pickett and Dr. John Freeman.

The statistical analyses, interpretation of the results, and writing of the thesis chapters were performed by Maya Djerboua, with frequent guidance and extensive feedback from Dr. Davison and Dr. Chen.

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List of Abbreviations

AIC – Akaike Information Criterion

CDC – Center for Disease Control

CI – Confidence Interval

FAS – Family Affluence Scale

GEE – Generalized Estimating Equations

HBSC – Health Behaviour in School-aged Children

ICC – Intra-class Correlation

QIC – Quasi-likelihood under the Independence model Criterion

RR – Relative Risk

SES – Socioeconomic Status

UNICEF – United Nations Children's Fund

WHO - World Health Organization

Chapter 1

Introduction

1.1 General Overview

Violence has become a growing concern in many countries and a significant public health issue in Canada and worldwide, especially within young people (1). Violent behaviours are problematic since they have the potential to cause detrimental health problems within adolescents who are still developing mentally and physically. These health issues include emotional health problems (e.g., trauma, stress, depression), issues with peer and social interactions (1), injury, disability, and even death (2, 3). One of the most common manifestations of youth violence is physical fighting (1, 2), where approximately one third of grade 9-12 students reported participating in at least one fight in the past year (4). The high prevalence of physical fighting among young people is problematic and concerning, and violent behaviours occur disproportionately in adolescents compared to other age groups.

Injury is a burdensome health problem in adolescents and is the most common reason for hospitalization, death, and disability within this age group (5-7). Physical fighting is a common cause of injury (7, 8), and injuries that are a result of fighting have been associated with a lower overall quality of life (7).

Numerous risk factors have been linked to physical fighting and injuries associated with fighting. One of the most important factors is family affluence. The level of affluence of a young person's family is related to family wealth, income, and expenditure. It is part of a larger construct called socioeconomic status (SES) which refers to an individual's level of wealth, income, education and position in society (9). Family affluence can affect health at various levels. At the area level, affluence can be measured by average family income in a neighbourhood, for example, and can be an indicator of availability and access to infrastructure and other resources required to

maintain and improve health (10, 11). While the evidence is inconsistent, recent studies on adolescent injury indicate that there are socioeconomic variations in injury occurrence and these variations differ by injury type (3, 12, 13). There is a lack of evidential support that specifically assesses the relationship between family affluence and fighting-related injury. The impact that fighting-related injury would have on the health system and quality of life of adolescents makes this an important health issue to address. As a result, health researchers have provided recommendations for future research to contribute additional evidence examining the relationship between family affluence and context-specific injuries such as those sustained in physical fights (12).

Previous studies have used a variety of family affluence and SES measures. This may be due to the conceptual and methodological difficulties associated with measuring this construct (11, 12, 14, 15). One of the most important data sources for measuring family affluence would be parental or guardian income (14), however it is difficult to collect this information from adolescents since they either do not know their parent's income or are not willing to divulge this information which in turn results in non-response (14). In light of these limitations, other measures have been used including using area-level measures of family income from census data, asking young people their perceived level of affluence (i.e., how well of do you feel your family is?) and measuring their possession of specific material goods that may indicate wealth (i.e., specific technologies, vehicles, etc). It is not clear whether each of these approaches results in the same or different information about the affluence of Canadian young people in a current context.

There is a necessity for research that focuses exclusively on physical fighting and fighting-related injuries in Canada, that assesses the trends of these outcomes over time, and that examines and compares their relationship using multiple measurements of family affluence.

1.2 Thesis Focus

This thesis aims to examine the association between family affluence (the main health determinant in this study) and two outcomes in Canadian young people: engagement in physical fighting and sustaining a fighting-related injury. This thesis is divided into two manuscripts. The first manuscript describes physical fighting and fighting-related injury by family affluence, as well as by general demographic characteristics such as sex and grade between 1993 and 2010. The aim is to determine if each outcome has significantly changed overall and within specific subgroups over time. This manuscript will also address conceptual factors that can provide a narrative in order to understand the reasoning behind the circumstances of school-aged children who participate in physical fights and who are receiving injuries. Data will be reported for who was involved in the fight, where and when the injury took place, and whether the injury required treatment.

The second manuscript further examines the association between family affluence and the outcomes of physical fighting and fighting-related injury. This manuscript addresses the limitations and recommendations of prior studies and considers multiple methods for measuring family affluence and also adjustment for additional risk factors in a multi-level, multivariate regression analysis (Figure 1.1). Both of these manuscripts are linked conceptually by the outcomes of physical fighting and injuries related to fighting.

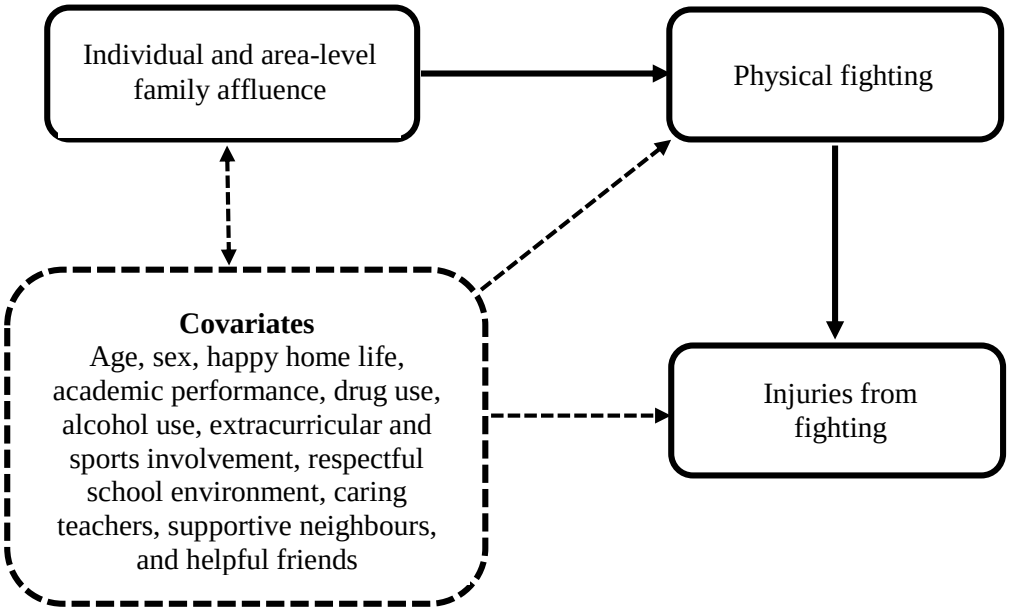

Figure 1.1 Conceptual framework for manuscript two - the association between family affluence and the outcomes of physical fighting and injuries from fighting.

1.3 Scientific Importance

The World Health Organization (WHO) and United Nations Children's Fund (UNICEF) have recently issued a call for a greater global effort to prevent child and youth injury, as it, along with violence, is one of the leading causes of death and disability among youth worldwide (5). There is a general lack of Canadian studies that examine in particular the risk factors and time trends for physical fighting and injury related to fighting. Family affluence is seen to be a very important risk factor since poverty and wealth have been repeatedly shown to influence various aspects of adult, child and adolescent health including mortality, morbidity, psychosomatic and somatic health, and self-perceived overall health (7, 16, 17). While there is evidence in other countries linking family affluence and adolescent injury (18, 19), there is very little information on the influence of family affluence on injuries specifically related to physical fighting. Few studies also compare multiple measurements of family affluence. There is a necessity for additional research that implements and compares multiple measures of family wealth in order to see if they reach similar conclusions.

1.4 Public Health Importance

Physical fighting is a prevalent and violent behaviour with a profound impact worldwide. It warrants public health attention and action. Furthermore, physical fighting, violent behaviours, and injuries related to these behaviours are largely preventable, and employing public health interventions can help reduce the prevalence of these outcomes in the future. According to UNICEF, every child has the right to a safe environment (8, 20), and this research can be further utilized and implemented to guarantee the safety of young people at the policy and community level.

In addition to informing public health intervention and policy development, this study can also contribute to the literature that focuses specifically on poverty and adolescent health, which is a much larger field of research. Adolescence is a period of physical and emotional growth in young people, and adolescents are especially sensitive to environmental and contextual factors that can impact their health behaviour. Addressing these factors at a young age through the development of health and social programs can help promote positive health behaviours, healthy environments and the reduction of risk for harm and injury.

1.5 Study Purpose and Population

The purpose of this study is to investigate the prevalence and patterns of physical fighting and fighting-related injuries among young Canadians. This research will utilize data from the Health Behaviour in School-aged Children (HBSC) study, which is a nationally representative survey among 11-15 year olds. The first analysis will include information from Canadian HBSC datasets from 1993 to 2010 to establish and assess time trends for the two outcomes. The total study sample is 61,465 students (6). Only data from the five most recent HBSC datasets were used because no information on the variables of interest were available in the first HBSC cycle. The second analysis will include cross-sectional data from the most recent 2009/2010 HBSC study, with a total sample of 26,078 students from 436 schools (6, 8).

1.6 Thesis Organization

This thesis conforms to the requirements and recommendations for manuscript-based theses outlined in the Queen's School of Graduate Studies "General Forms of Theses" (21). This chapter provides a general overview and outline of this thesis. The second chapter is a summary and detailed review of the literature that encompasses adolescent injury and violent behaviours particularly physical fighting, and the determinants and risk factors that impact fighting and fighting-related injury, especially family affluence. The specific overall study aims, objectives and hypotheses are provided at the end of chapter two. The third chapter is the first manuscript, which is a descriptive analysis that examines the patterns and time trends of physical fighting and fighting-related injuries within Canadian youth between 1993 and 2010. The fourth chapter is the second manuscript which assesses the relationship between family affluence and physical fighting and fighting-related injury using multi-level, multivariate etiological analyses and three measures for family affluence or income. The fifth and final chapter of this thesis is a general discussion of the findings, including a summary and interpretation of the results applying epidemiological concepts, strengths and limitation, public health implications, future directions, and conclusions. An appendix containing further information on the HBSC survey methodology, key variables, and power calculations has also been provided for additional reference.

1.7 References

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Chapter 2

Literature Review

2.1 General Overview

The purpose of this chapter is to discuss and summarize the literature surrounding physical fighting and injuries related to fighting. This literature review begins with a broad examination of physical fighting as a public health issue within the adolescent age group. It then proceeds to examine how physical fighting and fighting-related injury are inherently linked and the literature that assesses the association between both outcomes. Risk factors for both physical fighting and fighting-related injuries are then discussed with an emphasis on family affluence, wealth, or SES. Gaps and limitations that need to be addressed in future research are also discussed and the rationale for this thesis is provided. This chapter concludes with the objectives and hypotheses for this thesis.

The relevant literature was identified using key terms in PubMed, Medline, and Google Scholar. Key terms that were used to represent the population of interest included: "adolescent", "children" and "youth". The key words for the health outcomes of interest were "injury", "fighting", "physical fighting", "fighting-related injury", "violence", "violent injury", "assault injury", and "interpersonal violence". Key words used to detect literature that discussed the main exposure or determinant of interest included: "socioeconomic status", "family affluence", "poverty", "wealth", and "income". Few MeSH (Medical Sub Headings) terms exist that pertain to the research that is of interest for this review. MeSH terms that were identified for PubMed searches included: "wound and injuries", "adolescent", and "social class". Various combinations of these key terms were employed in each search engine to obtain the most appropriate literature possible. All dates of publication were considered, but studies were limited by language (English). The reference lists in the most relevant studies were also examined to obtain additional literature.

2.2 Key Definitions

For the purpose of this thesis, *physical fighting* is defined as a manifestation of interpersonal violence in which at least one person out of two or more individuals uses physical force or power with the intent to harm (1,2). *Injury* refers to any physical harm to the body (3). Injuries are typically caused "when a human body is subjected to energy that exceeds the threshold of physiological tolerance or results in lack of one or more vital elements, such as oxygen"(4). *Fighting-related injury* considers both of the definitions of physical fighting and injury to create a variable that identifies injuries that are a result of physical fighting encounters. Other terms used in the literature that relates to fighting-related injury include violent injury (3), assault injury (1), and injury that is the result of interpersonal violence (5–7). These have been assessed to be broader terms than "fighting-related injury", and may encompass other types of injury that manifest from other violent encounters such as weapon injuries, domestic abuse, and sexual assault. Additionally, "assault" is a term with legal implications where it is defined as an "unlawful physical attack or a threat of attack" (8). Physical fights among adolescents do not always occur in the context of a criminal assault involving a victim and a perpetrator (8). Despite previous statistics showing that the patterns of physical fighting among young people are consistent with non-fatal assaults (8), it is important to distinguish between the two behaviours as their contexts and circumstances vary. The term *fighting-related injuries* will be used throughout this thesis to refer specifically to injuries caused by physical fighting.

Family affluence is the key exposure of interest that will be referred to through this study. Similar terms for this concept found in the literature include family "income", "wealth", and "poverty". *Socioeconomic status (SES)* is also a related concept. *SES* refers to an individual's "social and economic position in society and is established by using measures of income, wealth, occupation, or education level" (9,10). It is a complex and multidimensional construct that can be measured at multiple levels. This thesis focuses only on the wealth or income aspect of this construct and is referred to as an individual's level of family affluence.

The research seen in this thesis focuses on school-aged individuals (11 to 15 years of age) in Canada who are primarily in grades 6 to10, and terms such as “adolescents”, “youth”, “young people”, and “students” will be used interchangeably throughout this thesis to refer to this particular age group.

2.3 Physical Fighting as a Public Health Issue in Canada

Interpersonal violence among young people has become an increasing concern worldwide and within Canada (11). It is a behaviour that has largely always been part of the human experience, and it is a behaviour that can manifest in various forms, including weapon use, physical conflict, and sexual assault (7). Its impact on the general population can be devastating, as each year over a million people suffer from non-fatal injuries related to interpersonal or collective violence (7). It is also one of the leading causes of death among individuals aged 15-44 (7).

One of the most common exhibitions of interpersonal violence is physical fighting. Physical fighting is an assaultive behaviour that is a significant public health issue worldwide since it increases risk for injury and is also a marker for multiple problem behaviours such as delinquency and antisocial actions (12,13). In addition, physical fighting can be a precursor for more serious violent behaviours such as homicide (14), and can affect emotional well-being through lower life satisfaction, poorer relationships, and worse perceptions of physical and social environments (11). Physical fighting has also been shown to cause emotional health problems in adolescents consistently across countries (15) and has been reported to be associated with an increased risk for adverse health outcomes such as mental health disorders, substance use, and risky sexual practices (2). It has also recently been shown that injuries obtained from fighting can also cause a significant reduction in intelligence and cognitive function among adolescents (16).

2.4 Physical Fighting in the Adolescent Population

Adolescence refers to the developmental period from the onset of puberty to near adulthood. It is a developmental period that is of particular interest in health research due to the physical and emotional changes that are associated with maturation, such as increased autonomy and decision-making, less geographical restrictions, and the development of friendships and networks which may influence health and health-related behaviours that can extend into adulthood (17–20). Adolescent health is also relevant in the context of physical fighting since fighting is viewed as a moderately common behaviour among teenagers (21). Adolescents reportedly engage disproportionately in violent behaviours compared to all other age groups (14), and violence perpetration peaks during the adolescent and young adult years (1). Adolescents appear to be an important target age group when employing interventions to reduce physical fight occurrences.

2.5 Physical Fighting and Fighting-Related Injuries

Injuries that are a result of fighting are seen to be an important public health issue. Injuries are a unique phenomenon when assessing health conditions since they are acute in nature, and are also externally caused, which implies that physical, social and environmental factors are relevant and large contributors to injury risk (22). This means that adjustments to these environments can make injuries preventable.

As would be expected, previous studies demonstrate that physical fighting is significantly associated with fighting injuries in adolescents. For example, Wagman Borowsky and Ireland studied a nationally representative school-based sample of young people and determined that students who participated in physical fights were more likely to report a fighting-related injury than those who did not engage in fights with a relative risk (RR) of 7.2 for girls (95% CI: 5.35 to 9.73) and 3.2 for boys (95% CI: 2.59 to 4.04) (23). Other significant factors for fighting-related injury from this study included a history of violent injury (RR=6.6, 95% CI: 4.91-8.88 for girls; and RR=3.3, 95% CI: 2.70-4.11 for boys) and being victims or witnesses of violent encounters (RR=4.4,

95% CI: 3.33-5.76 for girls; and RR=3.3, 95% CI: 2.71-4.06 for boys) (23). Separate relative risks were reported for boys and girls since more boys than girls reported one or more fighting-related injuries in the past year (5.8% versus 2.7%) (23). More detail about these additional risk factors will be covered later in this review. Buckley, Chapman and Sheehan (2012) also reported similar associations in a sample of 13-14 year old Australian students, mentioning that the odds of reporting an injury (medically treated or not) was associated with those who perpetrated violence such as getting into fights, using a weapon, or deliberately hurting someone else (OR=1.6, 95% CI: 1.03-2.52) (24). Hammig, Dahlberg and Swahn stated similar findings in a representative sample of American males in grades 7-12 where students who participated more frequently in group fights (a variable used in measures of fighting-related behaviours) had two times higher odds of obtaining a fighting-related injury than those who never fought (OR=2.08, 95% CI: 1.3-3.3) (25). This relationship where a higher frequency of physical fight participation was associated with increased odds of a fighting-related injury was also reported by Lowry and colleagues where adolescents who fought four or more times were more likely to report an injury caused by a fight than those who fought less frequently (14.9% vs 6.4%), or among adolescents who fought, as the number of fights increased, the odds of being injured from fighting increased (OR=1.12, 95% CI: 1.09-1.16). Physical fighting is demonstrated to be significantly associated with a greater likelihood for multiple or repeated fighting injury events that required medical treatment, and this association was seen consistently across many countries (26). It is important to emphasize though that these studies do not necessarily present physical fight participation as a risk factor that inevitably causes injury, but rather that those who participate in physical fights are also predisposed to report a fighting-related injury.

Among Canadian students ages 11 to 15, approximately 7.2% of male and 3.6% of female students reported a medically treated injury as a result of a physical fight in the past 12 months (27). This is consistent with the findings published by the Center for Disease Control (CDC) who reported that approximately 3.9% of grade 9-12 students in the United States have been in a physical

fight at least once in the past 12 months that resulted in a medically treated injury (28). The prevalence of injuries that resulted from fighting was also reported to be higher in males (5.1%) than females (2.6%) according to the CDC (28).

Fighting is the fifth most common cause of injury in Canada (preceded by sports, walking or running, biking, and skating), and the third most common cause of injury that is most likely to lead to medical treatment (such as the placement of a cast, stitches, or overnight admission in the hospital) (9). Fighting-related injuries are preceded only by automobile or cycling-related injuries in the prevalence of serious injury requiring medical treatment (9). This is important because serious injuries take longer to recover from and may have significant repercussions on a young person's quality of life and their overall long-term physical and emotional health (29).Young people who were treated for a fighting-related injury are also commonly readmitted to hospitals for recurring events or physical fight encounters. It is reported that 44% of youth aged 10 to 24 in the United States who have been admitted for a fighting-related injury are readmitted due to another physical assault or fight (30). Furthermore, a study by Cheng and colleagues (2006) reported that nearly half of the assault-injured patients aged 12 to 19 admitted into the study had reported two or more fights in the past year, and 64% had received treatment for another assault injury in the same year (31).

2.6 Trends of Physical Fighting and Fighting-Related Injury Over Time

Several studies worldwide have examined the temporal trends of physical fighting and other violent behaviours, but almost none have examined the trends of fighting-related injury over time.

Olsen and colleagues (2011) found that the prevalence of physical fighting one or more times in grade 9-12 American adolescents showed a significant linear decrease overall from 1999 to 2009 (32). It was also remarked that substantial work remains in reducing unintentional and

violent injuries among youth. Similar findings were recently found by Perlus and colleagues (2014) who noted that when assessing a nationally representative sample of grade 6 to 10 students, there was a significant linear decline in overall physical fight prevalence from 23.5% in 1998 to 18.8% in 2010 ($p<0.001$) along with a significant quadratic decrease where the majority of the decline occurred from 1998 to 2006 ($p<0.05$) (33).

A recently published international study by Pickett et al (2013) noted that in general, physical fighting in many countries (including Canada) has decreased from 2002 to 2010, although it is worth noting that this study assessed frequent physical fighting (3 or more fights in the past 12 months) as opposed to any physical fights (11).

Further research by Cheng, Wright, Fields and colleagues (2000) showed that when assessing injury trends over time by cause in 10 to 19 year old American adolescents, it was seen that assault injuries decreased linearly over time from 1996 to 1998 ($p=0.0047$), and particularly unarmed assault injuries decreased over time although this remained insignificant ($p=0.85$) (20). This is one of the few pieces in the literature that examines the trends of fighting or violence-based injuries, however the time period for this particular article is only two years which does not allow for assessment of long-term changes.

While studies state that the rates of physical fighting have reportedly declined over the past several years, rates remain significantly high enough to warrant public health action. For instance, while the prevalence of American students in grades 9-12 participating in at least one physical fight in the past year has decreased over time from 43% in 1991 to 33 % in 2011, a remaining third of students still engaged in physical fighting each year and this is problematic (34).

Furthermore, although many studies have tried examining the trends of many youth violence behaviours, much of the information that is available contain limitations that do not allow these statistics to be applicable to Canada. There is a necessity for research within Canada that is recent, nationally representative and also assesses trends within subgroups.

2.7 Risk Factors for Physical Fighting and Fighting-Related Injury

Previous studies have identified a number of risk factors among young people who participate in physical fighting or have experienced fighting-related injuries. These risk factors include: male sex (1,31,34–36), younger adolescent age (12,34), non-Caucasian races (1,34,37) and low individual family income (1,12,34). It is also important to consider the individual, family, neighbourhood and school effects that can influence the risk for engagement in physical fighting and fighting-related injury (38). Family factors include familial dysfunction or low parental support (1,34,39), inadequate parental or neighbourhood monitoring (1,34,37), and lower educational level of the young person and their caretakers (1). Neighbourhood characteristics such as the level of crime and quality of housing can also potentially impact the likelihood of physical fighting and injury (11,38,40,41). School-related factors such as school connectedness (1,42), relationship and perceptions of teachers (43), and academic performance (23) may be important to consider as well. Peer influence is also an important construct to consider (44). It has also been suggested that physical fighting injuries seem to reoccur among those who have previously been assaulted or have fought (1,3), and that risk-taking behaviours such as smoking, drinking alcohol or using drugs are also positively associated with increased risk for violent and assaultive injuries (1,3,34,45–47). Factors related to time use such as school sponsored extracurricular activities, sports teams, and neighbourhood youth groups can also be important to consider (43). These risk factors will be described in more detail throughout this section. Family affluence is the primary risk factor of interest, and will be further discussed at the end of this section.

2.7.1 Age, Sex, and Ethnicity

Age, sex, and ethnicity have all been shown to be to be significantly associated with physical fighting and fighting-related injury (48). A strong gender disparity has been observed in numerous studies (31,48,49). For example, Walsh and colleagues (2013) found the prevalence of physical fighting to be more frequent among males compared to females (34.5% vs 20.7% for

infrequent physical fighting (1 to 2 times), and 18.8% vs 10% for frequent physical fighting (3 or more times)) (15). Community violence was more commonly experienced by older children than younger children, but this relationship was also inconsistent across many studies (50). Many studies have reported that ethnicity is closely associated with physical fighting and violent behaviours where racial minorities such as African-American or Hispanic adolescents are more likely to participate in physical fights than Caucasian adolescents (36). Studies believe though that this is not because of biological or racial differences, but rather that the variations are because of socioeconomic environment, where racial minorities are more likely to be socioeconomically disadvantaged and live in structurally or financially deprived neighbourhoods (36).

2.7.2 Family Support

Family support is a factor that can influence the likelihood of an adolescent's involvement in physical fighting behaviour since a lack of a strong and supportive relationship with parents, teachers, and peers can also mean not having a source of protection or an appropriate way to find relief from violence (43,51). This can be distressful for adolescents and negatively impact their mental health and socialization skills, and lead to repeated offenses (43,51). Family environment has an important influence on the development and behavioural preferences of young people, and strong family ties can lead to more effective and frequent supervision, guidance, and monitoring, and also reduce the likelihood of violent behaviours such as fighting or carrying a weapon (2,43,52).

2.7.3 Neighbourhood Characteristics

Neighbourhoods with higher criminal activity and less recreational facilities with organized activities are reported to increase young peoples' exposure to and likelihood of violent activities (11,38,40,41,53). It is an important aspect to consider since neighbourhood structure and cohesiveness act as a buffer for social and psychological factors that influence one's likelihood of participating in violent behaviours (54).

2.7.4 School Factors

Adolescents spend the majority of their time in a school environment and are influenced by factors related to school. School connectedness or school engagement is described as the extent to which students feel included, supported, and engaged within the school and by the school community. It is a construct that can be protective against violent activities and injuries (1,42). Academic performance is an individual-level factor that is related to school, and high grade point average was found to be protective against fight-related injuries (OR=0.52, 95% CI: 0.29-0.95) (23).

2.7.5 Peer Influence

Peer influence is strong during adolescence, and plays a central role in mediating deviant and pro-social behaviours which may inform social norms and dictate the use of violence (7,44). Evidence suggests that students from lower socioeconomic groups are more drawn to and susceptible to peer influence (37). Adolescents are also more likely to participate in violent behaviours if they have previously been exposed to violence regardless of the source (family or otherwise) (23). This means that if an adolescent has been exposed to violence among their peers, and it is perceived to be acceptable, then that person may be more likely to engage in violent behaviours. Peer influence can also influence the likelihood of engaging in a fight regardless of whether it is in a school or neighbourhood setting (44).

2.7.6 Risk-Taking Behaviours

Risk-taking behaviours include, for instance, drug and alcohol use, impaired driving, violent behaviours and risky sexual practices. Jessor and Jessor's Problem Behaviour Theory proposes that a number of risk-taking behaviours are all interrelated and that they are all reflected by one underlying component related to their personality and social environment (24,55). Other risk-taking behaviours such as weapon carrying, binge drinking, and drug use have all been noted to be positively associated with physical fighting (48). Other risk-taking behaviours such as

gambling have been shown to be significantly associated with physical fighting (56). Risk behaviours have also been seen to be related to injury and not just physical fighting (27,46).

2.7.7 Extracurricular Activities and Sports Participation

Factors related to time use can also be important risk factors to consider for fighting-related injury. These include school sponsored extracurricular activities, neighbourhood youth groups, or sports teams, which can leave less available time for unstructured or unorganized activities involving deviant behaviours which can increase the likelihood of violence (43).

2.7.8 Family Affluence (Main Exposure)

Family affluence is a component of a larger construct called socioeconomic status (SES), which refers to an individual's social and economic position in society and is established by using measures of income, wealth, occupation, or education level (9,10). SES is a multidimensional construct that takes into consideration many social health determinants, can be measured at multiple levels besides the individual (such as family or neighbourhood), and can vary or change depending on the time point in an individual's lifespan (40). For instance, SES and its implications in early or later childhood can be dramatically different from the experience and influence of SES in adulthood (57).

SES is a health determinant of particular interest in child and adolescent health due to the fact that it is a construct that underlies many other social determinants that can influence health outcomes. There is a large body of literature that establishes that there is a profound gradient relationship between SES and physical health, whether it be self-perceptions of one's health or objective outcomes such as mortality or injury (39,41,58,59). Education level is one aspect of SES, and having a higher level of education can allow more access to knowledge about the benefits and risks of certain health behaviours. At an individual level, lack of education about risk-taking behaviours (such as drinking, smoking, drug use, violent behaviours, risky sexual practices, and risky driving (24,46,47)) can increase an individual's likelihood of accident or injury. This review

will focus on income or wealth as another aspect of SES. A young person's level of affluence is largely predicted by the affluence of their family. Family affluence as a risk factor for violent encounters and injuries related to physical fighting is a major theme of this thesis.

2.8 Impact of Family Affluence on Adolescent Health and Any Injury

Family affluence is an important aspect of SES in regards to injury and violence. At an individual or family level, the stresses of poverty and time required to search for employment or secure the essentials for daily living may lead to lack of parental support or supervision of children which may increase a child or youth's risk for injury (11,22,53). Additionally, poverty and lower affluence can restrict an individual's access to health resources and care, leading to a greater likelihood of more serious morbidity or mortality as a result of injury.

Theories exist on how poverty and neighbourhood-level income can influence the risk of violent encounters. One such theory is social disorganization theory by Shaw and McKay (1969), which suggests that characteristics at the neighbourhood level such as poverty and unsafe residences can weaken levels of social control; this can increase rates of crime and increase the risk for violence and injuries from violence (2,44,60,61). This theory can aid in conceptualizing the relationship between socioeconomic position and physical fighting injury.

At an area or neighbourhood-level, it is believed that low income or disadvantaged neighbourhoods can have increased exposures to hazards due to poor housing, higher density traffic, and more criminal activity which can increase risk of injury, and contrarily less access to resources that can help reduce risk of injury such as fire and police protection, road maintenance, and recreational facilities (11,38,40,41,53). The neighbourhood in which people live may influence various aspects of health (including violent behaviours and injury), depending on the availability and accessibility of health services, food and resource infrastructure, the predominant attitudes towards health, and the amount of stress and social support (62). Detrimental social characteristics at the neighbourhood level can negatively affect health, where for example cumulative violence

exposure in the neighbourhood can be associated with an increased risk gradient for poorer health (37,39). It is also hypothesized that this is because poorer neighbourhoods have lower levels of collective efficacy (the ability of neighbourhoods to implement strategies for monitoring their youth), which can increase the occurrence of community violence and can imply a greater likelihood of health-related outcomes such as injury (2,37,60,63). Therefore, research shows that violence is not randomly distributed in geographical space, but is rather concentrated in areas of disadvantage or residential instability.

There have been many studies conducted in Canada and worldwide that assess the impact of wealth and social position on child and adolescent injury risk and experiences. While family affluence is the main theme of this thesis, literature is also reviewed here that highlights SES as the exposure representing socioeconomic variation. These papers are cited in this section. Some studies have shown significant inverse relationships where lower socioeconomic position implies a higher risk of injury among adolescents. For example, an Australian study by Jolly, Moller and Volkmer (1993) showed a relative risk of 2.97 (95% CI: 2.71-3.25) for injury when comparing the lowest socioeconomic quintile to the highest (64). A Manitoba-based study by Brownell and colleagues (2010) also found that while child injury hospitalizations (ages 0-19) have decreased over time from 1986 to 2006 for all SES groups, SES was a significant predictor of injury hospitalizations where children with lower SES have higher rates of injury ($p<0.0001$), and even more importantly that there was a significant interaction between SES and year where the effect of SES on injury increased over time ($p<0.0001$), which further indicates that the socioeconomic gradient for child injury hospitalizations have changed significantly over time (58). This justifies the importance of studying the effects of affluence on injury in young people as there is substantial evidence that the socioeconomic gradient is worsening over time, and that this type of research could justify the development of interventions to reduce these inequalities. Faelker et al (2000) conducted a study in Kingston, Ontario examining the socioeconomic gradients of injuries treated in emergency departments in young people under 20 years of age, and found that there was a significant linear

trend for low to high SES when evaluating minor and moderate injuries ($p<0.01$) (65). An Alberta-based study by Gilbride et al (2006) found that most types of injury were seen in children (0-17 years) of low socioeconomic position (10).

Since past studies have established that there appear to be social gradients and inequalities in child and adolescent injuries, it has been recommended that future studies focus on the influence of socioeconomic factors on different types of injuries in adolescents (39). In Canada, while there are studies that have looked at the influence of affluence on childhood and adolescent injuries in general, there is limited epidemiological information that assesses the relationship between affluence and particular types or causes of injury, and this is especially true for physical fighting and injuries that are a result of violent encounters (39). The existing studies that examine socioeconomic variation and context-specific adolescent injury are examined in further detail in Section 2.9. Further information in this area can inform child and adolescent injury prevention methods. Previous research that examined the relationship between individual and area-level affluence with injuries indicate that there are socioeconomic patterns, although the nature and mechanism of the relationship is not well understood (40).

2.9 Physical Fighting and Fighting-Related Injuries: Relationship with Family Affluence and SES

Previous studies have suggested that an inverse relationship exists between socioeconomic variation and risk of physical fighting and related injuries. The studies discussed in this section explore various representations of socioeconomic variation, including SES, affluence, wealth, and income. A recent study Pickett and colleagues using data from the international Health Behaviour in School-aged Children Study (HBSC) examined physical fighting trends in 30 different countries and also the relationship that wealth has on physical fighting trends. Findings indicate that higher absolute wealth is associated with a lower likelihood of physical fighting involvement (11). The authors recommend further examination of this relationship and within more country specific

contexts, such as Canada, because differences in perceptions about violence across countries make it challenging to generalize this association. However, an American longitudinal study by Ellickson and McGuigan (2000) followed students from the 7th to 12th grade and discovered that the odds of presenting any violence was not significantly associated with neighbourhood SES (p-value=NS (not significant)) (67).

Studies that have assessed the association between socioeconomic variation and injury have been less conclusive when examining adolescent injuries as a whole, but showed clearer and more significant relationships when injuries were grouped according to cause or type (6,10,18,53,66). In a Canadian sample of 11 to 16 year olds, Simpson and colleagues found that when comparing students from not very well off families to those very well off, there seemed to be an inverse relationship between SES and fighting-related injury where students from less well off families had increased odds of obtaining a fighting injury (OR=2.14, 95% CI: 0.97-4.70), whereas for sports or recreational injuries there seems to be the opposite relationship where students from increasingly more well off families obtain sports injuries (OR=0.86, 95% CI: 0.65-1.14) (53). A Swedish study by Reimers and Laflamme (2007) also found that lower SES was associated with a higher risk of injuries from interpersonal violence in children aged 0-15 (RR=1.19, 95% CI: 0.75-1.88), and the relationship is even stronger for other types of injury such as those that result from cycling (RR=1.31, 95% CI: 1.04-1.67) or motor-vehicle incidents (RR=1.52, 95% CI: 0.93-2.47) (6). On the other hand, risk for fall injuries appear to have the opposite relationship where low SES is not associated with an increased risk of fall injuries (RR=0.94, 95% CI: 0.85-1.04) (6). Interpersonal violence in this case may encompass more than just physical fighting.

Previous studies exist as well that strictly examine the relationship between socioeconomic variation and injuries that result from fighting and other violent encounters. A Swedish study by Engstrom, Diderichsen, and Laflamme showed relative risks of 2-3 where injuries from violence were higher in 10-19 years olds from families of unskilled workers than those from families of high/intermediate skilled employees (68), however it is worth noting that this study refers to injuries

from violent encounters and these may not be exclusive to physical fighting. A study by Mazur and colleagues showed that among those who were injured in a fight, individuals whose families were "not at all well off" reported the highest rates of injury (2.7% in those not at all well off versus 1.6% among those who are "very well off") (69). When adolescent injury was examined by type (such as fighting or sports-related), there were significant associations between fighting injuries and lower levels of SES with high SES as the referent group (OR=2.4-13.05 depending on the individual-level variable used to represent SES) (53). Wagman Borowsky and Ireland studied a nationally representative school-based sample of young people and determined that students who reported having low family SES were significantly more likely to report a fighting-related injury compared to those from families of high SES with a relative risk (RR) of 1.62 for girls (95% CI: 1.21-2.17) and 1.56 for boys (95% CI: 1.27-1.91) (23).

While there are studies outside of Canada that demonstrate a significant relationship between low income and increased risk for fighting and injury, there are also reports that show insignificant results. For example, Meuleners, Lee and Hendrie showed insignificant results when assessing vulnerable SES groups for hospital admissions and repeat admissions in Australia due to interpersonal violence among adolescents aged 11-14 using Cox's proportional hazards regression (Hazard Ratio=1.39 (95% CI: 0.77-2.52) for extremely disadvantaged versus middle, HR=0.87 (95% CI: 0.42-1.79) for extremely disadvantaged versus extremely advantaged) (5). It is important to keep in mind however that this study takes into account interpersonal violence, which can also include weapon use, rape and physical abuse (5), and this may be measured or distributed differently from physical fighting alone (5). The SES measurement in this study was also measured at the area, and not an individual, level. Pickett and colleagues (2005) assessed injuries in 8 countries, and found no consistent association between low material wealth and fighting injuries and it was not statistically significant although the consistency of point estimates suggested the possibility of an association (27). In a representative sample of American males in grades 7-12, Hammig, Dahlberg and Swahn showed that students whose parents received public assistance such

as welfare (to represent poverty) had insignificantly lower odds of receiving a fighting-related injury compared to students whose parents did not receive welfare and were therefore were not considered poor (OR=0.67, 95% CI: 0.4-1.2) (25).

The impact of wealth and affluence on injuries related to fighting or violence was observed in older age groups beyond adolescence. For instance, in a Vancouver-based study by Bell, Schuurman, and Hameed (2009), a social gradient according to individual and neighbourhood level SES was observed when assessing the frequency of severe assault injury hospitalizations in Canadian adults aged 18 and over where individuals of low SES had greater odds of obtaining a severe trauma injury resulting from assault compared to individuals of high SES (individual-level OR= 1.13, 95% CI: 0.70-1.85; neighbourhood-level OR=3.08, 95% CI: 1.81-5.23) (54). This study did not define assault injuries and therefore it is unknown what violent behaviours were included in the data. However, this study did emphasize the importance of the inclusion of neighbourhood-level SES effects, and also accentuated that neighbourhoods are powerful markers of residential stability and community cohesion that can help buffer social and psychological factors that influence violent behaviours.

In addition to further exploring the relationship between socioeconomic variation and injuries that result specifically from fighting, there is also a need for research that uses multiple measures to represent family affluence. For example, Potter and colleagues (2005) studied SES and its relationship with recreational and non-recreational injuries using various measures to represent SES ($p<0.05$) (18,22). Their findings indicated that the use of different SES measurement provides inconsistent results when assessing the relationship between SES and adolescent injury. Previous researchers have also expressed a lack of consensus on how social position should be conceptualized, and how other terms such as social class, SES, and socioeconomic position are exemplified in research (22). Given the complexity of these terms, it is therefore challenging for researchers to discern which of these aspects is most appropriate for adolescent research (22). This

further justifies the focus of this thesis to be on family affluence as a representation of one aspect of SES, and to use multiple indicators to depict the construct of family affluence.

2.10 Summary

In summary, previous studies of physical fighting and fighting-related injuries, and studies of the association between these outcomes and affluence or SES, have largely been international with the patterns and temporal trends not well established in a Canadian context. While international studies have concluded that the trends of violent behaviours have decreased over time, there is necessity for research that assesses the long-term trends of physical fighting and injuries specific to fighting over time within Canada. Additionally, while there are studies that suggest that the direction of this relationship may be consistent across countries (namely lower affluence is associated with a higher prevalence of fighting outcomes and the reverse for higher affluence groups), the *extent* of this association may not be the same or consistent across countries and it is difficult to generalize to Canada due to differences in culture, norms, expectations and perceptions about violence and assault (7). This further justifies the necessity for country-specific research in regards to violence and health. In addition, there has been some inconsistency in previous studies in the findings about the relationship between family affluence and physical fighting and fighting-related injury, and in the way family wealth and fight-related injuries are conceptualized and examined. This further exemplifies the need for more epidemiologic information on this relationship that takes into consideration not only Canadian data, but also examines the way SES and the fighting outcomes are defined and measured.

2.11 Rationale for Thesis

There are studies within Canada that examine the relationship between family affluence and general adolescent injuries. However, there is limited epidemiological information in a Canadian context that is recent, nationally representative, and focuses exclusively on fighting-related injuries. More information regarding the time trends and contexts behind physical fighting

and fighting-related injuries is also necessary. There are also few Canadian studies that assess the socioeconomic variation in the risk of physical fight involvement and fighting-related injury. Furthermore, many previous studies have used a variety of income measures to assess if these wealth measures would reach similar findings. Some authors have recommended using a combination of socioeconomic measurements in efforts to quantify wealth factors that might impact overall injury rates (18). There has been great variability in the observed relationship between SES and injuries when using different SES or family affluence measurements (22).

This thesis will address and contribute new information that previous research has not been able to touch upon. This includes a better understanding of the relationship between family affluence and physical fighting and fighting-related injury within the adolescent age group while utilizing several measurements representing family affluence.

2.12 Objectives and Hypotheses

1. To perform a descriptive analysis of the prevalence and patterns of physical fighting and fighting-related injuries by sex, grade, and self-perceived family affluence at various time-points from 1993 to 2010. This will help identify vulnerable groups for further in-depth analysis and also establish time trends as well as the contextual information for fighting and fighting-related injury outcomes over time. It is hypothesized that subgroups who were at increased risk for both outcomes included: males, students who were younger or in lower grades (such as grade 6), and students who reported having a less affluent background. It is also hypothesized that the trends of physical fighting and fighting-related injury are consistent with the literature and have significantly decreased over time (11,28,34).

2. To assess the association between family affluence and experiences of physical fighting and fighting-related injury in the Canadian adolescent population while adjusting for additional covariates. The hypothesis is that lower family affluence increases the likelihood of participating

in a physical fight and is also associated with a higher risk of obtaining a fighting-related injury when adjusted for important covariates.

3. To compare and contrast three measurements representing family affluence seen in the HBSC studies. It is hypothesized that an inverse relationship between family affluence and physical fighting and fighting-related injury would be observed and that findings for all three affluence measures will be similar.

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Chapter 3

Trends and Demographic Characteristics of Physical Fighting and Fighting-Related Injuries among Canadian Youth from 1993-2010

3.1 Abstract

Introduction: Physical fighting is a concerning behaviour that puts adolescents at increased risk for injury. Few studies examine the demographic variations in the risk of physical fighting and fighting-related injuries, and the contextual factors and trends over time. The study objectives were: to describe physical fighting and fighting-related injury among Canadian adolescents; and to investigate the trends of fighting and fighting-related injuries between 1993-2010.

Methods: Canadian data from cycles 2-6 (1993-2010) of the Health Behaviour in School-aged Children (HBSC) Study were used, giving a cross-section of 61,465 grade 6-10 students. Prevalence and risk estimates of physical fighting and fighting-related injury were calculated and described by sex, grade and individual-level family affluence. A trend analysis was conducted across time cycles overall and within subgroups.

Results: A significant change over time for physical fights was observed overall (P_{trend}=0.015) and within female, grade 7-8, and high affluence subgroups, although further time-points are necessary to determine this pattern with certainty. There was a significant trend increase over time for fighting-related injury overall and within all subgroups (P_{trend}<0.001). Males had twice the risk of reporting a physical fight and fighting-related injury compared to females (p=0.001-0.044). There was a significant decreased risk of physical fight involvement from lower to higher grades, but an increasing risk for fighting-related injury with increasing grades (p_{trend}=0.001-0.261). Lower affluence was significantly associated with a higher risk of reporting a physical fight and fighting-related injury (p_{trend}=0.001-0.913).

Conclusion: Specific subgroups are at higher risk for physical fight participation and sustaining a fighting injury. Understanding the context and trends of these outcomes is informative for public health interventions.

3.2 Introduction

Physical fighting is a manifestation of interpersonal violence and has become a concerning public health issue worldwide within young people (1,2). In previous studies from the United States, nearly one third of all American adolescents reported participating in at least one physical fight in the past year (3–5).

Physical fighting puts adolescents at increased risk for injury (6–8), and injury is one of the most common reasons for death, hospitalization and disability in young people (9–11). Fighting is the fifth most common reason for youth injury in Canada, and the third most common reason for injuries requiring significant medical treatment such as a cast, stitches or overnight hospital admission. Only vehicle- and bicycle-related injuries are more common among young people for medically treated injuries (9). Due to the potential for serious harm, it is important for researchers to understand who is at risk for fighting and fighting-related injury, and what reasons or mechanism underpin these outcomes.

There is limited epidemiological information in a Canadian context that is recent and nationally representative. In Canada there is also minimal information on demographic and socioeconomic variation in the risk of physical fight involvement and fighting-related injuries. Considering family affluence in the distribution of fighting experiences and fighting-related injuries can be useful in directing future studies. Few studies consider the contextual factors of fighting and fighting-related injuries, such as where the event occurred and who was involved. Exploring context may provide additional commentary on preventing these outcomes. There is also little information regarding trends that indicate whether physical fights and fighting-related injuries have changed over time. International studies report that physical fighting has decreased over time, although it is difficult to generalize these findings to Canada (2).

The objectives of this study were: 1) to describe physical fighting and fighting-related injury among Canadian adolescents by sex, grade, and individual level of family affluence; and 2)

to investigate the trends of physical fighting and fighting-related injuries between 1993-2010 in the overall population and within certain subgroups.

3.3 Methods

The focus of this study was to investigate the prevalence of fighting and fighting-related injury among Canadian adolescents over the past 20 years.

Data Sources and Sample

This study used Canadian data from the Health Behaviour in School-aged Children (HBSC) Study (6). HBSC is a nationally representative study that was developed in collaboration with the World Health Organization (WHO) for the purpose of understanding health determinants and behaviours in young people. Canada has collected data every four years since 1998 through questionnaires that are administered to 11-15 year-old students in school classrooms. Six HBSC cycles have been undertaken in Canada from 1990-2010. Many of the core survey questions have remained the same which permits trend analysis (12).

Data from cycles 2-6 (1993-2010) were used since data for the outcomes of interest were not available for the first cycle. A total study sample of approximately 61,465 Canadian students in grades 6-10 was included: 7020 (1993/1994), 11415 (1997/1998), 7235 (2001/2002), 9717 (2005/2006), and 26078 (2009/2010). Analysis was undertaken for each cycle independently due to differences in sampling procedures and slight variability in wording and coded responses for each survey item.

Study Variables

Physical Fighting data was available for HBSC cycles 4 (2001/2002), 5 (2005/2006), and 6 (2009/2010). Participants were asked how many times they were in a physical fight in the past 12 months. Students who completed this question were categorized as follows: no physical fights, 1

time, 2-3 times, and 4 or more times. A dichotomous variable ('No physical fights' and 'One or more physical fights') was created for cross-tabulations.

Fighting-related injury was the second main outcome. Data was available in HBSC cycles 2-6. Participants were asked whether they had been injured in the past 12 months, and the cause of their one most serious injury. Responses that said 'Yes' to being injured with 'Fighting' chosen as the cause were coded as a fighting-related injury.

Data for *sex*, *grade*, and *self-perceived affluence* were available in all datasets and were used as key descriptor subgroups. Participants were asked early in the questionnaire to select their *sex* and *grade* (specific responses grouped by: grade ≤6, grade 7-8, and grade ≥9). Grade categories correspond roughly with students in primary, middle, and secondary schools. *Self-perceived affluence* was measured by the question 'How well off do you think your family is?' with five possible responses which were then grouped into 3 smaller categories: high affluence ('Very well off' and 'Well off'), average affluence ('Average'), and low affluence ('Not well off' and 'Not at all well off').

Scenario Variables

Variables describing the context of the injury and physical fight encounter were assessed, and included: who the fight was with; whether the injury caused missed school or activities; the type of injury; whether medical treatment was required; the location where the injury occurred; whether the injury happened during an activity or club; the season that the injury happened; and where treatment was received.

Time was the main aspect considered for the trend analysis. Trends of physical fighting and fighting-related injury were assessed in terms of differences in overall prevalence and prevalence within subgroups for each one-year study time-point.

Statistical Analysis and Survey Weights

SAS 9.3 (SAS Inc., Cary, NC) was used for all analyses. Each HBSC cycle had various sampling procedures. In accordance with international protocols, cycles 2-5 were designed to be self-weighted and considered characteristics of the Canadian population for the sampling process (12,13). Cycle 6 includes survey weights by province and territory within grade groups. Over-represented provinces and territories were given weights of <1, and under-represented groups were given weights of >1. Survey weights ranged from 0.017-3.655 (6,11). Prevalence estimates were derived from specific time cycles, and cross-tabulations were performed to obtain frequencies, percentages, and relative risks (RR) with 95% confidence intervals (CI). The Cochrane-Armitage test for trend was used for the outcome prevalence across cycles to establish the significance of the increasing or decreasing trends over time.

3.4 Results

Distribution of the HBSC participants by demographic characteristics and outcomes can be found in Table 3.1.

Prevalence of Physical Fighting

The prevalence of physical fighting one or more times ranged from 35.1%-41.2%, and peaked at 41.2% in the 2005/2006 time cycle (Table 3.2). The prevalence from 2001-2010 displays a significant change over time despite the prevalence decrease in the 2009/2010 cycle (P_{trend}=0.015). A significant difference in prevalence from 2001-2010 was also observed in specific groups including females (P_{trend}<0.001), grade 7-8 students (P_{trend}=0.008), and high affluence individuals (P_{trend}=0.002). We do recognize however, that further time-points are necessary to determine the extent and direction of this trend with certainty.

In demographic subgroups, the prevalence of physical fighting was higher in males (48.3-53.4%) (Table 3.2). Males also had approximately twice the risk of reporting a physical fight than females for each time cycle ($p<0.001$) (Table 3.3).

As compared to students in grades ≥9, students in grades ≤6 had approximately 20-30% significantly higher likelihood of reporting a physical fight in the past year, while grade 7-8 students had approximately 10-20% increased risk (Table 3.3). This decreasing risk of physical fight involvement from lower to higher grades was significant within each HBSC cycle ($P_{trend}<0.001$).

Compared to students from high affluence families, participants who reported low affluence were 20-30% more likely to report a physical fight in the past 12 months, while those of average affluence had approximately 10-15% higher risk. Table 3.3 shows a significant decline in risk from high to low affluence groups for all HBSC cycles ($P_{trend}< 0.001$).

Table 3.4 reports who each individual engaged in a fight with. Approximately 43% of those who participated in at least one fight reported fighting with a friend or someone they knew, followed by: brother or sister, total stranger, parent or adult family member, and boyfriend, girlfriend, or date.

Prevalence of Fighting-Related Injury

Overall fighting-related injury ranged from 1.1-2.3% (Table 3.2). The trend test indicated a significant increase over time in the overall prevalence of fighting-related injury and within all subgroups ($P_{trend}<0.001$).

In Table 3.3, males had 1.5-2.5 fold increased risk of reporting a fighting-related injury compared to females ($p<0.05$). Individuals in grades ≤6 had 30-60% *reduced* risk of reporting a fighting-related injury compared to higher grades (Table 3.3). This association was only significant for 1993/1994, 2001/2002, and 2009/2010. Grade 7-8 participants for most cycles except 2005/2006 had a 24-40% lower risk of reporting a fighting-related injury compared to those in grades ≥9. In Table 3.3, there is an increasing risk for fighting-related with higher grades for HBSC cycles in 1993/1994, 2001/2002, and 2009/2010 ($p_{trend}<0.05$).

Table 3.3 shows that those with low self-perceived affluence were 2-3 times significantly more likely to report a fighting-related injury compared to high affluence individuals for cycles 4-6. For individuals of average affluence, there was a 13-60 % insignificant higher risk of fighting-related injury compared to higher affluence participants for all cycles except the last. Lower affluence was associated with an increased risk of reporting a fighting-related injury ($p_{trend}<0.001$).

Context of Fighting-Related Injury

Table 3.5 shows participants who reported a fighting-related injury in the past 12 months by variables describing the circumstances of the injury. Some survey questions were not available for all cycles.

For all cycles available, over 50% of those who reported a fighting-related injury missed at least one day of school or activities because of their injury.

The three most common results for fighting-related injury were: broken bones, cut or puncture wounds, and bruises or internal bleeding. Broken bones were most common in 1993/1994, and bruises/ internal bleeding for 1997/1998 and 2001/2002.

Information on whether the injury needed medical treatment was available in 3 cycles. For 1993/1994, 57.6% of fighting-related injuries required medical treatment. This decreased to 50.2% in 2005/2006 and less than half (46.8%) in 2009/2010.

The earliest three HBSC cycles stated that most fighting-related injuries occurred in the home or yard, school, and street or parking lot. There is a shift from 2005/2006 onwards where the most common place an injury occurred was in the street followed by the school and home.

Determining if the injury happened during an organized activity or club was possible for the middle three time periods. For all available cycles, 10.1-26.8% of fighting-related injuries occurred during an organized activity.

For the first two cycles, fighting-related injuries most commonly occurred in autumn followed by summer, then spring for 1993/1994 (16%) and winter for 1997/1998 (14.9%). The

2001/2002 cycle presented a different order with the most common season being spring (43.1%), followed by winter (25.7%), autumn (16.5%), and summer (14.7%).

Data pertaining to the place where the patient was treated were available for 2001/2002 and 2005/2006. Patients were most commonly treated for their injury in the emergency room and doctor's office or health clinic.

3.5 Discussion

This study shows that physical fighting is a relatively common behaviour within Canada (35-40%), and that obtaining an injury related to fighting (1-2%) is rarer. Fighting and fighting-related injury prevalence differed significantly over time overall and within specific subgroups. Males are significantly more likely than females to both participate in a physical fight and obtain a fighting-related injury. Students in grades 6 or below were more likely to participate in physical fights than their older counterparts, while being in a lower grade was protective against fighting-related injury. Individuals who perceived their families as less affluent were at increased risk of obtaining both outcomes compared to participants of higher affluence.

It is possible that because youth are becoming more exposed to violent media, they are also increasingly desensitized to violence and less inhibited when engaging in violent activities (14). Adolescents who are more prone to violent behaviours may have poorer problem solving skills, social skills and coping strategies for solving confrontations, which can result in physical altercations (15). This is a plausible explanation for the significantly different prevalence estimates over time. It is difficult to determine if these fight prevalences are increasing or decreasing over time due to the unusually high prevalence at the 2005/06 time-point. Therefore, more time-points are necessary in future research to confidently examine the time patterns of physical fighting. Further research is also needed to explain the biological and sociological mechanisms for these increases. Fighting prevalence changed significantly over time within specific subgroups. This

included females, middle school students, and higher affluence students. Further research is needed to understand why physical fighting over time has altered in these groups.

While physical fighting has altered significantly over time within females, descriptive analyses showed that males are significantly more likely than females to participate in physical fights and obtain a fighting-related injury for all time-points. This gendered difference was also reported in previous international studies (5,6,16). Scientists have postulated numerous biological and social reasons for the higher prevalence of violent behaviours in males, including the increases of testosterone associated with puberty, increased strength from muscle mass, and social theories that reinforce the male gender (17,18). Individuals who perceived their families as less affluent were also at increased risk of obtaining both outcomes. This relationship with physical fighting is consistent with previous studies (1). However, for the relationship between family wealth and fighting-related injuries, further analysis accounting for multiple affluence measurements and additional covariates needs to be done (19).

Individuals in grades 6 or below were more likely to participate in physical fights than their older counterparts. However, the opposite effect was seen where being in a lower grade was protective against fighting-related injury when compared to higher school levels. These patterns may be because younger adolescents are still developing mentally and physically, and may use physical confrontations to resolve issues. “Play fighting” or “rough-and-tumble play” is a common behaviour among younger people and these behaviours decrease as students approach adulthood (20). Concurrently, adolescents also undergo physiological changes such as increased muscle mass and hormonal changes during puberty. The elevated strength in older adolescents may intensify the physical force exerted in fights, which can increase the likelihood of injury (17,21). The way grade school and high school students interpret situations may vary, where the circumstances and consequences behind physical confrontations may become more severe as adolescents get older; as a result, there may be more intent to harm (22).

Findings associated with the context of fighting and fighting-related injuries showed that the person participants most frequently fought with was "a friend or someone I know" and a sibling. This is logical since adolescents habitually interact with these people. The next most popular response was "other". There is no information in the data that describes the remaining possible options for this category. It is postulated that the "other" category can represent rivals that the students know enough of to not warrant being a stranger, but not enough to be "friends". Future surveys should present the option to describe who the "other" person is.

From 1993-2002, the most common places that a fighting-related injury occurred was in a home or yard, and school. Adolescents spend the majority of their time at home and school, which makes the increased likelihood of obtaining a fighting-related injury more plausible. Information was only available for one cycle (1993/1994) that asked whether the injury occurred during or outside of school hours. This would be useful in further datasets to provide information on the context behind fighting–related injuries and how often fights and injuries occur in the context of physical bullying or domestic violence for example. From 2005 onwards, the most common response shifted from the home to the street. It is unknown why there is a shift in location over time.

Earlier cycles (1993-1998) suggest that fighting-related injuries most commonly occur during the fall followed by summer. This could be because Canadian adolescents return to school and are more likely to go outside during these seasons, which allows for increased physical interactions. In 2001/2002, fighting-related injuries were most likely to occur during the spring, where young people also engage in more outdoor activities. This environmental change may allow them to participate in more physical conflicts. It is unclear why there is this seasonal shift for this cycle only.

Data suggest that many of the reported injuries are serious enough to receive medical attention at the emergency room or doctor's office. The fact that most of these injuries tend to happen outside of activities or clubs suggests that there may be some association between these

outcomes and levels of supervision. A potential solution could be increased student involvement in supervised activities.

Strengths of this study include that this research uses nationally representative data. This supports its generalizability to the Canadian adolescent population. The large sample size also provides substantial power to detect significant differences between subgroups. The results from this study can help identify vulnerable groups and contextual factors that may pose risk. These findings can help establish priority areas for preventing physical fights and the additional risk of injury.

This study also contains important limitations. First, the self-reported nature of the data may present potential misclassification for both the exposures and outcomes due to the objectivity of each variable. For example, asking how "well off" somebody is may not accurately measure family income or the nature of the material wealth. Furthermore, fighting-related injury can be misclassified as sports-related if an injury occurred because of a fight during a sport or martial arts. This indicates that not all fighting-related injuries are being captured.

Students who were absent on the day of the survey due to injury or suspension for engaging in a fight may not have been selected to participate. Furthermore, the study does not consider adolescents who dropped out of school. These individuals may be fundamentally different in how well off they are and their experiences with violence compared to students still enrolled in school. These can indicate selection bias (2).

There are also only three time-points available for measuring physical fighting. The limited number of data-points for the trend analysis makes it difficult to assess whether the trend test shows a linear or exponential pattern. More data-points would be informative for trend interpretation.

A last limitation is that the survey only asks participants about the circumstances of their one most serious injury. If fighting was not the cause of their most serious injury, data will be truncated. Other less serious fighting injuries may be masked in some circumstances. This means that fighting-related injuries may be under-reported in the sample.

3.6 Conclusion

Physical fighting is a common behaviour among young Canadians and a public health issue that has become more concerning in the past two decades. Specific subgroups are at higher risk than others for physical fight participation, and sustaining an injury from these encounters. Understanding the context of these conflicts and injuries can be informative in creating interventions that can reduce the occurrence of these outcomes in the future.

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Table 3.1 Characteristics of the participants in the Health Behaviour in School-aged Children Study from 1993-2010.

	HBSC Cycle									
	1993-94*		**1997-98***		**2001-02**		**2005-06**		**2009-10**	
Overall	N=7020		N=11415		N=7235		N=9717		N=26078	
Descriptors										
Age (Mean±SD)	13.5±1.7		13.8±1.6		13.6±1.5		14.0±1.5		13.8±1.6	
	n	%	n	%	n	%	n	%	n	%
Sex										
Male	3350	(47.9)	5500	(48.4)	3357	(46.4)	4604	(47.4)	12815	(49.2)
Female	3644	(52.1)	5870	(51.6)	3878	(53.6)	5111	(52.6)	13254	(50.8)
Grade										
≤6	2329	(33.2)	2137	(18.7)	2063	(28.5)	1723	(17.7)	5165	(19.8)
7-8	2356	(33.5)	4296	(37.7)	2788	(38.5)	3670	(37.8)	10471	(40.2)
≥9	2335	(33.3)	4967	(43.6)	2384	(33.0)	4324	(44.5)	10442	(40.0)
Self-reported Affluence										
Low	923	(13.2)	1562	(13.9)	597	(8.9)	808	(8.6)	2339	(9.5)
Average	2931	(42.0)	4890	(43.5)	2315	(34.3)	3003	(32.0)	8276	(33.6)
High	2574	(36.9)	4784	(42.6)	3826	(56.8)	5585	(59.4)	13998	(56.9)
Unknown	549	(7.9)	-	-	-	-	-	-	-	-
Total	6977	(100)	11236	(100)	6738	(100)	9396	(100)	24613	(100)
Missing	43		179		497		321		1466	
Outcomes										
Physical Fighting	-	-	-	-	4542	(65.0)	5652	(58.8)	16203	(64.4)
None					1192	(17.0)	1705	(17.7)	4092	(16.3)
1 time					787	(11.2)	1372	(14.3)	3067	(12.2)
2-3 times					472	(6.8)	885	(9.2)	1786	(7.1)
4 or more					6993	(100)	9614	(100)	25148	(100)
Total					242		103		930	
Missing										
Fighting-Related Injury										
No injury	4371	(63.3)	6962	(63.6)	3574	(52.0)	5364	(56.0)	12959	(51.6)
Yes	92	(1.3)	119	(1.1)	116	(1.7)	216	(2.2)	543	(2.1)
No, injury not related to fighting	2442	(35.4)	3870	(35.3)	3184	(46.3)	4001	(41.8)	11632	(46.3)
Total	6905	(100)	10951	(100)	6874	(100)	9581	(100)	25134	(100)
Missing	115		464		361		136		944	

*= No physical fighting variables from HBSC 1993-1994 and 1997-1998.

Table 3.2 Prevalence of physical fighting (one or more times) and fighting-related injury for each HBSC cycle (1993-2010) overall and by demographic characteristic (sex, grade, and self-reported affluence). Trend analysis across HBSC time cycles also reported.

	Physical Fight (1 or more times) n (%)				Fighting-Related Injury n (%)					
HBSC Cycle	**2001-02**	**2005-06**	**2009-10**	**P trend†**	**1993-94**	**1997-98**	**2001-02**	**2005-06**	**2009-10**	**P trend†**
Variable										
Sex										
Male	1552 (48.3)	2421 (53.4)	5944 (48.7)	0.167	57 (1.7)	74 (1.4)	64 (2.0)	149 (3.3)	360 (2.9)	<0.001
Female	899 (23.8)	1541 (30.3)	2997 (23.2)	0.001	34 (0.9)	44 (0.8)	52 (1.4)	67 (1.3)	183 (1.4)	<0.001
Grade										
≤6	733 (37.7)	819 (48.1)	1992 (40.9)	0.275	17 (0.7)	14 (0.7)	24 (1.2)	32 (1.9)	87 (1.8)	<0.001
7-8	984 (36.3)	1612 (44.3)	3652 (36.4)	0.008	28 (1.2)	48 (1.2)	43 (1.6)	106 (2.9)	196 (1.9)	<0.001
≥9	734 (31.4)	1531 (35.8)	3300 (32.3)	0.335	47 (2.0)	57 (1.2)	49 (2.1)	78 (1.8)	260 (2.6)	<0.001
Self-reported Affluence										
Low	239 (40.4)	414 (51.3)	964 (42.3)	0.452	11 (1.2)	20 (1.3)	17 (3.0)	41 (5.1)	91 (4.0)	<0.001
Average	850 (36.9)	1299 (43.5)	3073 (37.9)	0.367	41 (1.4)	55 (1.2)	44 (2.0)	68 (2.3)	210 (2.6)	<0.001
High	1272 (33.4)	2132 (38.4)	4504 (32.8)	0.002	32 (1.3)	42 (0.9)	52 (1.4)	102 (1.8)	223 (1.6)	0.001
Overall*	2451 (35.1)	3962 (41.2)	8945 (35.6)	0.015	92 (1.3)	119 (1.1)	116 (1.7)	216 (2.3)	543 (2.2)	<0.001

Note: No physical fighting variables from HBSC 1993-1994, and 1997-98.

* = Overall n and % calculated from total HBSC population for that cycle.

† = Cochrane-armitage test for trend for physical fighting and fighting-related injury across HBSC time cycles. 2001-2010 for physical fighting, and 1993-2010 for fighting-related injuries.

Table 3.3 Relative risks and 95% confidence intervals for the outcomes of physical fighting and fighting-related injury by demographic characteristics across HBSC cycles, 1993-2010.

	Physical Fighting (1 or more times) Relative Risk (95% CI)			Fighting-Related Injury Relative Risk (95% CI)				
HBSC Cycle	**2001-02**	**2005-06**	**2009-10**	**1993-94**	**1997-98**	**2001-02**	**2005-06**	**2009-10**
Variable								
Sex								
Male	2.03 (1.90-2.17)	1.76 (1.67-1.85)	2.10 (2.03-2.18)	1.84 (1.20-2.80)	1.82 (1.26-2.64)	1.45 (1.01-2.08)	2.50 (1.88-3.33)	2.08 (1.75-2.49)
Female	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref
P-value	<0.001	<0.001	<0.001	0.004	0.001	0.044	<0.001	<0.001
Grade								
≤6	1.20 (1.10-1.30)	1.34 (1.26-1.43)	1.27 (1.21-1.32)	0.37 (0.21-0.63)	0.58 (0.33-1.04)	0.58 (0.36-0.94)	1.04 (0.69-1.56)	0.68 (0.54-0.87)
7-8	1.16 (1.07-1.25)	1.24 (1.17-1.31)	1.13 (1.09-1.17)	0.60 (0.38-0.95)	0.98 (0.67-1.44)	0.76 (0.51-1.14)	1.60 (1.20-2.14)	0.76 (0.63-0.91)
≥9	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref
P-trend	<0.001	<0.001	<0.001	0.001	0.116	0.023	0.261	<0.001
Self-reported affluence								
Low	1.21 (1.09-1.35)	1.34 (1.24-1.44)	1.29 (1.22-1.36)	0.96 (0.49-1.90)	1.47 (0.87-2.50)	2.12 (1.23-3.64)	2.78 (1.95-3.96)	2.43 (1.91-3.09)
Average	1.10 (1.03-1.18)	1.13 (1.08-1.20)	1.16 (1.12-1.20)	1.13 (0.72-1.79)	1.28 (0.86-1.91)	1.41 (0.95-2.10)	1.24 (0.91-1.68)	1.59 (1.32-1.91)
High	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref
P-trend	<0.001	<0.001	<0.001	0.913	0.117	0.005	<0.001	<0.001

*= No physical fighting variables from HBSC 1993-1994 and 1997-1998.

Table 3.4 Reports of physical fighting (one or more times) by whom they fought with from the Canadian HBSC Survey, 2001-2006.

	Physical fighting (1 or more times) across HBSC cycles			
	2001-02 N=7235		**2005-06** N=9717	
	n	**%**	**n**	**%**
Overall	2451	(35.1)	3962	(41.2)
Who did you fight with?				
Total stranger	222	(9.7)	272	(7.1)
Parent or adult family member	30	(1.3)	100	(2.6)
Brother or sister	515	(22.4)	1101	(28.6)
Boyfriend, girlfriend or date	47	(2.0)	71	(1.8)
A friend or someone I know	987	(42.9)	1666	(43.3)
Other	499	(21.7)	637	(16.6)
Total	2300		3847	
Missing	151		115	

Note: 'Who did you fight with' variable is not included in the 2009-2010 HBSC Survey.

Table 3.5 Reports of injuries related to fighting by variables describing the scenario from the Canadian HBSC Survey, 1993-2010.

	Fighting-related injuries across HBSC cycles									
	1993-94		1997-98		2001-02		2005-06		2009-10	
Variable	**n**	**(col%)**	**n**	**(col%)**	**n**	**(col%)**	**n**	**(col%)**	**n**	**(col%)**
Injury caused missed day of school or activities	51	(55.4)	68	(57.1)	59	(51.8)	116	(57.1)	311	(61.5)
Results of injury										
Broken bone	33	(36.7)	18	(15.7)	16	(13.8)				
Sprain/strain	7	(7.8)	7	(6.1)	10	(8.6)	-	-	-	-
Cut or puncture wound	20	(22.2)	10	(8.7)	14	(12.1)				
Concussion or head/neck injury	6	(6.7)	9	(7.8)	7	(6.0)				
Bruises or internal bleeding	16	(17.8)	44	(38.3)	32	(27.6)				
Burns	0	(0)	6	(5.2)	29	(25.0)				
Internal injury (operation)	-	-	-	-	5	(4.3)				
Other	8	(8.9)	21	(18.3)	3	(2.6)				
Total	90		115		116					
Missing	135		464		692					
Injury needed medical treatment	53	(57.6)	-	-	-	-	103	(50.2)	245	(46.8)
Place that injury occurred										
Home/Yard	28	(31.1)	50	(42.0)	42	(38.9)	43	(20.5)	93	(18.5)
School	23	(25.6)	30	(25.2)	26	(24.1)	50	(23.8)	127	(25.2)
Sports Arena/Facility	7	(7.8)	10	(8.4)	7	(6.5)	23	(11.0)	43	(8.5)
Street/Parking Lot	13	(14.4)	14	(11.8)	23	(21.3)	62	(29.5)	142	(28.2)
Park	6	(6.7)	-	-	-	-	-	-	-	-
Commercial/business area	-	-	-	-	3	(2.8)	-	-	-	-
Other	13	(14.4)	15	(12.6)	7	(6.5)	32	(15.2)	98	(19.4)
Total	90		119		108		210		503	
Missing	136		514		533		148		1334	
Injury happened during activity, league or club	-	-	12	(10.1)	13	(11.4)	55	(26.8)	-	-
Season that injury occurred										
Winter	11	(13.6)	17	(14.9)	28	(25.7)	-	-	-	-
Spring	13	(16.0)	16	(14.0)	47	(43.1)				
Summer	28	(34.6)	35	(30.7)	16	(14.7)				
Fall	29	(35.8)	46	(40.4)	18	(16.5)				
Total	81		114		109					
Missing	365		647		858					
Place treated for most serious injury										
Doctor's office/health clinic	-	-	-	-	30	(30.9)	47	(24.9)	-	-
Emergency room					33	(34.0)	43	(22.8)		
Hospital admission overnight					9	(9.3)	25	(13.2)		
					7	(7.2)	6	(3.2)		
School health services					18	(18.6)	68	(36.0)		
Other					97		189			
Total					898		379			
Missing										

Chapter 4

Physical Fighting, Fighting-Related Injuries and Family Affluence among Canadian Youth

4.1 Abstract

Background: Physical fighting is an assaultive behaviour that can lead to injury. Family affluence is a health determinant that can influence injury. This study examines the relationship between family affluence and two outcomes: physical fighting and fighting-related injury in Canadian adolescents. Three measurements were used to represent family affluence and assess whether these measures demonstrated different associations with these outcomes.

Methods: Canadian data from the 2009/2010 Health Behaviour in School-aged Children Study were used. It consists of a nationally representative sample of 26,078 grade 6-10 students. A subset analysis of 10,429 grade 9-10 students was conducted to account for additional confounders. Modified Poisson regression was used to compare the risk of physical fighting and fighting-related injury in youth from different levels of family affluence. Three indicators were used to represent family affluence: self-perceived affluence, a family affluence scale (FAS), and area-level average household income.

Results: The overall prevalence was 35.6% for physical fighting and 2.7% for fighting-related injuries. Both outcomes were more frequent in males than females. An inverse gradient was present where risk for both outcomes increased with decreasing levels of affluence irrespective of the affluence measurement. The self-perceived affluence variable showed a significantly stronger gradient in girls than boys. FAS showed a similar inverse gradient within females, but a threshold effect in males where there was a strong effect in the low FAS group, but a null effect in the moderate FAS group. The area-level income variable presented a significantly higher likelihood for physical fighting only in females (p=0.001-0.075). For fighting-related injury, none of the area-level income models showed significant risk estimates with the exception of the bivariate association where low income females were twice as likely to report a fighting-related injury compared to higher income groups (p=0.030). Post hoc power calculations indicate that there was insufficient power to detect injury effects associated with the area-level income measure.

Conclusion: It appears that a socioeconomic gradient exists where lower affluence is associated with a higher risk of reporting a physical fight and fighting-related injury irrespective of the measure used. While the patterns were generally the same with all three measurements, the strength of this gradient varied across measures. This demonstrates that each indicator may not measure affluence to the same extent. Further analyses are needed to explore concepts and mechanisms underlying each affluence measure.

4.2 Background

Violence among young people is one of the most visible forms of violence in society and a major concern in many countries (1). One common manifestation of violence is physical fighting, which is an assaultive behaviour that is a significant public health issue worldwide. It has been proposed as one of the earliest markers for multiple risk behaviours such as substance use, truancy, and other problem behaviours (2), and is consistently shown to cause injury (2). Injury is one of the most important negative health outcomes seen in young people today (3). Adolescent injuries are a significant concern due to their enormous burden on adolescents, families and communities, with costs associated with premature death, pain, disability, reduced productivity, and emotional trauma (3).

There are numerous factors related to fighting and injuries. One such factor is family affluence or wealth. Previous studies have examined the association between wealth and one's predisposition for violence (4). There is a general scarcity of literature in Canada regarding physical fighting and injuries specific to fighting among young people and its relationship with family affluence. One international study conducted in 30 countries, including Canada, found that higher absolute wealth is associated with a lower likelihood of frequent fight involvement (4). Previous research has also assessed the association between measures of wealth and its related construct socioeconomic status (SES) and adolescent injuries. These provided mixed results and authors noted that there was no optimal measurement for family affluence (5). Furthermore, the results for these relationships varied by cause, type and severity of injury (6). In order to quantify these associations, there is a need for research on multiple indicators of family affluence and studies that include context-specific injury information (7).

The current study examines the relationship between family affluence and two outcomes: physical fighting and fighting-related injury in Canadian adolescents. Three different

measurements were used to represent family affluence to further assess whether these measures demonstrated different associations.

4.3 Methods

Data Source

This study used Canadian data from the Health Behaviour in School-aged Children (HBSC) study. It is a cross-sectional survey that was developed in collaboration with the World Health Organization (WHO) with the intent of studying health determinants and behaviours in young people 11-15 years of age (8). The HBSC study protocol and this specific secondary analysis received ethics approval from the Queen's University General Research Ethics Board.

Study Sample

A two-stage cluster sampling approach was employed for the most recent 2009/2010 HBSC cycle where students were clustered within schools. This resulted in an original sample size of 26,078 students from 436 schools in 11 provinces and territories. Another analysis with only grade 9-10 students was undertaken to consider potential covariates that were not available in the grade 6-8 version of the HBSC survey, such as those pertaining to drug use (as these were not asked of younger students). This resulted in a sub-sample size of 10,429 grade 9-10 students.

Main Exposure: Family Affluence

Family affluence is the main exposure of this study. Many variables were available to represent this construct, and three methods of measuring family affluence were used for data analysis: self-perceived affluence, a family affluence scale (FAS), and area-level average household income.

Self-perceived family affluence was indicated by a question in the student survey that asked students how well off they perceived their families to be. These responses were represented as a

five-point scale: ‘very well off’, ‘quite well off’, ‘average’, ‘not very well off’, and ‘not at all well off’. Responses were re-categorized as three categories for the analysis: high (‘very well off’, ‘quite well off’), moderate (‘average’), and low (‘not very well off’, ‘not well off at all’).

The second method used for measuring family affluence was the *Family Affluence Scale II (FAS)*, which is a validated measure of four questions that uses a set of material items to reflect family expenditure where possession of greater numbers of these items can represent increasing affluence, or lacking them can represent material deprivation (9). It is useful since students may not have an accurate idea of how much money their guardians make or have, and the FAS is an alternative approach that approximates affluence based on the kinds and quantity of items the student’s family can afford. Items in the FAS scale include: 1) having a bedroom for oneself, 2) number of vehicles, 3) family vacations in the past 12 months, and 4) number of computers. Responses from all four FAS questions were totaled to create a FAS score which ranged from 0 to 9. For this study, the FAS score was divided into 3 ordinal categories to represent an individual's family affluence: low affluence (0-2), moderate affluence (3-5), and high affluence (6-9). This categorization is based on recommendations from previous studies (10,11).

Area-level income was the third method for measuring family affluence. The postal code of the school that each student attended was available in the HBSC data. The school postal code was linked and merged with information on the average household income among private households within a 1 km buffer of the school from the 2006 Statistics Canada Census Subdivision data. Average income was calculated by dividing the aggregate income of the group of families or households within this 1 km school buffer by the number of families or households in that respective group. A private household is a person or group of persons who occupy a private dwelling and do not have a usual place of residence elsewhere in Canada. Because of the log-normal distribution of the variable, the area-level average household income measurement was divided into percentile-based tertiles.

All three measurements rely on different methods to quantify the concept of family affluence in adolescence. Self-perceived affluence is the most subjective measure since it relies on self-report to measure an adolescent's affluence, and depending on what their frame of reference or definition of "well off" is, it may be variable. FAS is a more objective measurement in that it aims to use material items to measure family expenditure. FAS also relies on HBSC survey questions to gauge material wealth, however it does indirectly measure wealth without asking an adolescent about their parent's income. This is done primarily to decrease the likelihood of non-responses. Area-level income is a more objective affluence measurement again since it relies on income Census data reported directly by parents. Despite these different approaches to measuring family wealth, these measurements are expected to be correlated and yield similar results.

Outcome 1: Physical Fighting

Physical fighting was assessed with the question 'During the past 12 months, how many times were you in a physical fight?' Five ordinal responses were available, ranging from 'none' to '4 times'. These responses were re-categorized as a dichotomous response for analysis: 'none' and 'yes (one or more times)'.

Outcome 2: Fighting-Related Injury

Fighting-related injury was assessed using two survey items. The first question asked the number of times the participant was injured in the past 12 months. The second question asked what the cause of their one most serious injury was. If participants selected 'Yes' in response to whether they were injured in the past 12 months and selected 'Fighting' as the cause of their one most serious injury, then they were coded as having a fighting-related injury. Respondents who either were not injured in the past 12 months or were injured by other means besides fighting were coded as not having a fighting-related injury.

Potential Covariates

Potential covariates were identified based on previous literature and were adjusted for in the analysis. Confounders were selected based on either their association with the outcomes of physical fighting and fighting-based injuries, or their independent affiliation with both family affluence and the outcomes without being on the causal pathway. Effect modification was assessed and determined to be significant based on the interaction term (between each family affluence variable and sex) in the regression models while adjusting for other factors.

Demographic factors such as sex and age were previously established to be important predictors for physical fighting participation and injury and thus were considered a priori as covariates (12–18). Other potential confounders that were assessed in the analysis were academic performance (19), happy home life or supportive families (20–22), respectful school environment (school connectedness) (12,23), caring and understanding teachers (21,24), extracurricular activities (21), sports involvement (21), and drug and alcohol use (25–27). Drug use questions were only available for grade 9-10 students, therefore this variable was only considered for the analysis of grade 9-10 participants.

Survey Weights

The HBSC data were weighted within grades by province or territory to ensure that the results were proportionate and nationally representative of the actual student population. Grade groups that were over-represented in provinces and territories were given a weight of <1, and those who were under-represented were given weights of >1. The survey weights for each grade ranged from 0.017-3.655.

Statistical Analysis

The association between family affluence and the outcomes of physical fighting and fighting-related injury was assessed using modified Poisson regression analyses with log link function to estimate relative risks (RR) and 95% confidence intervals (CI). All statistical analysis procedures were conducted using the PROC GENMOD procedure from SAS Version 9.4 software (SAS Institute Inc., Cary, North Carolina). The analysis took into consideration the clustered nature of the data where students (individual-level) were nested within schools (area-level). This was done by using generalized estimating equations (GEEs) to create robust error estimates (28). The highest affluence category was chosen as the reference group for each of the multi-level analyses. A two-stage approach was undertaken for the analysis. Firstly, bivariate models were fitted for each affluence exposure and outcome. Secondly, multivariate regression models were fit while stratifying by sex and adjusting for confounders that were chosen based on a backwards elimination criteria of $p<0.15$ to create the most parsimonious model.

4.4 Results

The individual- and area-level characteristics of the 2009/2010 HBSC sample can be seen in Table 4.1. Sex was a significant effect modifier for all physical fighting outcome models based on type 3 test statistics ($p_{interaction}<0.05$). Therefore results were stratified by sex.

The overall prevalence was 35.6% for physical fighting and 2.7% for fighting-related injuries. Both outcomes were more frequent in males than females. However, the relationship between family affluence and both outcomes varied depending on the affluence measurement that was used in each model. For the self-perceived affluence variable, the prevalence of physical fighting was highest in the low affluence group and the prevalence decreased with each increasing affluence category (low: 42.3%, moderate: 37.9%, high: 32.8%). This pattern was also observed for the FAS (low: 43.9%, moderate: 34.8%, high: 34.9%) and the area-level income measurement (low: 36.4%, moderate: 35.8%, high: 34.1%).

Fighting-related injury also presented an inverse gradient where the prevalence was 4.6%, 3.3% and 1.9% for the low, moderate and high self-perceived affluence groups respectively. The FAS and area-level income variables showed a slight gradient effect although some of the affluence categories contained the same prevalence estimates: (low: 7.2%, moderate: 2.5%, high: 2.5% for FAS; low: 2.8%, moderate: 2.8%, high: 2.4% for area-level income).

Table 4.2 shows the results of the regression analyses for the physical fighting outcome. The bivariate analysis for the self-perceived affluence measure showed that low affluence males had a 14% higher risk of being in at least one physical fighting compared to high affluence males ($p=0.003$), while the risk increase was 8% for moderate affluence males ($p=0.005$) as compared to high. Within the female stratum, participants with low self-perceived affluence had a 66% increased likelihood of reporting one physical fight compared to those with high self-perceived affluence ($p<0.001$) while the moderate affluence group had a 39% higher risk ($p<0.001$). When adjusted for all significant confounders, the risk for both strata decreased although the risk within females of low affluence remained significantly higher compared to the referent (RR=1.39, $p<0.001$), and females of moderate affluence had a 30% increased risk compared to high affluence females ($p<0.001$).

The FAS variable demonstrated a similar gradient effect in the female stratum (low FAS: RR=1.50 $p<0.001$; moderate FAS: RR=1.12 $p=0.016$). When adjusted, the risk for each category slightly decreased but only a significant effect was detected for the low FAS category (RR=1.42 and $p=0.002$). However, the male population generated results where comparisons of the low and high FAS groups presented insignificant increases in risk, a significant decrease in risk was present when contrasting the moderate and high FAS groups ($p_{(bivariate)}=0.008$, $p_{(multivariate)}=0.010$).

The area-level average household income variable only presented a significantly higher likelihood for physical fighting in the female population when comparing lower income females to higher income females for the unadjusted analysis (low income: RR=1.32 $p=0.001$, moderate

income: RR=1.17 p=0.031). In the adjusted analysis, lower income females were 26% more likely to report a physical fight than high income females (p=0.003).

Table 4.3 displays the regression analysis results for fighting-related injuries. Males of low self-perceived affluence were 64% more likely to have obtained a fighting-related injury (p=0.022) and moderate affluence males were 51% more likely (p=0.001) in the unadjusted models, indicating a socioeconomic gradient. However, none of the adjusted models presented a significant association between levels of self-perceived affluence and fighting-related injury within the male population. Females in general had higher risk estimates when examining the association between self-perceived affluence and fighting-related injury. When unadjusted, low affluence females had nearly 4 times the risk of obtaining a fighting-related injury compared to high affluence females (p<0.001), and moderate affluence females had almost twice the risk (p<0.001). After adjusting for confounders though, the risk decreased to 3 times when comparing low and high affluence groups (p<0.001), and when examining the moderate affluence group (RR=1.74, p=0.024).

When looking at the FAS variable, low FAS males were nearly 3.5 times more likely to report a fighting-related injury (p<0.001) while moderate FAS males were 22% *less* likely to report a fighting-related injury when unadjusted (p=0.362). However the multivariate models showed that the risk decreased for lower income males (RR=2.10, p=0.006) and moderate FAS males (RR=0.83, p=0.240). For females, the association between FAS and fighting-related injury showed an inverse gradient where risk estimates increased with lower FAS groups, although no estimates were significant.

In regards to area-level income, post hoc power calculation revealed that we did not have sufficient power to detect true injury effects if they did in fact exist. None of the models showed significant risk estimates with the exception of the bivariate association within females where low income females were twice as likely to report a fighting-related injury (p=0.030).

4.5 Discussion

This study is unique in its contribution of assessing the relationship between family affluence and physical fighting and fighting-related injury among Canadian adolescents by using several indicators for family affluence and focusing specifically on injuries caused by fights as opposed to general injuries. Lower levels of affluence were generally associated with a higher risk of participating in a physical fight and obtaining a fighting-related injury. These associations varied in strength depending on the affluence measurement that was used, and within male and female subgroups.

With regard to the overall prevalence of physical fighting (35.6%) and fighting related injuries (2.7%) in the entire HBSC population, the findings are consistent with what is seen in previous research. The sex-based differences highlighted for both outcomes is consistent with prior findings. Sex was a significant effect modifier that interacted with family affluence. When assessing the prevalence of physical fighting and fighting-related injury, males reported higher frequencies of each outcome than females. However, when assessing the relationship between family affluence and the risk of each outcome, it appears that risk estimates were higher in females than males for both outcomes, especially when examining the self-perceived affluence measurement. Furthermore, the associations within the female stratum remained significant when adjusted for additional confounders. A previous U.K. study by Nasr and colleagues contained similar results where they assessed this relationship, stratified the results by sex, and concluded that the risk estimates were higher in girls than boys (29).

When using the FAS measurement, there were remarkable differences between the male and female adolescent population when assessing the association between family wealth and the outcomes of physical fighting and fighting-related injury. Within male adolescents, there was significant protective effect when comparing an individual's risk of participating in a physical fight between the moderate and high material wealth groups, while the increased risk between the low

and high affluence groups was insignificant. Among the male adolescent population, those in the lower FAS affluence group had significantly higher risk (almost 3 times) of obtaining a fighting-related injury than those in the high affluence group, whereas the decreased risk in the moderate affluence group was null when compared to the high affluence group. This appears to be a threshold effect where there is no significant difference between the high and moderate material wealth groups in regards to injury, but the risk sharply increases when comparing the low and high affluence groups. This may be due to a number of reasons. It is suspected that parents and adolescents from disadvantaged homes are not likely to be 'reached' by many health promotion resources, or parents in these areas may be unaware of the risks related to violence and are less exposed to interventions compared to parents from high or moderately affluent homes that have the minimum resources (such as electronics or transportation) that allow them to be 'reached out' (29). It is also suspected that poorer families experience financial stress and may not have the time or resources to thoroughly supervise or monitor their children. While individuals in the low FAS group constitute a very small proportion of the HBSC sample (2.4%), this cannot be ignored as this population contains a large percentage of the individuals who participate in physical fights and are injured as a result. It is important to address this issue due to detrimental health outcomes that result from physical fighting and fighting-related injury, and the mechanism behind this needs to be better understood. This threshold effect was not observed for the female population though and a socioeconomic gradient was observed instead. More research needs to be done to understand why this threshold effect was only witnessed in boys.

When assessing area-level average household income, there was a small increase in the prevalence of physical fighting and fighting-related injury in the lower income group. When assessing its association with physical fighting, there was a significant increase in risk when comparing the lower affluence category to the higher affluence one, although this became insignificant for the multivariate model. This is suspected to be because of neighbourhood

characteristics such as neighbourhood-level poverty and poorly maintained or unsafe residences that can weaken levels of social control and result in increased crime rates, which increases risk for violence and injuries (6,20,30).

The analyses with the area-level income measurement resulted in null findings when examining grade 9-10 students in the subset analysis. The area-level measurement may have yielded inconsistent results because the school postal code may be a poor approximation for area-level family income and there was likely insufficient power to detect injury effects as the estimated prevalence of fighting injuries was higher than the actual prevalence that was recorded. Future research may benefit from using a measure that more accurately estimates the affluence of an individual's neighbourhood home rather than school as well as ensuring a large enough sample so as to have an adequate number of injury events occur.

Differences in risk suggest that the prevalence of physical fighting alone is higher in males than females, but the socioeconomic gradient in association with fighting and injury is stronger in females than males, where low income females are at exceptionally higher risk of obtaining both outcomes compared to higher income females. This suggests that when implementing public health interventions, focus on the male population at all affluence levels may be equally effective since it is suspected that male aggression and fighting is encouraged because of biological reasons such as increased testosterone levels, or social predispositions that reinforce gender norms (31,32). However when directing interventions at girls, it is imperative to focus public health efforts on low income females as they are at significantly higher risk of reporting both outcomes compared to females from highly affluent families. It is also important to involve parents, guardians and other grown up figures in a young person's life who can influence and monitor their behaviour, especially aggressive ones (33).

Strengths and Limitations

This study contains methodological strengths. For instance, it uses a large and nationally representative dataset that allows the results to be viewed with respect for the Canadian population. Further analysis focusing on a subset of grade 9-10 students accounted for additional variables not available in the entire dataset (such as the marijuana use variable). A comparison of the multiple measures of family wealth is another strength of this study since many measures exist and affluence is a construct that can be difficult to conceptualize and measure, especially in young people. This study explores various aspects of this construct and provides additional information for future research. This study also employs the use of robust error estimates for the regression analysis to account for the multi-level data.

There are also several methodological limitations in this study. Firstly, the area-level income variable used the school postal code to estimate area-level average household income, which may not be the most appropriate or accurate proxy since the school area may not be comparable to an individual's neighbourhood. A more ideal method would be to use individual postal codes to approximate the wealth of an area that individuals reside in. Unfortunately in the 2009/2010 dataset there were significant amounts of missing data for home postal code and thus it was not an ideal measure. Secondly, the HBSC sample is nationally representative to Canada and it may be challenging to generalize these findings to different countries due to the underlying cultural differences in the acceptance of violence within different societies. There is potential for misclassification of the exposures and outcomes where the self-reported affluence question may misclassify participants depending on their frame of reference and perception of what "well off" truly means. The outcomes of fighting and fighting-related injury may also be misclassified if an injury occurred due to a fight during sports activities or martial arts and was classified as a sports-related injury instead. The injury survey items only asked about a participant's "one most serious injury". If there were multiple instances of injuries for an individual in the past year, then the true

prevalence of fighting-related injuries may under estimated as some fighting injuries will be masked by more serious injuries caused by other circumstances. Material deprivation in the adolescent population also cannot be easily resolved since young people have little control over improving their family's finances. This makes it a difficult point of intervention.

The FAS has been critiqued for its current validity since electronics and computers are becoming generally more affordable and may not be good affluence proxy measures. The FAS has been updated for the 2013/2014 HBSC Study to accommodate these societal and economic changes.

4.6 Conclusion

The present study indicates that a socioeconomic gradient exists where lower affluence is associated with a higher risk of participating in a physical fight or obtaining a fighting-related injury. Although the relationships stayed the same, this gradient varied in strength depending on the affluence measurement that was used to assess this relationship. Self-perceived affluence yielded the most significant results and showed a gradient effect; the FAS showed a significant threshold effect within males; and the area-level income showed a weaker gradient effect than the self-perceived affluence indicator and was only significant within female students. The variation in the results demonstrate that each affluence indicator may not measure affluence in the same way or to the same extent. Further analysis needs to be done to explore these measures and their underlying concepts and mechanisms. Further exploration of the interaction effect of sex in regards to the mechanism also needs to be better understood.

List of Abbreviations

CI: Confidence Interval; FAS: Family Affluence Scale; HBSC: Health Behaviour in School-aged Children; RR: Relative Risk; SES: Socioeconomic Status; WHO: World Health Organization

Competing Interests

The authors declare that they have no competing interests.

Author's Contributions

MD and CD conceived the concept and design of this study. BC also participated in the design of this study. MD carried out the statistical analyses and drafted this manuscript. CD and BC helped with data interpretation and provided feedback for this manuscript. All authors read and approved the final manuscript.

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Table 4.1 Description of physical fighting and fighting-related injuries by individual and area-level affluence characteristics in the 2009/2010 HBSC Study.

		Physical Fighting						Fighting-Related Injury					
		Overall		Males		Female		Overall		Males		Females	
	Overall N	n	(%)	n	(%)	n	(%)	n	(%)	n	(%)	n	(%)
Overall	26078	8945	(35.6)	5944	(48.7)	2997	(23.2)	665	(2.7)	443	(3.7)	222	(1.7)
Individual-level Characteristics													
Self-perceived Affluence													
Low	2278	964	(42.3)	555	(54.3)	408	(32.6)	104	(4.6)	51	(5.0)	53	(4.2)
Moderate	8103	3073	(37.9)	1882	(51.0)	1190	(26.9)	267	(3.3)	168	(4.6)	98	(2.3)
High	13746	4504	(32.8)	3228	(46.5)	1274	(18.7)	268	(1.9)	202	(2.9)	67	(1.0)
Total	24127	8541		5666		2873		639		421		218	
Family Affluence Scale													
Low	576	253	(43.9)	147	(54.9)	106	(34.3)	41	(7.2)	33	(12.7)	8	(2.5)
Moderate	7734	2688	(34.8)	1687	(46.1)	999	(24.5)	193	(2.5)	115	(3.2)	78	(1.9)
High	15295	5338	(34.9)	3607	(49.2)	1731	(21.7)	376	(2.5)	255	(3.5)	121	(1.5)
Total	23605	8279		5441		2836		610		403		206	
Area-level Characteristics													
Average Household Income													
Low	8251	3006	(36.4)	1910	(48.2)	1096	(25.6)	230	(2.8)	138	(3.6)	92	(2.2)
Moderate	8178	2931	(35.8)	1930	(49.9)	999	(23.2)	224	(2.8)	147	(3.8)	77	(1.8)
High	8415	2872	(34.1)	2010	(47.7)	862	(20.5)	197	(2.4)	147	(3.5)	50	(1.2)
Total	24884	8809		5850				651		432		219	

Table 4.2 Modified Poisson regression analyses of the association between physical fighting and individual and area-level family affluence stratified by sex.

	Bivariate Model				Multivariate Model [a]			
	Male		Female		Male		Female	
	RR (95% CI)	p-value	RR (95% CI)	p-value	RR (95% CI)	p-value	RR (95% CI)	p-value
Self-perceived affluence								
Low	1.14 (1.05-1.25)	0.003	1.66 (1.45-1.90)	<0.001	0.99 (0.91-1.09)	0.886	1.39 (1.20-1.60)	<0.001
Moderate	1.08 (1.02-1.15)	0.005	1.39 (1.27-1.53)	<0.001	1.02 (0.95-1.09)	0.575	1.30 (1.17-1.43)	<0.001
High	1.00 (Ref)		1.00 (Ref)		1.00 (Ref)		1.00 (Ref)	
Family Affluence Scale								
Low	1.09 (0.92-1.28)	0.317	1.50 (1.23-1.85)	<0.001	1.01 (0.86-1.19)	0.888	1.42 (1.14-1.79)	0.002
Moderate	0.93 (0.89-0.98)	0.008	1.12 (1.02-1.23)	0.016	0.93 (0.88-0.98)	0.010	1.06 (0.97-1.17)	0.213
High	1.00 (Ref)		1.00 (Ref)		1.00 (Ref)		1.00 (Ref)	
Average household income								
Low	1.07 (0.96-1.18)	0.220	1.32 (1.15-1.53)	<0.001	1.03 (0.93-1.14)	0.536	1.26 (1.08-1.46)	0.003
Moderate	1.08 (0.99-1.17)	0.086	1.17 (1.01-1.36)	0.031	1.07 (0.98-1.16)	0.130	1.15 (0.99-1.34)	0.075
High	1.00 (Ref)		1.00 (Ref)		1.00 (Ref)		1.00 (Ref)	
Sub-Cohort Analysis[b]	**Bivariate Model**				**Multivariate Model [c]**			
	RR (95% CI)	p-value	RR (95% CI)	p-value	RR (95% CI)	p-value	RR (95% CI)	p-value
Self-perceived affluence								
Low	1.13 (0.98-1.30)	0.086	1.63 (1.31-2.01)	<0.001	0.95 (0.80-1.12)	0.550	1.37 (1.09-1.72)	0.008
Moderate	1.12 (1.02-1.24)	0.023	1.29 (1.11-1.51)	0.001	1.03 (0.93-1.13)	0.582	1.17 (0.99-1.39)	0.073
High	1.00 (Ref)		1.00 (Ref)		1.00 (Ref)		1.00 (Ref)	
Family Affluence Scale								
Low	1.11 (0.82-1.49)	0.501	1.32 (0.87-2.02)	0.194	0.94 (0.71-1.26)	0.695	1.44 (0.99-2.07)	0.052
Moderate	0.89 (0.81-0.98)	0.016	1.20 (1.02-1.40)	0.027	0.87 (0.79-0.97)	0.011	1.07 (0.89-1.27)	0.478
High	1.00 (Ref)		1.00 (Ref)		1.00 (Ref)		1.00 (Ref)	
Average household income								
Low	0.98 (0.84-1.15)	0.809	1.04 (0.82-1.30)	0.768	1.01 (0.85-1.19)	0.944	1.01 (0.81-1.25)	0.965
Moderate	0.99 (0.86-1.14)	0.917	1.03 (0.83-1.27)	0.797	1.04 (0.89-1.22)	0.581	0.97 (0.77-1.21)	0.775
High	1.00 (Ref)		1.00 (Ref)		1.00 (Ref)		1.00 (Ref)	

[a] Multivariate regression analysis adjusted for sex, age, academic performance, caring teachers, respectful students, alcohol use, happy home life, and club involvement. P(interaction) < 0.001 for self-perceived affluence, P=0.016 for FAS, and P=0.032 for area-level income. [b] A sub-cohort of 10,429 grade 9-10 students was analyzed to account for confounders only available in the grade 9 and 10 version of the HBSC survey. [c] Multivariate regression analysis for Grade 9 and 10 HBSC survey only and adjusted for sex, age, academic performance, caring teachers, respectful students, alcohol use, marijuana use, happy home life, and club involvement. P(interaction)=0.020 for self-perceived affluence, P=0.115 for FAS, and P=0.723 for area-level income.

Table 4.3 Modified Poisson regression of the association between fighting-related injury and individual and area-level family affluence stratified by sex.

	Bivariate Model				Multivariate Model [a]			
	Male		Female		Male		Female	
	RR (95% CI)	p-value	RR (95% CI)	p-value	RR (95% CI)	p-value	RR (95% CI)	p-value
Self-perceived affluence								
Low	1.64 (1.07-2.49)	0.022	4.03 (2.34-6.94)	<0.001	1.07 (0.67-1.73)	0.775	2.94 (1.69-5.11)	<0.001
Moderate	1.51 (1.19-1.92)	0.001	2.14 (1.36-3.36)	0.001	1.32 (0.98-1.77)	0.063	1.74 (1.07-2.83)	0.024
High	1.00 (Ref)		1.00 (Ref)		1.00 (Ref)		1.00 (Ref)	
Family Affluence Scale								
Low	3.47 (2.05-5.87)	<0.001	1.50 (0.56-4.02)	0.424	2.10 (1.23-3.58)	0.006	1.34 (0.54-3.38)	0.528
Moderate	0.88 (0.68-1.15)	0.362	1.24 (0.90-1.70)	0.193	0.83 (0.62-1.13)	0.240	1.14 (0.81-1.60)	0.462
High	1.00 (Ref)		1.00 (Ref)		1.00 (Ref)		1.00 (Ref)	
Average household income								
Low	1.08 (0.75-1.55)	0.677	2.00 (1.07-3.73)	0.030	0.82 (0.55-1.22)	0.335	1.51 (0.77-2.97)	0.229
Moderate	1.13 (0.82-1.57)	0.450	1.66 (0.92-2.99)	0.094	1.02 (0.71-1.48)	0.903	1.62 (0.81-3.23	0.172
High	1.00 (Ref)		1.00 (Ref)		1.00 (Ref)		1.00 (Ref)	
Sub-Cohort Analysis[b]	**Bivariate Model**				**Multivariate Model [c]**			
	RR (95% CI)	**p-value**	**RR (95% CI)**	**p-value**	**RR (95% CI)**	**p-value**	**RR (95% CI)**	**p-value**
Self-perceived affluence								
Low	1.64 (0.91-2.95)	0.102	4.10 (1.77-9.53)	0.001	1.28 (0.66-2.47)	0.469	2.79 (1.12-6.91)	0.027
Moderate	1.32 (0.93-1.87)	0.126	2.25 (1.12-4.51)	0.023	1.33 (0.83-2.13)	0.233	1.76 (0.84-3.68)	0.133
High	1.00 (Ref)		1.00 (Ref)		1.00 (Ref)		1.00 (Ref)	
Family Affluence Scale								
Low	3.68 (1.75-7.74)	<0.001	0.78 (0.20-3.03)	0.719	1.74 (0.85-3.57)	0.129	0.80 (0.22-2.93)	0.734
Moderate	0.67 (0.45-1.01)	0.057	1.31 (0.81-2.11)	0.271	0.55 (0.32-0.94)	0.030	1.13 (0.68-1.87)	0.634
High	1.00 (Ref)		1.00 (Ref)		1.00 (Ref)		1.00 (Ref)	
Average household income								
Low	1.16 (0.68-1.98)	0.581	1.33 (0.67-2.65)	0.413	1.20 (0.72-1.99)	0.489	1.12 (0.51-2.44)	0.778
Moderate	1.42 (0.90-2.24)	0.133	1.38 (0.68-2.81)	0.377	1.61 (0.97-2.69)	0.068	1.52 (0.67-3.49)	0.319
High	1.00 (Ref)		1.00 (Ref)		1.00 (Ref)		1.00 (Ref)	

[a] Multivariate regression analysis adjusted for sex, age, respectful students, alcohol use, happy home life, and sport team. P(interaction)=0.027 for self-perceived affluence, P=0.290 for family affluence scale, and p=0.172 for area-level income. [b] A sub-cohort of 10,429 grade 9-10 students was analyzed to account for confounders only available in the grade 9 and 10 version of the HBSC survey.[c]Multivariate regression analysis for Grade 9 and 10 HBSC survey only and adjusted for sex, age, academic performance, respectful students, alcohol use, marijuana use, and happy home life. P(interaction)=0.385 for self-perceived affluence, P=0.085 for FAS, and P=0.989.

Chapter 5

General Discussion

5.1 Summary of Key Findings

The purpose of this thesis was: 1) to assess the patterns and trends of physical fighting and fighting-related injury over time, 2) to investigate the association between family affluence and the outcomes of physical fighting and fighting-related injury using a nationally representative sample of Canadian youth, and 3) to compare three measures of family affluence that are available in the HBSC study.

The first manuscript was descriptive in nature and focused on the trends of physical fighting and fighting-related injury from 1993-2010 at various time-points that corresponded with five HBSC cycles. The findings have provided results that are consistent with previous research wherein physical fighting remains a relatively common behaviour (35-41%) and injuries related to fighting remain a rare outcome (1.1-2.3%) (1–3). The key study findings show that there was a significant change in the overall prevalence of both physical fighting and fighting-related injury over time, although trends were difficult to determine with certainty for physical fighting because of the limited number of time-points and a peak in prevalence in the 2005/2006 cycle. The existing data appears to indicate that the prevalence of physical fighting altered over time within specific subgroups such as females, middle school students (grade 7-8), and high affluence groups, while fighting-related injuries have significantly changed over time within all student sub-categories. Crude estimates of risk also established that the male subgroup and individuals from less affluent backgrounds are at increased risk for physical fight participation and obtaining a fighting-related injury. Adolescents who perceive themselves as less affluent were identified as high risk for the

outcomes of interest, which provides further reasoning and directional focus for intervention. Age and sex were also identified as additional risk factors to take into account when assessing the contributing factors to physical fighting and fighting-related injury. This manuscript also contains results from analyzing contextual questions that assess the circumstances of physical fighting and the resulting injuries. It was reported that participants most commonly fought with a friend or someone they knew, which was followed by a sibling. Another very common response was "other". It is suspected that this category conceptually may refer to a rival (sports or otherwise), where participants do not know the other person well enough to call them a friend or someone that they know, but not well enough that they are considered a "total stranger". In all five cycles, fighting-related injuries among adolescents most commonly occurred in their home or yard, their school, and in a street or parking lot. Over half of participants who reported a fighting-related injury missed at least one day of school or usual activities, which suggests that the injuries as a result of fighting were serious. Fighting-related injuries were most commonly reported to occur during the fall in the earliest HBSC cycles, and in the spring during the 2001/2002 HBSC cycle, which may indicate a seasonal effect. This is logical though since youth are likely to be in school and playing actively outdoors during the fall and spring, which provides more opportunities to physically engage and interact with one another both inside and outside of school. A vast majority of the students conveyed that their injury did not occur during an organized activity such as a league or a club, which further suggests that a majority of fighting-related injuries are happening during unstructured or unsupervised time.

The second manuscript focused on physical fighting and injuries related to fights within Canadian adolescents in order to determine if they were significantly associated with three different measures of family affluence. This study was meant to examine these relationships in further depth by using a regression model that accounts for the clustered nature of the data and also accounts for additional factors known to influence this relationship. The key findings established that there is an

inverse association between both individual and area-level family affluence and the risk or occurrence of physical fighting and injuries related to fighting. In other words, as affluence or wealth decreased, the risk for injury or fight participation increased. Physical fighting is a much more prevalent outcome than injuries related to fighting, and while it is rarely reported to result in severe trauma, its potential for injury and emotional harm cannot be ignored, and its association with additional risk behaviours (such as heavy drinking and substance abuse) warrants attention. These collective behaviours are one of the biggest threats to an adolescent's health and well-being (4–6). Likewise, while the prevalence of fighting-related injury is very small in the general population and the injuries themselves are not usually life-threatening (the first manuscript reported that the most common result of a fighting-related injury are broken bones, cuts and puncture wounds), there are potential negative outcomes associated with fighting injuries such as the emotional trauma, disability, pain or decreased levels of overall health and well-being of adolescents, and these should not be ignored (7).

5.2 Application of Epidemiological Concepts

5.2.1 Internal Validity

Internal validity refers to the extent to which the results of a study are free from bias and confounding (8). Some sources that can violate internal validity include selection bias, information bias and confounders. This section will include a discussion of internal validity and the various biases that threaten it in manuscript one followed by manuscript two.

Selection bias is when there are systematic differences in characteristics between those who are selected to participate in a study and those who are not, as well as when the characteristics of those in the study population differ from those in the target population (8). There is the possibility that selection bias may be present in the analyses that underpin both manuscripts. Firstly, the sampling methodology of the HBSC study does not include certain groups of adolescents, such as

individuals who attend private schools, incarcerated youth, home schooled students, high school drop outs, youth who live on First Nation reserves, or those who did not have consent or permission from their school or parents (9). All of these groups have varying backgrounds of affluence that cannot be captured or represented in this study. Presumably, those who attend private school may be more well off than those who attend public school, and students who live on First Nation reserves, are incarcerated, or are high school dropouts may be more likely to be from low affluence families. Exclusion of these groups may underrepresent low affluence and high affluence groups in the Canadian adolescent population. Likewise, their structured time or use of time may differ from those who attend public school. More structured or supervised use of time may provide less opportunity to engage in unsupervised or deviant behaviours, such as physical fighting. Supervised time in activities may also be provided in safer environments, which also gives less opportunity to receive a fighting-related injury. Therefore, if some excluded groups are less well off and are less likely to engage in structured or supervised activities, the risk of physical fighting behaviours and fighting-related injuries in these excluded groups may be underreported in the sample. This underestimation may bias the true effect of family affluence on both outcomes towards the null.

The HBSC methodology states that the HBSC survey is administered to classes for 45-70 minute classroom sessions (9,10), which means that logically the surveys only take a day to administer, complete and return. This indicates that students who were absent the day that the survey was administered are not included in the sample. If students were absent from school the day the survey was distributed due to an injury or other reasons associated with fighting or with their financial circumstances, then the students who have experienced physical fighting encounters, obtained an injury related to fighting, or have specific financial circumstances that impact school attendance may be underrepresented in the sample population.

Information bias refers to bias as a result of measurement error, which is an error in correctly classifying participants with respect to their exposure or outcome status (8). Potential

sources of measurement error are always important to consider in epidemiological studies. For both manuscripts, there is potential measurement error in regards to exposure. To measure family affluence, self-perceived affluence was used for both manuscripts, and the family affluence scale (FAS) and area-level average household income based on a 1 km buffer surrounding the school postal code were used in addition to the self-perceived affluence variable for manuscript two. For the self-perceived measurement of affluence, it is difficult to objectively measure a young person's exact income. In addition, even if multiple families had the same income or expenditure, there is the possibility of variation in answering this question depending on what the individual's perception of "well off" means and the referent group they are using. There were also non-responses for some of the affluence measures (~5-9%, see Table 4.1), which may indicate that some young people are not comfortable with sharing that information. The 2009/2010 FAS uses four items intended to represent family expenditure and family wealth: cars, computers, vacations, and non-shared bedrooms. This version of the FAS has been available in the HBSC survey since the fourth cycle of the HBSC survey in 2002. It is meant to be an indirect measure of family wealth since young people may not know or be comfortable with being asked how much their parents make, but may be able to respond about material items often associated with wealth. While there are many studies that show that the FAS measurement has content validity (11–14), it is also important to consider the cultural and societal changes over time that have occurred. Computers and laptops are not only becoming more affordable, but there is a shift in computer culture where adolescents are becoming increasingly more dependent on computers for educational, creative and socializing purposes compared to the initial implementation of the FAS in 2002 (15). This puts into question the applicability of the FAS to the general population at the time of the 2009/2010 HBSC survey. In fact, the FAS questions have been changed in the 2013/2014 HBSC cycle. If we assume that this measurement in general has poor validity and has fallen out favour for measuring present-day

affluence, then this may result in misclassification error if individuals of equal affluence answer the material asset questions differently depending on what items their families possess (15,16).

This research measured area-level income for each student by using a 1 km buffer surrounding the school as a proxy for their home neighbourhoods. The area-level income characteristics for the school are assigned to each student, which may not be applicable to the students if they do not live within 1 km of their school. This can result in error since we were not able to truly capture the area-level characteristics of the home neighbourhood that the student lived in. A 1 km buffer based on individual home postal codes would have been more ideal for this study, however while the questionnaire in the most recent HBSC study did ask the students for their postal codes, the response rate was low (~60%) and the number of missing observations made this less ideal to use for area-level affluence.

There is also the potential for error in correctly classifying the outcomes of physical fighting and fighting-related injury. For example, if an injury occurred because of a fight during a sports game or martial arts, it is hard to determine if the injury is considered a fight- or sports-related injury. If injuries occurred as a result of a fight during sports games or activities (and were reported as sports injuries), then fighting-related injuries may be underreported in this sample. It is also essential to recognize that the injury data we are using comes from a question about a student's "one most serious injury" and this can have limitations associated with the masking of less serious injury types. This line of questioning therefore is not necessarily the most comprehensive way to measure specific injury type prevalence.

Another type of information bias which is always important to consider in cross-sectional studies is *recall* or *response* bias. This refers to the potential inaccuracy in participants being able to recall or remember experiences or information from the past (8). Due to the self-reported nature of questionnaires, this bias is a legitimate concern for any cross-sectional study.

Social desirability bias is another possible threat to the internal validity of the study, and it refers to the tendency of participants to answer question in such a way that is viewed favourably by others or receives less judgment. A construct such as family income or wealth is likely sensitive to social desirability bias where individuals from less affluent backgrounds might be more likely to inflate their affluence, and individuals of high status may deflate their affluence in an effort to be perceived as "normal". If used in analyses, these data may deviate the true effect to the null. Physical fighting is also a violent behaviour that may be viewed unfavourably in the general population and therefore may be underreported in the sample. Likewise, in an effort for participants to appear tough, physical fighting may also be over-reported. While there is a chance of either of these occurring in the study, the errors as a result of this bias are not anticipated to be differential.

5.2.2 External Validity

External validity, or generalizability, refers to the degree to which the results of a study can be reliably generalized to a broader population from which the sample was taken (8). Both manuscripts seen in this thesis assess the research questions using a large, nationally representative sample of Canadian adolescents. The sampling methodology and the use of provincial and territorial weights to account for under- and over-weighted populations in the most recent HBSC study help ensure its representativeness. Therefore, if it is assumed that minor violations to the internal validity of each study are present, then it can be safely assumed that the results that were derived from each manuscript can be applied to the overall Canadian population of young people. Having said this however, we do need to ensure that associations are not inappropriately attributed, where for example an obvious or underlying sub-population characteristic might affect generalizability. In addition, while the use of the HBSC data might allow us to generalize to the general population within Canada, the generalizability of the study results may not be able to be extended to similar developed countries outside of Canada. This is particularly because there are

school policies pertaining to fighting and violence that vary across countries, as well as the societal and cultural norms and expectations related to physical fighting and violence. The economic situations within each country also vary. Walsh and colleagues (2013) studied the prevalence of physical fighting and weapon carrying among adolescents in five different countries (Belgium, Canada, Israel, FYR Macedonia, and the USA) all of which have diverse backgrounds in regards to political and social context, policies about weapon carrying, levels of societal violence, and intervention strategies. The authors found that there were large variations across the countries, which are likely suspected to be because of these societal differences (17). This study shows the importance of social and cultural contexts when generalizing findings.

5.2.3 Causation

One very important aspect of epidemiological research is recognizing whether etiological relationships have grounds for causation. Bradford Hill's criteria of causation covers many possible aspects that infer causality, and this section will contain a discussion that refers to the postulates of this criteria (temporality, strength of association, consistency, dose-response relationship, and biological plausibility) and how they relate to each manuscript.

Temporality. Temporality is a very important postulate since exposures must precede the occurrence of the outcome in order to establish causal inference. The cross-sectional nature of the HBSC dataset where information on both the exposure and outcome were collected at the same time causes difficulty in determining whether the exposure precedes the outcomes. It was not anticipated to be a significant issue though for both manuscripts since for young people, their economic situation is largely dictated by their family income and not personal finance, which means that it is a variable that would have already been established before the survey was completed and likely before the occurrence of any fighting or injury event. Fights and fighting injuries are more acute and sudden in nature and are less likely to dictate their financial circumstances since it occurs

for a short period of time. Therefore, temporality was not anticipated to be problematic in either study.

Strength of association. Both studies presented in this thesis measured the strength of each association using relative risks (RR) as the effect estimate and high affluence groups as the referent group. The results showed a weak crude association between family affluence and physical fighting (females: RR=1.66 for low affluence, and RR=1.39 for moderate affluence; males: RR=1.14 for low affluence, and RR=1.08 for moderate affluence), although the degree of significance was strongest for the self-perceived affluence measurement since the p-value was much smaller than the predetermined level of significance where p-value <0.05. The association became less strong when adjusted for multiple covariates. Weaker associations were observed when using the FAS and area-level income measurements, with area-level income having the weakest association with physical fighting. Fighting-related injuries on the other hand were seen to have stronger relationships with the affluence measurements (females: RR=4.03 for low self-perceived affluence, and RR=2.14 for moderate self-perceived affluence; males: RR=1.64 for low self-perceived affluence, and RR=1.51 for moderate self-perceived affluence).

Strong and significant associations were only consistently seen for the measurement representing self-perceived affluence. Therefore, the strength of the association between the exposure and outcome is difficult to establish since it is not seen consistently for measures that are supposed to measure the same construct.

Consistency. There are various aspects of consistency that can be measured in this thesis. For example, the literature review of this thesis examines prior studies that have also assessed the relationship between family affluence and the outcomes of physical fighting and injuries related to fighting among adolescents. The association between affluence and violent behaviours such as physical fighting has not been shown to be consistently significant across epidemiological studies. The relationship between affluence and injuries related to fighting has also not been extensively

studied, and the few studies that have already looked in this relationship and have provided inconsistent results (6,18,19).

The first manuscript examines the consistency of this relationship over time using the HBSC data that was administered at various time-points from 1993 to 2010. The trend results from this study did demonstrate the same inverse association between family affluence and each outcome at the various time-points. This demonstrates that the HBSC data has been consistent in measuring this association over time within Canada.

The second manuscript further examines the relationship between family affluence and physical fighting and injury by seeing if the relationship is consistent when using the three different measurements representing family affluence. While each measurement consistently yielded similar results where there is an inverse association between income and fighting and fighting-related injury, the extent that this relationship occurred varied for each measurement. The self-perceived affluence measurement showed highly significant results for both outcomes even when assessing this relationship with males and females. The FAS measurement showed less consistent results when the results were stratified by gender. The inverse relationship with physical fighting was presented as significant within the female population, but not for the male population which displayed a very strong threshold effect when assessing this variable with fighting-related injury. The area-level income measurements showed many null results for the unadjusted and adjusted models for both outcomes. Consistency is therefore difficult to determine with certainty due to the lack of consensus in the results for each affluence measurement present.

Dose-response relationship. This postulate evaluates whether there is a gradient effect between the exposure and outcome. Both the bivariate and multivariate analyses between the exposure of affluence and the outcomes of physical fighting and fighting-related injury demonstrated a dose-response relationship where the risk of participating in a physical fight or obtaining a fighting-related injury increased with lower levels of wealth or income, indicating an

inverse gradient. Manuscript one showed a significant trend depicting this gradient when assessing self-perceived affluence ($p_{trend}<0.001$). This dose-response relationship was not necessarily depicted though when assessing the FAS and area-level income measurements in manuscript two. When assessing the relationship between FAS and physical fighting, there only seemed to be a significant inverse dose response relationship within the female stratum. However, for the relationship between FAS and fighting-related injury, there seemed to be a significant and large increase in risk within males when the low affluence group was compared to the high affluence group (RR=3.47, p<0.001), and a null effect when comparing the moderate affluence group to the high affluence group (RR=0.88, p=0.362), which may represent more of a threshold effect than a dose-response effect in regards to material wealth. With respect to the area-level measurement, a dose-response relationship only appears to be present within the female population for both of the outcomes, although the risk estimates are only significant for the bivariate models and the multivariate model for physical fighting. In regards to the association between family affluence and the two outcomes interest, a dose-response relationship appears to be conditional on the measurement that is used; consequently it is hard to establish if this is a true dose-response relationship.

Biological plausibility. In regards to the biological plausibility, both manuscripts have a theoretical basis from social and conceptual frameworks and theories assessing how social determinants such as family expenditure can influence health behaviours in individuals and their potential for certain health outcomes. For example, according to the social disorganization theory, it is plausible that lower affluence at the neighbourhood level and unsafe residences can lead to lower levels of social control, which can possibly increase risk for violence and injury (20). The results from the manuscripts also fit into the larger body of health research that indicate there are important and significant relationships between family wealth and physical fighting behaviours as well as injuries caused by specific activities such as fighting.

5.2.4 Confounding and Effect Modification

Confounding is when the true measured association between the exposure and outcome is masked by another factor that is independently related to both the exposure and outcome without being in the causal pathway (8). This is quantified as a change of at least 10% between the crude effect estimates and after the estimates have been adjusted for important confounders. The statistical analysis used in the second manuscript involved multivariate analysis to consider potential additional factors that may be associated with both the exposure and outcome. Confounders that were found to be significant for the physical fighting models based on the backwards selection criteria ($p<0.15$) included sex, age, academic performance, caring teachers, respectful students, excessive alcohol use, happy home life, and extracurricular involvement. Important factors that are significantly associated with fighting-related injury include sex, age, respectful students, excessive alcohol use, happy home life, and participation in sports teams. However, there were a couple of instances of potential confounding that simply could not be accounted for in this thesis due to the unavailability of certain variables in the entire sample, and as such this unmeasured potential confounding may have altered the results. For example, drug use was one such variable that was difficult to assess in the entire HBSC population. There are two versions of the HBSC survey: one for grade 6 to 8 students, and the other for grade 9 to 10 students. While the two survey versions contain essentially the same sets of questions, the grade 6 to 8 HBSC survey omitted questions about drug and substance use and this may have been a concern, particularly among the older members of this grades 6-8 sub-cohort. If drug use was taken into account in the multivariate model, then only the grade 9 to 10 students who answered the question would have been included in the sample. This would have reduced the sample size by approximately 50%, thus decreasing study power. Therefore, the entire sample was included in the regression analysis without being able to account for the confounding effect of drug use. However, a multivariable analysis of the sub-cohort of grade 9 and 10 students was undertaken to account for

marijuana use as a proxy for substance use, and was found to be a significant confounder in the analysis of the sub-cohort. Furthermore, residual confounding may still exist after adjusting for all measurable and significant confounders due to errors in correctly measuring or classifying participants. Inaccuracies in correctly classifying participants according to each confounder variable can distort the true relationship between family affluence and the outcomes of interest.

Effect modification is when the relationship between the exposure and outcome varies on different levels of another factor, which means that it is important to stratify the relationship of interest by this modifying variable. In this analysis, sex was found to significantly modify or interact with the family affluence variable, which means that the nature and magnitude of the effect between family affluence and the outcomes of physical and fighting-related injury were significantly different in boys and girls. The results from manuscript two were presented in strata respective to sex. Previous studies have also assessed the associations between family affluence and physical fighting and fighting-related injuries while stratified by sex (21–26).

5.2.5 Models and Goodness-of-fit

The second manuscript of this thesis utilizes several regression models to accurately quantify the likelihood of the outcomes of interest. It is good epidemiological practice to understand the methods that are used to choose the statistical model that best fits the data. The modified Poisson regression models featured in manuscript two can use the quasi-likelihood under the independence model criterion (QIC) to compare model fit via the GEE method. QIC is meant to be analogous to the Akaike Information Criterion (AIC) seen in generalized linear models, which uses likelihood based methods to compare models (27,28). QICu approximates the QIC when the GEE model is correctly specified (27,28). Both the QIC and QICu are recommended to be used for equally suitable structures with similar sample sizes when comparing models (28). The model with the smallest QIC value is usually chosen for model selection and represents the best combination of

covariates that most accurately depict the relationship (29). When assessing physical fighting as the outcome of interest, the self-perceived affluence exposure presented the model with the smallest QIC and QICu statistics (see Appendix F). For the outcome of fighting-related injury, the regression model with area-level income contained the smallest QIC and QICu values (see Appendix F). These results indicate that the self-perceived affluence and area-level measurements best fit the HBSC observations for the outcomes of physical fighting and fighting-related injury respectively.

5.2.6 Comparison of Family Affluence Measurements

A secondary objective of the second manuscript was to compare the three measurements used to represent family affluence to see if they would reach similar results when included in each modified Poisson regression model. Each affluence measurement yielded different results when assessing their association with physical fighting and fighting-related injury. The self-perceived affluence measurement presented a highly significant relationship in both the bivariate and multivariate models. The FAS measurement contained significant results in some cases, such as comparing low affluence to the referent, but not significant in the case of comparing average affluence to the referent. This appears to present a threshold effect. Lastly, the area-level average household income measurement yielded mostly insignificant results. It is possible that due to the self-reported nature of the self-perceived affluence measurement that the results could have been biased away from the null effect. Therefore, future researchers could exercising precaution when using this variable due to its lack of objectivity. Validity studies could also be done to further assess the true precision of this indicator.

The FAS measurement is more objective than the self-perceived affluence question since it uses a composite scoring system to assess material wealth. However, as previously mentioned in section 5.2.1, the measurement may be falling out of favor due to societal and economic changes over time that deem certain questions featured in the FAS irrelevant. Hence is why the FAS has

been modified in the 2013/2014 HBSC study. Therefore, should future researchers choose to use the FAS measure or apply the results from studies that have used the FAS, they should exercise precaution and determine if the questions asked in the FAS are relevant in context to their cultural and societal conditions.

The area-level income measurement utilized census data to approximate average household income in the school area within a 1 km buffer. Out of the three affluence measurements, this measure is the most objective since it does not rely on self-reported data. It important for researchers to understand the implications though of using the school postal code instead of an individual's postal code to assess area-level income. Using the school area may not be a perfect proxy for neighbourhood income, especially if the participant lives outside of the 1 km buffer of the school. Therefore, researchers should consider more accurate and precise data that represents the income level of a participant's neighbourhood. This could include more effective ways of extracting home postal codes from individual participants to link to Census data.

5.3 Strengths of this Thesis

This thesis contains two manuscripts with unique contributions whilst using a large, nationally representative sample of Canadian adolescents. The HBSC study uses provincial and territorial weights to help enhance the representativeness of the sample to the Canadian adolescent population. This representation of the young people supports its generalizability to the Canadian adolescent population. A large sample size in the analyses underpinning both manuscripts also provided substantial power to detect significant differences across the study subgroups where such differences exist.

Child and adolescent injury in Canada is considered a public health priority and a leading cause of death among adolescents, and there is a necessity for etiological studies that focus on context-specific injuries. This thesis provides additional epidemiological information on the

patterns of injuries in the context of fighting in the adolescent population, as well as additional evidence of the relationship between family affluence and fighting-related injury in the Canadian adolescent HBSC population.

Manuscript one helped identify demographic and socioeconomic groups that are most likely to engage in physical fights and who are also most vulnerable to injuries from participating in these fights. Acknowledging vulnerable populations will help define priority areas for preventing physical fights among adolescents and decrease the risk of fighting-related injury. This will give clearer direction for awareness and health promotion programs. This study also provided to a certain degree a qualitative aspect where questions that assessed the context and circumstances of each injury were asked. The consideration of these questions provides additional richness to the results of this study.

Manuscript two used multiple socioeconomic measures in the assessment of the association between affluence and physical fighting and fighting-related injuries. This follows the recommendations of previous studies for the use of more than one indicator and a critique of the ability of any single measure to accurately represent family affluence (26). This can provide valuable insight for future HBSC studies wishing to assess family affluence among adolescents and compare affluence measurements, including what precautions to take with these measurements and how to direct validity studies on these measurements.

Another methodological strength of this study was the use of Poisson regression modeling with robust error estimates to account for the clustered data. The utilization of Poisson regression models for dichotomous outcomes tends to provide wider confidence intervals for the relative risk, which leads to more conservative results (30,31). Robust error variations, or sandwich estimators, are featured in the modified Poisson regression to account for the clustered binary data. The multi-level analysis is important to consider since the sampling methodology for the HBSC selected whole schools to obtain participants for this study. Since participants from the same school are

more similar than students between two schools, accounting for the variance at the school level is important since we cannot assume that the participants are independent. Therefore, using a regression technique that accounts for this clustering effect, such as the modified Poisson regression model, increases the strength and validity of the study results.

5.4 Future Research Directions

There are many opportunities for further research that can arise from the two studies in this thesis. In manuscript one, a clear relationship was established between physical fighting and fighting-related injury with various demographic characteristics such as sex, grade and self-perceived family affluence. Trend analyses of each outcome can be further explored when future HBSC studies become available. This is especially pertinent for the outcome of physical fighting since the study described in manuscript one concluded that there were not enough time-points in the study data to accurately describe the prevalence trends. Three time-points from 2001 to 2010 concluded that there was a general upward trend in physical fights, although this is suspected to be because the highest prevalence was estimated in the middle time point (2005/2006) which directed the trend test statistic upwardly. More time-points would help establish if the prevalence trend was consistently increasing over time. Furthermore, in manuscript one the study also included variables that describe the scenario or circumstances of the fighting-related injuries or physical fighting encounters. While these variables provided interesting perspectives, a qualitative study that thoroughly explores the impressions and themes of physical fighting and fighting-related injury from the perspective of young people may further enrich the literature surrounding physical fighting and violence among the adolescent population.

The study described in the second manuscript of this thesis found that adolescents from less affluent families are more likely to engage in at least one physical fight or obtain an injury related to fighting. There is a requirement for further understanding of the physical and behavioural

mechanisms that directly link individual and area-level income and the various types of adolescent injuries (19). This manuscript also discovered that sex was an important effect modifier for the outcome of physical fighting, and highlighted important differences between the two sexes when assessing the association between family affluence and the outcomes of interest. Further exploration of the interaction between sex and affluence in relation to violent outcomes is warranted, whether it be to establish the mechanism, or replicate the findings with an international sample. It would be useful to confirm the consistency of the results since the modification effect may only have been relevant in the context of the Canadian cultural or economic circumstances at that cross-sectional time-point. Some of the regression models, in particular the FAS and area-level income models, had low power (<40%) to detect true differences in risk between the different affluence categories (see Appendix E). Future researchers who would like to replicate the findings of this study should look into using a larger sample size in order to increase the power and to more accurately detect true effects. Due to the lack of potential confounders that could not be accounted for this study, a dataset with all of the important confounders that were established in this study would also be beneficial and provide more evidence about the true relationship between family affluence and the outcomes of physical fighting and fighting-related injury.

Both studies were cross-sectional studies, and while temporality was not expected to be an issue in this thesis, prospective studies may be useful for confirming causal inference in future research.

5.5 Public Health and Policy Implications

The results from this thesis contribute to the existing and continuously growing body of research emphasizing the risk among adolescents from low affluence backgrounds for physical fighting and injury. Fighting-related injury is an outcome that has not been extensively covered in

injury research and this thesis provides a unique contribution in the aspect of the relationship between affluence and risk for injury.

The findings from our research suggest that public health interventions to reduce the occurrence of physical fighting encounters and fighting-related injuries should justifiably be focused on adolescents who are from less affluent families. The affluence and injury gradient is much stronger in girls, therefore when using public health approaches in the female population, focusing intervention efforts on young and less well-off females is justifiable. While boys are more frequently involved in physical fights and develop injuries related to fighting, the results demonstrate less emphasis on the socioeconomic gradient in this population; therefore public health interventions to reduce these outcomes can be aimed collectively at the male population. However, males with low material wealth were also shown to be significantly more likely to obtain a fighting-related injury. Although the gradient is not as prominent when assessing the association between family affluence and physical fighting, the potential for physical and emotional trauma as a result of a fighting-related injury cannot be overlooked. Interventions that are collectively aimed at male adolescents to prevent physical fights would be the optimal way to intervene; however focusing on males with low material wealth may further decrease their risk of developing an injury in the future. Additionally, these findings may imply the importance of further studying the difference in the development and conception of physical fighting behaviours between boys and girls.

One intervention for reducing physical fight occurrences in adolescents includes social development programs which work to reduce aggressive behaviours and violence among adolescents by promoting positive and cooperative behaviours through anger management, behaviour modifications, adoption of social perspectives, moral development, improving social skills, solving social problems, and resolving conflicts (32). Also, encouraging children and adolescents to get more involved in extracurricular activities (which have been shown to be a more constructive and safe activity for young people), or developing and increasing the availability of

cost-effective activities for children and adolescents in high-risk areas to spend their free time after school can be effective (32).

While interventions may be practicable for the current adolescent population in reducing violent encounters and the long-term consequences of such behaviour, prevention strategies with families and before a child reaches adolescence may be one of the most important methods to reduce future physical fights and fighting-related injuries. Children as early as preschool can start exhibiting physical aggression, which in some cases can transform into serious violent behaviours during adolescence and adulthood (33,34). Therefore, preventing such serious behaviours are of paramount importance while children are still young and developing. Prevention strategies, such as preschool enrichment programs, can be focused at families who are high risk such as those who have less affluent backgrounds or low levels of education. There are also strategies that influence the interactions that youth experience on a regular basis. These include home visitations (where nurses or healthcare professionals visit a child's home to provide support and counselling for high risk families), parental support and education (which works to improve family relations and child-rearing techniques), mentoring programs, and family therapy to improve communication and interaction (32,34).

Many of the interventions and implications mentioned here are aimed at schools or families. However, many correlates of physical fighting and other aggressive behaviours exist beyond these areas. At a policy level, it may be beneficial for school board members and municipal governments to consider modifying and improving school and neighbourhood settings by changing teaching practices, improving school and municipal policies and rules, and improving infrastructure (e.g., better lighting, more recreational spaces) to create safer and more enriching environments for young people to learn and spend the vast majority of their time.

There are also implications at the societal level. The findings indicate that poverty is an important economic barrier to safer and healthier environments for children to thrive in, and it is a

vital issue to address. Public health efforts that have addressed this issue include reducing poverty concentration in impoverished areas and implementing interventions such as moving high risk families to areas of higher wealth (32). Studies have shown that public health interventions are effective at reducing harm in youth. For example, a retrospective cohort study by D'Souza and colleagues (2008) in New Zealand assessed the impact of eliminating child poverty as an injury prevention strategy, and discovered that reducing poverty had the potential to reduce child mortality from unintentional injury by 3.3 to 6.6% (35). While D'Souza and colleagues did not assess the reduction in injury morbidity, the findings demonstrate the importance and public health implications of reducing poverty.

It is also recognized that there are cultural factors embedded in society that stimulate and support violence, and as such, using approaches such as public information campaigns to change social norms and promote pro-social behaviour should be aimed at high-risk areas and families (especially those that are of low affluence). Collaborations between schools and other key players such as community mental health agencies, community development organizations and governments are necessary to reduce the occurrence of physical fights and other violent behaviours among youth (34).

5.6 Conclusion

Physical fighting and injuries related to fighting have become an increasingly concerning public health problem among adolescence as the prevalence for both of these outcomes have increased over time. Adolescents who are at increased risk for both of these outcomes are those who come from backgrounds of low affluence. Public health interventions should focus on poverty reduction as well as targeted violence and injury prevention initiatives in order to further reduce the occurrence of both physical fights and injuries related to fighting in adolescents.

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Appendix A
HBSC Survey Methodology

HBSC Student Questionnaire and Data Collection

The student questionnaire is the main source of information for the HBSC studies, and there are two versions of the questionnaire: one for Grades 6, 7 and 8, and a second survey for Grades 9 and 10. Surveys are made available in English, French, and Inukitut. Questionnaires are administered by teachers to classes during one 45-70 minute classroom session (40 minutes in previous HBSC cycles(1,2)), and students completed the questionnaires individually at their own pace sometimes after they are given instructions on completing the survey at the start of the session. Grade 6 and 7 students are read the surveys aloud to accommodate various reading comprehension levels, while students in higher grades completed the survey at individual paces under the supervision of the researchers. Surveys may also be read aloud by teachers in classes where literacy was a concern. Students then returned completed and unsigned surveys in sealed envelopes to ensure anonymity. Completed questionnaires are then returned to Queen's University for data entry.

Consent

Three levels of consent are mandatory in order for students to participate in the HBSC study. At the first level, permission is needed from school jurisdictions of participating schools to invite schools and students to partake in the study. At the second level, school principals of sampled schools are invited to participate. At the third level, active parental consent (signed consent forms allowing participation) and passive parental consent (participation allowed if consent form is not returned expressing refusal of participation) are obtained. After each level of consent is achieved, participation from the students is voluntary.

Sampling Procedure

For the 2010 HBSC study, a sample of Grade 6 to 10 students was recruited from across Canada. For each province (except for Prince Edward Island and New Brunswick), a two-stage cluster sampling approach was employed. Whole classes of students were selected to participate through school directories and lists that are in eligible and consenting school jurisdictions. Private and special schools such as on-reserve schools were not included. The number of classes chosen to participate from schools was based on grades in the school, the number of teachers, total enrollment, and enrollment by grade with variation by province taken into consideration (1,3,4). Classes were provided equal opportunity to participate and were ordered on sample lists and proportionally distributed accordingly by jurisdiction, language of instruction, public/Roman Catholic designation, community size and provincial location (1,3,4). In regards to each of the three territories, the 2010 study included all Grade 6 to 10 students who were able to participate in order to obtain census data for the entire student population. Earlier cycles however included small numbers of classes from each territory to be accurately proportionate to the general population (4).

This sampling approach has been relatively constant since its inception in Canada in 1989/1990. However, based on 1990 and 1994 protocols, Canada only sampled students from Grades 6, 8 and 10 to match the target age groups (11, 13, and 15 years old) as accurately as possible (4). However, in 1998 Canada started sampling from Grades 6 through 10 in order to achieve the best overall representation of the three target age groups and has remained that way to the current 2010 study (4).

It is acknowledged that since the sampling methods of earlier HBSC studies are different to a certain extent, the comparability of each sample is debatable.

Response Rates

An estimated 77% of eligible students participated in the 2010 HBSC study in Canada (3), which is a slight increase from the previous HBSC cycle (74%) (1). For Cycles 5 and 6, 10% or less of students refused participation or spoiled questionnaires intentionally, and the remainder of students were unable to participate due to failure to return consent forms, failure to receive parental consent or school absence when the survey was administered (1,3).

Survey Weights

Prior the 2010 study, based on the sampling procedures of schools that required the consideration of characteristics of the Canadian population (such as province, language of instruction location, community size, and school type), the sample was designed to be self-weighting in accordance with international protocols (1,2). For the 2010 study, the results of the Canadian data were weighted so that students' responses for provinces or territories contribute to national results in proportion to the actual student population within the national grade group population (3,4). Over-represented provinces and territories are given a weight of less than 1, and under-represented jurisdictions in the data are given a weight of greater than 1 (3,4). The weights for each grade from 6 to 10 are calculated independently (3,4).

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Appendix B

Key Survey Items

Exposure variables for Manuscript 1

HBSC Cycle	Exposure	Question/Variable Measurement
2009/2010	Sex	Q1. *'Are you male or female?'* (1=Male, 2=Female)
	Grade	Q4. *'What grade are you in?'* (1=Grade 8, 2=Grade 9, 3=Grade 10, 4=Grade 11 in Grade 9-10 survey) (1=Grade 5, 2=Grade 6, 3=Grade 7, 4=Grade 8, 5=Grade 9 in Grade 6-8 survey)
	Self-Perceived Affluence	Q50. *'How well off do you think your family is?'* 1=Very well off 2=Quite well off 3=Average 4=Not very well off 5=Not at all well off
2005/2006	Sex	Q1. *'Are you male or female?'* (1=Male, 2=Female)
	Grade	Q3. *'What grade are you in?'* (1=Grade 8, 2=Grade 9, 3=Grade 10, 4=Grade 11 for Grade 9-10 survey) (1=Grade 5, 2=Grade 6, 3=Grade 7, 4=Grade 8, 5=Grade 9 for Grade 6-8 Survey)
	Self-Perceived Affluence	Q53. *'How well off do you think your family is?'* 1=Very well off 2=Quite well off 3=Average 4=Not very well off 5=Not at all well off
2001/2002	Sex	Q1. *'Are you male or female?'* (1=Male, 2=Female)
	Grade	Q4. *'What grade are you in?'* ____
	Self-Perceived Affluence	Q75. *'How well off do you think your family is?'* 1=Very well off 2=Quite well off 3=Average 4=Not very well off 5=Not at all well off
1997/1998	Sex	Q1. *'Are you male or female?'* (1=Male, 2=Female)

	Grade	Q3. *'What grade are you in?'* _____
	Self-Perceived Affluence	Q39. *'How well off do you think your family is?'* 1=Very well off 2=Quite well off 3=Average 4=Not very well off 5=Not at all well off
1993/1994	Sex	Q1. *'Are you male or female?'* 1=Male 2=Female
	Grade	There is a survey for each grade (6, 8 or 10).
	Self-Perceived Affluence	Q35. *'How well off is your family?'* 1=Very well off 2=Well off 3=Average 4=Not at all well off 5=Not at all well off 6=I don't know

Outcome variables for Manuscript 1

Outcome: Physical Fighting

HBSC Cycle	Question/Variable Measurement
2009/2010	Q42. *'During the past 12 months, how many times were you in a physical fight?'* 1=I have not been in a physical fight in the past 12 months 2=1 time 3=2 times 4=3 times 5=4 times or more
2005/2006	Q40. *'During the past 12 months, how many times were you in a physical fight?'* 1=I have not been in a physical fight in the past 12 months 2=1 time 3=2 times 4=3 times 5=4 times or more Q41. *'The last time you were in a physical fight during the last 12 months, with whom did you fight?'* 1=I have not been in a physical fight in the last 12 months 2=A total stranger 3=A parent or other adult family member 4=A brother or sister 5=A boyfriend/girlfriend or date 6=A friend or someone I know 7=Someone not listed above

2001/2002	Q63. *'During the past 12 months, how many times were you in a physical fight?'* 1=I have not been in a physical fight 2=1 time 3=2 times 4=3 times 5=4 times or more Q64. *'The last time you were in a physical fight, with whom did you fight?'* 1=I have not been in a physical fight 2=A total stranger 3=A parent or adult family member 4=A brother or sister 5=A boyfriend/girlfriend or date 6=A friend or someone I know 7=Someone not listed above

Outcome: Fighting-related Injuries

HBSC Cycle	Question/Variable Measurement
2009/2010	Q43. *'During the past 12 months, how many times were you injured and had to be treated by a doctor or nurse?'* 1=I was not injured in the past 12 months 2=1 time 3=2 times 4=3 times 5=4 times or more Q44. *'Where were you when this one most serious injury happened?'* 1=I was not injured in the past 12 months 2=At home/in yard (yours or someone else's) 3=School, including school grounds, during school hours 4=School, including school grounds, after school hours 5=At a sports facility or field (not at school) 6=In the street/road/parking lot 7=Other location Q45. *'What were you doing when this one most serious injury happened?'* 1=I was not injured in the past 12 months 7=Fighting Q46. *'Did this one most serious injury need medical treatment such as the placement of a cast, stitches, or staying in a hospital overnight?'* 1=I was not injured in the past 12 months 2=Yes 3=No

	Q47. *'Did this <u>one most serious injury</u> cause you to miss at least one full day from school or other usual activities, such as sports or lessons?'* 1=I was not injured in the past 12 months 2=Yes, I lost at least one day of activity How many full days did you miss? ___ 3=No, I did not lose a day of activity
2005/2006 (Questions taken from Grade 9-10 Survey)	Q44. *'During the past 12 months, how many times were you injured and had to be treated by a doctor or nurse?'* 1=I was not injured in the past 12 months 2=1 time 3=2 times 4=3 times 5=4 times or more Q45. *'Where were you when this one most serious injury happened?'* 1=I was not injured in the past 12 months 2=At home/in yard (yours or someone else's) 3=School, including school grounds, <u>during school hours</u> 4=School, including school grounds, <u>after school hours</u> 5=At a sports facility or field (not at school) 6=In the street/road/parking lot 7=Other location Q46. *'What were you doing when this one most serious injury happened?'* 1=I was not injured in the past 12 months 7=Fighting Q47. *'Did this most serious injury happen while participating in an organized activity, league, or club?'* 1=I was not injured in the past 12 months 2=yes, organized activity 3=No, unorganized activity Q48. *'Where were you treated for this <u>one most serious injury</u>?'* a. I was not injured in the past 12 months b. Doctor's office/health clinic c. Emergency room d. Hospital admission overnight e. School health service f. Other location 1=Yes, 2=No Q49. *'Did this <u>one most serious injury</u> need medical treatment such as the placement of a cast, stitches, surgery, or staying in a hospital overnight?'* 1=I was not injured in the past 12 months 2=Yes 3=No

	Q50. *'Did this <u>one most serious injury</u> cause you to miss at least one full day from school or other usual activities, such as sports or lessons?'* 1=I was not injured in the past 12 months 2=Yes, lost at least one day of activity How many full days did you miss? _____ 3=No, did not lose a day of activity
2001/2002	Q31. *'During the past 12 months, how many times were you injured and had to be treated by a doctor or nurse?'* 1=I was not injured in the past 12 months 2=1 time 3=2 times 4=3 times 5=4 times or more Q32. *'What were the main results (damage to the body) of this <u>one most serious injury</u>?'* a. I was not injured in the past 12 months b. Bone was broken, dislocated or out of joint (includes broken/chipped teeth) c. Sprain, strain, or pulled muscle d. Cuts, puncture, or stab wound e. Concussion or other head or neck injury, knocked out, whiplash f. Bruises, black and blue marks, or internal bleeding g. Internal injury requiring an operation h. Burns i. Other: write it here _____ 1=Yes, 2=No Q33. *'Where were you when this one most serious injury happened?'* 1=I was not injured in the past 12 months 2=At home/in yard (yours or someone else's) 3=School, including school grounds 4=At a sports facility or field (not at school) 5=in the street/road/parking lot 6=At a commercial/business area (such as a restaurant, shopping mall, cinema, etc.) 7=Countryside (such as a lake, beach, forest, park, etc.) 8=Other location: write it here _____ Q34. *'What were you doing when this one most serious injury happened?'* 1=I was not injured in the past 12 months 8=Fighting Q35. *'Did this most serious injury happen while participating in an organized activity, league, or club?'* 1=I was not injured in the past 12 months 2=Yes, organized activity 3=No, unorganized activity Q36. *'Where were you treated for this one most serious injury?'* a. I was not injured in the past 12 months. b. Doctor's office/health clinic

	c. Emergency room d. Hospital admission overnight e. School health service f. Other: write it here 1=Yes, 2=No Q37. *'Did this one most serious injury cause you to miss at least one full day from school or other usual activities, such as sports or lessons?'* 1=I was not injured in the past 12 months 2=Yes, lost at least one day of activity 3=No, did not lose a day of activity Q38. *'In what month did this one most serious injury happen?'* Q39. *'In what year did this one most serious injury happen?'* 1=I was not injured in the past 12 months 2=2001 3=2002
1997/1998	Q42. *'During the past 12 months, how many times were you injured, and had to be treated by a doctor or nurse?'* 0=I was not treated by a doctor or nurse for an injury 1=1 time 2=2 times 3=3 times 4=4 or more times Q43. *'Where were you when this injury happened?'* 1=At home (yours or someone else's) 2=At school (including school grounds) 3=At a sports facility or field (not at school) 4=In the street/road 5=At another location: Write it here _____ Q44. *'At the time of the injury (a) what were you doing, and (b) how did it happen? Please fill in beside (a) and (b) below'*. Q45. *'Did this most serious injury happen while participating in an organized activity or league?'* 1=Yes 2=No Q46. *'Did this most serious injury cause you to miss at least one full day of school or other usual activities?'* 1=Yes 2=No If "Yes", how many days did you miss? ____ Q47. *'Did any of the following happen as a result of this one most serious injury?'* a. Had a cast put on b. Got stitches

	c. Needed crutches or a wheel chair d. Had an operation e. Stayed in hospital overnight. 1=Yes, 2=No Q48. *'What were the results of this one most serious injury?'* a. Bone was broken, dislocated or out of joint b. Sprain, strain or pulled muscle c. Cuts, puncture, or stab wounds d. Concussion or other head or neck injury, knocked out, whiplash e. Bruises, black and blue marks, or internal bleeding f. Burns g. Other: Please write it here _____ 1=Yes, 2=No
1993/1994	Q37. *'During the past 12 months, were you hurt or injured and had to be treated by a doctor or a nurse?'* 1=Yes 2=No If yes, how many times were you injured and treated? ___ Q38. *'In what month did the injury occur?'* _____ In what year did the injury occur? Please circle: 1992 1993 Q39. *'Did this injury need medical treatment such as a cast, stitches, surgery or staying in the hospital overnight?'* 1=Yes 2=No Q40. *'Did this injury cause you to miss at least one full day of school or other usual activities?'* 1=Yes 2=No Q41. *'Where did this injury occur?'* 1=In your house or yard 2=In someone else's house 3=At school 4=In a sports arena or playing ground 5=In the street/road near your house 6=In the street/road not near your house 7=In a park or recreational area 8=On a farm 9=At work 0=In some other place (please describe) _____ Q42. *'Which of the following best describes how you were injured?'* 9=During a fight with another person

	Q43. *'Which of the following best describes the main result of this injury?'* 1=Broken or dislocated bone 2=Sprain, strain or a pulled muscle 3=Cut or puncture wound 4=Concussion or other head or neck injury 5=Bruises or internal bleeding 6=Burns 7=Poisoning 8=Other (please describe) _____

Exposure Variables for Manuscript 2 from HBSC Cycle 2009/2010

For the second manuscript, three methods of measuring family affluence were used. The first was self-reported family affluence and was indicated by one question in the 2009/2010 HBSC survey asking students how well off they perceive their families to be. The responses were represented as a five point scale: very well off, quite well off, average, not very well off, and not well off at all. For the analysis in this manuscript though, responses were grouped as tertiles instead of quintiles: high (very well off, quite well off), average, and low (not very well off, and not well off at all).

The second method of measuring family affluence was the Family Affluence Scale II (FAS II). It is a measure that uses a set of material items chosen to reflect family expenditure, in which possessing these items can represent affluence, or lacking them can mean material deprivation (1). These items include having a bedroom for oneself, vehicles, family vacations, and computers. Each item pertains to a question in the HBSC survey and each response was coded with a value, giving a composite FAS II score that can range anywhere from 0 to 9. For this study, the FAS II from respondents were split in three ordinal categories to reflect the individual's level of family affluence. Taking into consideration previous studies that have used the FAS, the FAS II score were divided into the following categories: low affluence (0 to 2), middle affluence (3 to 5), and high affluence (6 to 9) (2-3). Validity studies have shown the FAS II to be a valid and useful indicator for socioeconomic status in adolescents (3).

The third method represented an area-level measure of income by linking the postal codes of the schools that participated in the HBSC study to 2006 Census data from Statistics Canada. The census data linked pertained to average household income within a 1 km buffer of the school. Each individual's average household income value (represented in the Canadian dollar) were then categorized into tertiles based on equidistant percentile cut-offs. The exact cut-off values for each tertile can be found in the table below.

Exposure Variables	**HBSC Question**	**Coding**	**Categories**
Self-Reported Family Affluence	'How well off do you think you family is?'	1 = Very well off 2=Quite well off 3=Average 4=Not very well off 5=Not at all well off	1 to 2 = Low (not very well off) 3 = Average 4 to 5 = High (well off)

Family Affluence Scale II (FAS) *Numbers in parentheses denote score value of question. Scores are totalled to present a composite FAS II score ranging from 0 to 9.	'Do you have your own bedroom for yourself?'	1=No(0) 2=Yes(1)	0 to 2 = Low Affluence 3 to 5 = Middle Affluence 6 to 9 = High Affluence
	'Does your family own a car, van or truck?'	1=No(0) 2=Yes, one(1) 3=Yes, two or more(2)	
	'During the past 12 months, how many times did you travel away on holiday (vacation) with your family?'	1=Not at all(0) 2=Once(1) 3=Twice(2) 4=More than twice(3)	
	'How many computers does your family own?'	1=None(0) 2=One(1) 3=Two(2) 4=More than two(3)	
Area-level Income	Student postal code in HBSC survey will be linked to 2006 Statistics Canada Census Subdivision data on average household income within a 1 km buffer of the school.	N/A	<$53179 = low income $53179-70065 = moderate income >$70065 = high income

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Outcome variables for Manuscript 2 from HBSC 2009/2010 Cycle

Outcome	Question/Variable Measurement
Physical Fighting	Q42. *'During the past 12 months, how many times were you in a physical fight?'* (0=I have not been in a physical fight in the past 12 months, 1=1 time, 2 times, 3 times, 4 times or more)
Fighting-related injuries	Q43. *'During the past 12 months, how many times were you injured and had to be treated by a doctor or nurse?'* 1=I was not injured in the past 12 months 2=1 time 3=2 times 4=3 times 5=4 times or more Q45. *'What were you doing when this one most serious injury happened?'* 1=I was not injured in the past 12 months 7=Fighting

Potential covariates from 2009/2010 HBSC Survey for Manuscript 2

Covariate	Measurement/Indicator
Age	Q2. 'What month were you born?' Q3. 'What year were you born?'
Sex	Q1. 'Are you male or female?' (1=male, 2=female)
Geographic location	Q86. Student Postal Code. (rural vs. urban)
Alcohol use/drunkenness	Q60. 'Have you ever had so much alcohol that you were really drunk?' 1=No, never 2=Yes, once 3=Yes, 2-3 times 4=Yes, 4-10 times 5=Yes, more than 10 times
Drug use (marijuana use will be proxy for all drug use)	Q63. 'Have you ever used or taken cannabis (e.g. hashish/marijuana/pot/grass)?' a. In your life b. In the last 12 months c. In the last 30 days For each option, there is a 7 –Point response scale, where: 1=Never, 2=1-2 times, 3=3-5 times, 4=6-9 times, 5=10-19 times, 6=20-39 times, 7=40 time or more
Happy home life	Q67. 'Please show how much you agree or disagree with the following statements.' c. I have a happy home life. Possible responses shown as a 5-point Likert scale, where: 1=Strongly agree, 2=Agree, 3=Neither agree or disagree, 4=Disagree, 5=Strongly disagree Happy home life is meant to represent family support and stability

Helpful friends	Q56. 'Think about the group of friends with whom you spend most of your leisure time. Most of my friends in my group…' k. Help others in need Responses are given as a 4-point scale, where: 1=Never or rarely, 2=Sometimes, 3=Often, 4=I don't know The indicator for helpful friends is assumed to be a proxy for positive peer influence.
Extracurricular and Sports involvement	Q76. 'Are you involved in any of these kinds of clubs or organizations?' a. I am not involved in any kind of club of organization. b. Sport club or team (1=Yes, 2=No) For 76a, there is one box to check off indicating that there is no involvement in any extracurricular activities. 76a will be examined to take into consideration any kind of extracurricular involvement. 76b will also be assessed for sports participation due the belief that fights in adolescents may occur during sports games or practices.
Respectful School Environment	Q23. 'Here are some statements about the students in your class(es). Please show how much you agree or disagree with each statement.' e. The students in my class(es) treat each other with respect. Responses for this question are shown as a 5-point scale, where: 1=Strongly agree, 2=Agree, 3=Neither agree nor disagree, 4=Disagree, 5=Strongly disagree Respectful school environment is meant to represent a place where students feel safe and non-threatened, and responses that disagree or strongly disagree with that statement may indicate tensions or an imbalance of respect or power which can potentially represent bullying.
Supportive teachers	Q22. 'Please show how much you agree or disagree with each statement.' i. 'I feel that my teachers accept me as I am.' Responses are given as a 5-point scale, where: 1=Strongly agree, 2=Agree, 3=Neither agree nor disagree, 4=Disagree, 5=Strongly disagree.
Supportive neighbours	Q72. 'Please say how you feel about these statements about the area where you live.' e. I could ask for help or a favour from neighbours. Possible responses are shown as a 5-point scale, where: 1=Strongly agree, 2=Agree, 3=Neither agree nor disagree, 4=Disagree, 5=Strongly disagree This variable is meant to be an indicator or representation of neighbourhood quality or influence since previous literature has supported the influence of neighbourhood or areas that the individual inhabits.

Appendix C

Sample Size Flow Chart

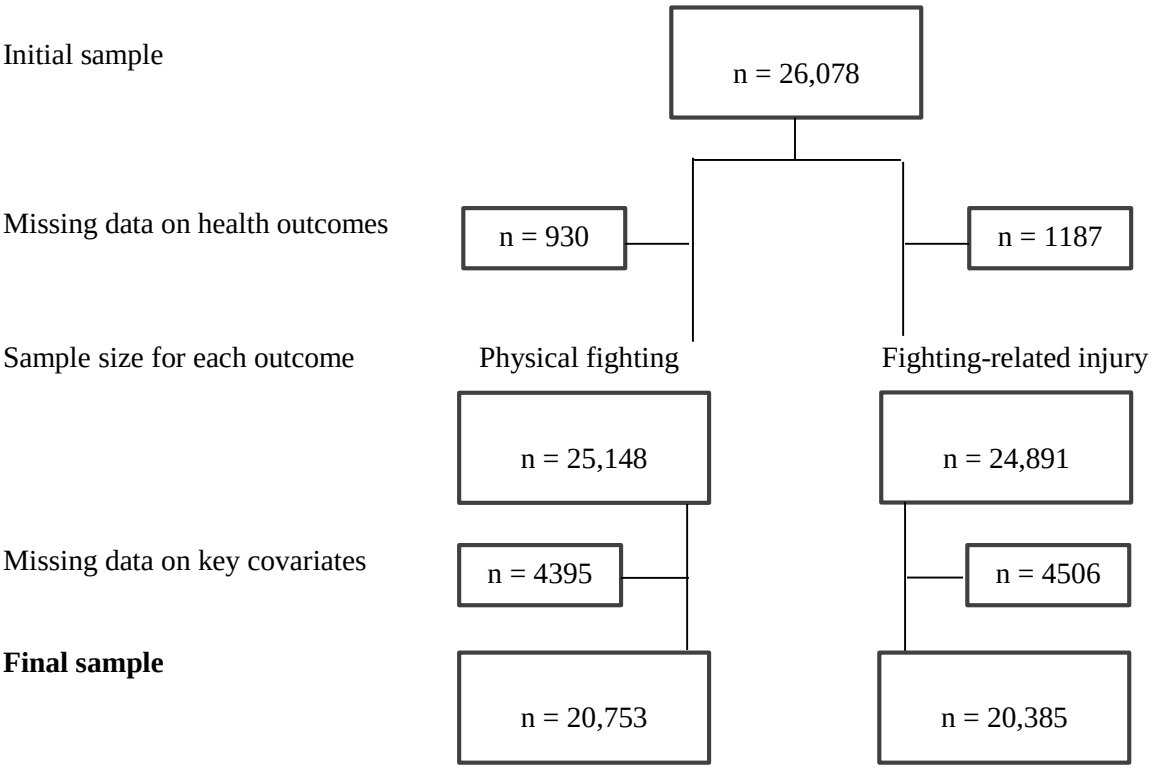

Figure 5.1 Flowchart explaining available sample of young Canadians from 2010 HBSC Study for manuscript 2.

Appendix D

Intraclass Correlation Coefficients

Outcome	Covariance Parameter Estimate	Variance at the school level
Physical Fighting	0.0563	0.0168
Fighting-related Injury	0.4199	0.1132
Subset Analysis		
Physical Fighting	0.0696	0.0207
Fightng-related Injury	0.3684	0.1007

A null model using PROC GLIMMIX with log link and Poisson distribution was run to assess the amount of variance attributable to the school level, which produced intra-class correlation coefficients. The following equation by Powers and Xie (2008) was used to calculate the intra-class correlations (1):

$$\rho = \frac{\sigma_u^2}{\sigma_u^2 + \sigma_\varepsilon^2} = \frac{\sigma_u^2}{\sigma_u^2 + \pi^2/3}$$

Where:

ρ is the intra-class correlation.

σ_u^2 is the group-level unexplained covariance

σ_ε^2 or $\pi^2/3$ is the individual-level (residual) unexplained covariance

The first model which assessed the outcome of physical fighting one or more times versus never accounted for approximately 1.7% of the total variance. The second model assessed fighting-related injuries versus no injuries and injuries caused by other means besides fighting, and determined that approximately 11% of the school-level factors accounted for the total variance. The next set of models came from a subset analysis of the HBSC data which only assessed students who filled out the grade 9 and 10 version of the HBSC survey. The null models from the subset data looked at the same outcomes as the first models. The null model which assessed the outcome of physical fighting demonstrates that 2.1% of the

school level factors account for the total variance, while the null model from the subset analysis which assessed the outcome of fighting-related fighting showed that area-level factors accounted for 10% of the total variance.

If intra-class correlations s are greater than 5%, then it is assumed that the clustering effects are present and cannot be ignored since they will produce biased effects. Therefore, in this case, multi-level analyses are appropriate.

Reference

1. Powers DA, Xie Y. Multilevel Models for Binary Data. Statistical Methods for Categorical Data Analysis. 2nd ed. Bingley, United Kingdom: Emerald Group Publishing; 2003.

Appendix E

Post hoc Power Calculations

Appendix E presents the definitions and equations used to calculate study power post hoc, followed by summary tables presenting the minimum detectable differences and risk estimates that can be detected by each of the analyses seen in Manuscript 1 and 2.

Since no standard methods exists for calculating power in multi-level models, power was estimated based on the classical power calculation for cross-sectional or cohort studies with a design effect of 1.2 to account for the clustered nature of the HBSC survey (1).

$$\text{Power} = \Phi Z_{(1-\beta)} = \Phi \{d [(nr)/p(1-p)(1+r)]^{1/2} - Z_{\alpha/2}\} \qquad \alpha=0.05$$

n is the sample size for the HBSC cycle

%exp is the proportion of the population with the exposure of interest

n exp is the number of adolescents in the HBSC cycle who have the exposure of interest

r is the ratio of unexposed to exposed

RR is the relative risk

p is the proportion of HBSC adolescents who have the outcome (physical fighting or fighting-related injuries)

p0 is the proportion of those with the outcome (physical fighting or fighting-related injury) who do not have the exposure of interest

p1 is the proportion of those with the outcome (physical fighting or fighting-related injury) who have the exposure of interest

d is the difference between p1 and p0

$Z_{\alpha/2}$ is the level of significance

$Z_{1-\beta}$ is the level of power

Manuscript 1

Outcome: Physical Fighting

Cycle 6: 2009/2010												
Variable	$n_{adjusted}$	***%exp***	n_{exp}	***r***	***RR***	***p***	p_0	p_1	***d***	$Z_{\alpha/2}$	$Z_{(1-\beta)}$	***Power***
Grade												
Gr. 6 vs Gr. 9	21732	0.198	4303	2.02	1.27	0.356	0.323	0.409	0.086	1.96	7.68	100.00
Sex												
Male vs Female	21732	0.492	10692	1.03	2.10	0.356	0.232	0.487	0.255	1.96	37.29	100.00
Self-perceived affluence												
Low vs High	21732	0.095	2065	5.99	1.29	0.356	0.328	0.423	0.095	1.96	6.39	100.00

Cycle 5: 2005/2006												
Variable	$n_{adjusted}$	***%exp***	n_{exp}	***r***	***RR***	***p***	p_0	p_1	***d***	$Z_{\alpha/2}$	$Z_{(1-\beta)}$	***Power***
***Grade**												
Gr. 6 vs Gr. 9	8096	0.177	1433	2.51	1.34	0.412	0.358	0.481	0.123	1.96	6.04	100.00
Sex												
Male vs Female	8096	0.474	3838	1.11	1.76	0.412	0.303	0.534	0.231	1.96	19.13	100.00
Self-perceived affluence												
Low vs High	8096	0.086	696	6.91	1.34	0.412	0.384	0.513	0.129	1.96	4.50	100.00

Cycle 4: 2001/2002												
Variable	$n_{adjusted}$	***%exp***	n_{exp}	***r***	***RR***	***p***	p_0	p_1	***d***	$Z_{\alpha/2}$	$Z_{(1-\beta)}$	***Power***
Grade												
Gr. 6 vs Gr 9	6029	0.285	1718	1.16	1.20	0.351	0.314	0.377	0.063	1.96	2.05	97.98
Sex												
Male vs Female	6029	0.464	2797	1.16	2.03	0.351	0.238	0.483	0.245	1.96	17.92	100.00
Self-perceived affluence												
Low vs High	6029	0.089	537	6.38	1.21	0.351	0.334	0.404	0.070	1.96	1.20	88.49

Outcome: Fighting-Related Injuries

Cycle 6: 2009/2010												
Variable	$n_{adjusted}$	***%exp***	n_{exp}	***r***	***RR***	***p***	p_0	p_1	***d***	$Z_{\alpha/2}$	$Z_{(1-\beta)}$	***Power***
Grade Gr. 6 vs Gr. 9	21732	0.198	4303	2.02	0.68	0.022	0.026	0.018	0.008	1.96	0.97	83.40
Sex Male vs Female	21732	0.492	10692	1.03	2.08	0.022	0.014	0.029	0.015	1.96	5.58	100.00
Self-perceived affluence Low vs High	21732	0.095	2065	2.50	2.43	0.022	0.016	0.040	0.024	1.96	4.92	100.00

Cycle 2: 1993/1994												
Variable	$n_{adjusted}$	***%exp***	n_{exp}	***r***	***RR***	***p***	p_0	p_1	***d***	$Z_{\alpha/2}$	$Z_{(1-\beta)}$	***Power***
Grade Gr. 6 vs Gr. 9	5837	0.332	1938	1.00	0.37	0.013	0.020	0.007	0.013	1.96	1.62	94.74
Sex Male vs Female	5837	0.479	2796	1.09	1.84	0.013	0.009	0.017	0.008	1.96	0.74	77.03
Self-Perceived Affluence Low vs High	5837	0.132	770	2.80	0.96	0.013	0.013	0.013	0.012	1.96	-1.75	4.01

Manuscript 2: **HBSC Cycle 6**

Outcome: Physical Fighting in Males

***Variable**	$n_{adjusted}$	*%exp*	n_{exp}	*r*	*RR*	*p*	p_0	p_1	*d*	$Z_{\alpha/2}$	$Z_{(1-\beta)}$	*Power*
Self-Perceived Affluence Low vs High	10679	0.088	943	6.73	1.17	0.487	0.465	0.543	0.078	1.96	2.51	99.40
Family Affluence Scale Low vs High	10679	0.024	251	27.69	1.12	0.487	0.492	0.549	0.057	1.96	-0.19	42.47
Area-level Income Low vs High	10679	0.328	3507	1.05	1.01	0.487	0.477	0.482	0.005	1.96	-1.54	6.18

Outcome: Physical Fighting in Females

***Variable**	$n_{adjusted}$	*%exp*	n_{exp}	*r*	*RR*	*p*	p_0	p_1	*d*	$Z_{\alpha/2}$	$Z_{(1-\beta)}$	*Power*
Self-Perceived Affluence Low vs High	11045	0.101	1119	5.38	1.74	0.232	0.187	0.326	0.139	1.96	8.16	100.00
Family Affluence Scale Low vs High	11045	0.025	278	25.64	1.58	0.232	0.217	0.343	0.126	1.96	2.92	99.82
Area-level Income Low vs High	11045	0.334	3692	0.98	1.25	0.232	0.205	0.256	0.051	1.96	3.21	99.93

Outcome: Fighting-Related Injuries in Males

Variable	$n_{adjusted}$	***%exp***	n_{exp}	***r***	***RR***	***p***	p_0	p_1	***d***	$Z_{\alpha/2}$	$Z_{(1-\beta)}$	***Power***
Self-Perceived Affluence Low vs High	10679	0.088	943	6.73	1.72	0.037	0.029	0.050	0.021	1.96	1.23	89.07
Family Affluence Scale Low vs High	10679	0.024	251	27.69	3.63	0.037	0.035	0.127	0.092	1.96	5.63	100.00
Area-level Income Low vs High	10679	0.328	3507	1.05	1.03	0.037	0.035	0.036	0.001	1.96	-1.74	4.09

Outcome: Fighting-Related Injuries in Females

Variable	$n_{adjusted}$	***%exp***	n_{exp}	***r***	***RR***	***p***	p_0	p_1	***d***	$Z_{\alpha/2}$	$Z_{(1-\beta)}$	***Power***
Self-Perceived Affluence Low vs High	11045	0.101	1119	5.38	4.20	0.017	0.010	0.042	0.032	1.96	5.65	100.00
Family Affluence Scale Low vs High	11045	0.025	278	25.64	1.67	0.017	0.015	0.025	0.010	1.96	-0.70	24.51
Area-level Income Low vs High	11045	0.334	3692	0.98	1.83	0.017	0.012	0.022	0.010	1.96	1.35	91.15

1. Roberts C, Freeman J, Samdal O, Schnohr CW, Looze M, Nic Gabhainn S, Ianotti R, Rassmussen M. the International HBSC Study Group. The Health Behaviour in School-aged Children (HBSC) study: methodological developments and current tensions. Int J Public Health. 2009;14:140–150.

Appendix F

Goodness-of-fit Statistics

Table 5.1 Goodness-of-fit statistics for the multivariate regression models adjusted for covariates chosen in the backwards selection process.

	Physical Fighting		Fighting-related Injury	
	QIC	QICu	QIC	QICu
Individual-level characteristics				
Self-reported Affluence	44746.95	44714.49	5181.42	5153.88
Family Affluence Scale	45432.96	45401.98	5113.50	5087.91
Area-level characteristics				
Average Household Income	45018.25	44973.46	5078.88	5044.16
Sub-Cohort Analysis				
Individual-level characteristics				
Self-reported affluence	16305.20	16280.68	2139.70	2119.79
Family Affluence Scale	16259.01	16234.03	1947.70	1932.90
Area-level characteristics				
Average Household Income	16294.40	16259.52	2106.77	2085.90

To examine which family affluence measurement best fit the data and best represented family affluence for Manuscript 2, the goodness-of-fit statistics (QIC and QICu) of each model (bivariate and multivariate models) were assessed. Smaller statistics are preferred and believed to represent a better fit of the data to the model.

The above table shows the QIC statistics for all the multivariate models seen in Tables 4.2 and 4.3. The self-perceived affluence model presented the smallest statistics in regards to the outcome of physical fighting, and the area-level average household income measurement had the smallest statistics with respect to fighting-related injuries.

The QIC and QICu statistics are meant to compare model fit with likelihood-based methods when using the GEE method.

These statistics can inform future researchers in which affluence measurement would be best to use in HBSC studies based how to data fit the multivariate model. The models seen in this study appear to favour the self-perceived affluence measurement for assessing physical fighting and area-level income measurement for fighting-related injury. It is important then for researchers

to pay attention to the goodness-of-fit criteria. This criteria may also give researchers an idea of what variables may be important confounders to consider when assessing the relationship between wealth and physical fighting and fighting-related injury and building a regression model that best depicts this relationship.

Appendix G

Ethic Approval

QUEEN'S UNIVERSITY HEALTH SCIENCES & AFFILIATED TEACHING HOSPITALS RESEARCH ETHICS BOARD-DELEGATED REVIEW
December 10, 2013

Ms. Maya Djerboua
Department of Public Health Sciences
Queen's University

Dear Ms. Djerboua
Study Title: EPID-453-13 Physical Fighting and Fighting-Related Injuries in Canadian Adolescents: A demographic analysis and assessment of the effects of family affluence
File # 6011541
Co-Investigators: Dr. C. Davison, Dr. B. Chen

I am writing to acknowledge receipt of your recent ethics submission. We have examined the protocol for your project (as stated above) and consider it to be ethically acceptable. This approval is valid for one year from the date of the Chair's signature below. This approval will be reported to the Research Ethics Board. Please attend carefully to the following listing of ethics requirements you must fulfill over the course of your study:

Reporting of Amendments: If there are any changes to your study (e.g. consent, protocol, study procedures, etc.), you must submit an amendment to the Research Ethics Board for approval. Please use event form: HSREB Multi-Use Amendment/Full Board Renewal Form associated with your post review file # **6011541** in your Researcher Portal (https://eservices.queensu.ca/romeo_researcher/)

Reporting of Serious Adverse Events: Any unexpected serious adverse event occurring locally must be reported within 2 working days or earlier if required by the study sponsor. All other serious adverse events must be reported within 15 days after becoming aware of the information. Serious Adverse Event forms are located with your post-review file **6011541** in your Researcher Portal (https://eservices.queensu.ca/romeo_researcher/)

Reporting of Complaints: Any complaints made by participants or persons acting on behalf of participants must be reported to the Research Ethics Board within 7 days of becoming aware of the complaint. Note: All documents supplied to participants must have the contact information for the Research Ethics Board.

Annual Renewal: Prior to the expiration of your approval (which is one year from the date of the Chair's signature below), you will be reminded to submit your renewal form along with any new changes or amendments you wish to make to your study. If there have been no major changes to your protocol, your approval may be renewed for another year.

Yours sincerely,

Albert J. Clark

Chair, Health Sciences Research Ethics Board
December 10, 2013

Investigators please note that if your trial is registered by the sponsor, you must take responsibility to ensure that the registration information is accurate and complete