EXAMINING THE RELATIONSHIP BETWEEN TRAUMATIC BRAIN INJURY AND SUBSTANCE USE AND MENTAL HEALTH OUTCOMES IN THE CANADIAN POPULATION

by

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To those whom have experienced a Traumatic Brain Injury, and those that work diligently to improve their quality of life following injury.

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Abstract

This thesis examines the associations between substance use/ misuse and mental health outcomes among Canadians with a Traumatic Brain injury (TBI). Its primary aim is to explore whether or not individuals with a TBI have higher rates of substance use/misuse and poorer mental health than Canadians without a TBI, and to examine two competing hypothesis that help to explain these behaviours -- the impaired brain functioning and the general coping hypotheses. Drawing on data from the 2009-2010 Canadian Community Health Survey, a nationally representative cross-sectional survey, this research assessed substance use and mental health outcomes among those with a TBI, as well as two control groups: (1) individuals with a back or spinal injury; and (2) healthy non-injured controls. Analyses include descriptive statistics and multivariate regressions (logistic and multinomial) adjusting for a range of injury and socioeconomic variables. Those with a TBI demonstrated significantly elevated rates of binge drinking, illicit drug use, and having an anxiety disorder relative to non-injured Canadians, and provided partial support for both the impaired brain functioning and general coping hypotheses to substance use. These findings indicate that public health policy should increase awareness amongst healthcare and social workers on the necessity of continued follow-up of those who experience a TBI in order to reduce future health conditions and to reduce the likelihood of re-injury.

List of Abbreviations Used

AIS	Abbreviated Injury Scale
BAC	Blood Alcohol Content
BSI	Back and Spinal Injury Group
CAT	Computerized Axial Tomography
CCHS	Canadian Community Health Survey
CIHI	Canadian Institute for Health Information
DA	Dopamine
DAT	Dopamine Transporter Protein
DSM-IV	Diagnostic and Statistical Manual of Mental Health Disorders, 4th edition
ED	Emergency Department
ERN	Error-Related Negativity Signal
FIM™	Functional Independence Measure Scale
fMRI	Functional Magnetic Resonance Imaging
FRN	Feedback-Related Negativity Signal
GCS	Glasgow Coma Scale
HR	Health Region
HUI	Health Utilities Index
ICU	Intensive Care Unit
ISS	Injury Severity Score
LBP	Lower Back Pain
LOC	Loss of Consciousness
LSD	Lysergic Acid Diethylamide
MDD	Major Depressive Disorder
NIMH	National Institute of Mental Health
OR	Odds Ratio
PCP	Phencyclidine
PTSD	Post-Traumatic Stress Disorder
RRR	Relative Risk Ratio
RTS	Revised Trauma Score
SES	Socioeconomic Status
SPECT	Single Photon Emission Computer Tomography
TBI	Traumatic Brain Injury
TRISS	Trauma Injury Severity Score
WCST	Wisconsin Card Sorting Task

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CHAPTER ONE: INTRODUCTION

Traumatic brain injury (TBI) is the leading cause of disability caused by trauma and death worldwide,[1,2] particularly in the younger population, as well as one of the leading causes of death and disability in North America.[3,4] TBI is the leading cause of morbidity and mortality among young adults. This population is in the prime of their lives and therefore education, career advancement, and family rearing can suffer as a consequence of TBI.

TBI results from an external force to the head affecting the brain causing temporary or permanent neurological dysfunction, and are rated in severity based on loss of consciousness, post injury amnesia, and reaction to stimuli.[5]

The burden of TBI can be minimal in cases of mild injury (e.g., mild concussions) but can also be quite severe in moderate to severe cases (e.g., physical paralysis). There are a variety of personal consequences to TBI. These can be categorized into: neurological impairments, cognitive impairments, psycho-social and behavioural changes, as well as lifestyle consequences.[5]

Unfortunately, rates of substance use and misuse are elevated among persons who have experienced a TBI. For the purpose of this thesis the following definitions of substance use and substance misuse should be observed. Firstly, substance use describes the presence of (vs. nonexistence of) usage of a substance either legal (i.e., alcohol) or illegal (e.g., cannabis). Secondly, substance misuse is used to described the use of any illegal drug or the use of a legal drug (i.e., alcohol) in a manner/frequency that often results in harmful consequences; an example is binge drinking. Over 30 years of research

has described differing views of the association between TBI and substance use/misuse.[2] The majority of research has examined alcohol, likely because to date we know that alcohol is the most commonly misused substance in this population.[6] Some studies have found rates of substance misuse among the head injured population as high as 50-60%,[7–10] whereas other studies have found substance misuse rates as low as 37%.[6] Although there is variability in the rates of substance misuse reported in the head injured population, even the lowest rates are elevated relative to base-rates in the general population.[9]

An interesting discussion is whether or not problem substance use precedes TBI, is a consequence of injury, or both precedes and follows the injury event. Substance misuse could precede and potentially cause TBI due to impaired inhibition and impaired judgment which can place substance misusers in high risk situations where TBI is more likely to occur (e.g., violent altercations and impaired driving).[9] If problem substance use is a consequence of TBI, it is important to identify potential mechanisms to explain this effect. Taylor and colleagues have suggested that alcohol and other substance seeking behaviors among the head injured population may be due to organic brain syndromes that result from brain injury.[9] For example, dopaminergic (DA) neurocircuitry is recruited for both the natural reward pathway and for cueing and delivery of drugs;[11,12] animal studies have shown decreased DA expression in the areas of the brain associated with sensation of reward following TBI.[13] Therefore TBI patients may be self-medicating to address a deficit in the function of reward pathways via drugs that act on the reward centres of the brain. Another explanation of the pathway between TBI and substance use lies within Bandura`s learning theory.[14] Learning theorists argue that persons will carry out an

action, in this case substance use, to obtain a desired reinforcement. The premise of this explanation is that the brain injured population uses substances as a means to cope with the various novel psychosocial challenges they are facing.[11,15] Specifically, TBI patients may learn to misuse substances in order to reduce negative affect; the reduction of negative affect they would experience from substance use could then negatively reinforce continued misuse in future. The question of the pathway between TBI and subsequent substance use needs to be further addressed in the literature.

1.1 RATIONALE

The literature currently has opposing views regarding the magnitude of the association between substance use and TBI. Regarding the magnitude of the association, unfortunately, most studies have examined clinical samples which are not representative of the entire head injured population. Clinical samples provide very little or no insight into TBI patients whom do not seek care. Moreover, use of clinical samples of TBI patients may result in an inflation of substance use rates relative to actual rates in the general population.[2]

In addition, the literature is unclear as to mechanisms that might explain how TBI leads to increased substance use following injury. Clearly, substance use rates are high in those who have experienced TBIs. The key question is why- which pathway may help to explain these elevated rates? Two hypotheses demonstrate potential to address the cause of elevated rates of substance use following injury in individuals who have experienced TBI: the impaired brain functioning and coping response hypotheses. ***The impaired brain functioning hypothesis*** as a mechanism to explain alcohol and other substance misuse following TBI stipulates that impairments in DA neurocircuitry leads to consumption of

substances as a compensatory response. ***The coping response hypothesis*** involves self-medication via alcohol and/or other substances as a means to adjust to adverse lifestyle changes arising from the experience of a TBI.

The first aim of this thesis was to examine whether and to what extent these hypotheses help to explain the high rates of substance use and misuse in individuals who have experienced TBI. In order to do so, this project compared alcohol, cigarette smoking and illicit drug use and misuse in individuals who have experienced a TBI relative to two control groups: healthy controls and lower and upper back/ spinal cord injured (BSI) controls. Those with a BSI are likely to suffer from similar psychosocial adjustments as those with TBI due to the similarity in the chronicity of injury. Therefore, it is useful to compare those with a TBI to those with a BSI as the major difference between the two groups is injury location which lends to a difference in brain functioning between the groups. This allows for an examination of the effect brain impairment has on substance use measures when controlling for the psychosocial changes that occur with chronic injury. Comparisons with healthy individuals are included to examine whether the elevated rate of substance use is due primarily to the coping response hypothesis. If both chronically injured groups, TBI and BSI, show negligible differences from one another in substance use or problem use and both show significantly greater usage rates than the healthy controls, then there is evidence that the coping response mechanism rather than the brain impairment mechanism is responsible for elevated substance use rates in the TBI population. If in contrast, there is significantly greater substance use in the TBI group compared to both control groups and negligible differences between the back/ spine injury and health control groups, this would suggest that the brain impairment

hypothesis is a better explanation for elevated substance use rates in the TBI population. Finally, if there is significantly greater substance use in the TBI group compared to the BSI group and, in turn, significantly greater substance use in the BSI group compared to the healthy controls, this would suggest that both brain impairments and coping response mechanisms may be at play in explaining elevated substance use among individuals who have experienced TBI.

The second aim of this thesis is to investigate the association between TBI on mental health outcomes. There are well documented relationships between those with a TBI and a variety of mental health issues. In addition, mental health problems intuitively lead to reduced quality of life and increased difficulties in terms of rehabilitation. Poor quality of life caused by mental health issues has an association with the social coping hypotheses which may be evidenced by increased coping behaviours. Due to these reasons we will examine whether ratings of mental health such as stress, mood disorders, anxiety, and general mental health differ between the TBI group, the BSI group, and non-injured controls.

Due to the nature of the data set it is impossible to remove persons from the analysis who misused substances *prior* to their TBI; therefore this thesis examines the effects of substance misuse post-injury regardless of pre-injury substance misuse status. This study will adjust for a range of socio-demographic covariates and confounders (i.e., age, education, income, province of residence, anxiety, depression, and minority status). In addition, this study uses a general population survey, which to my knowledge has not been previously conducted with respect to this issue in Canada. This approach will provide a national Canadian population health perspective on the relationship between

TBI and substance use problems and will provide evidence that may contribute to steering policy and rehabilitative approaches in the Canadian TBI population.

1.2 RESEARCH QUESTIONS

The research questions for this thesis are as follows:

1. To what extent do persons with a TBI engage in alcohol and other drug use?

2. Can either the general coping hypothesis or the impaired brain functioning hypothesis help explain substance use patterns among those with an injury?

3. To what extent is TBI associated with poor mental health outcomes?

1.3 HYPOTHESES

From these research questions we can offer a series of hypotheses to be tested:

1. Relative to non- head injured persons, it is hypothesized that significantly higher rates of substance use and related problems (i.e., substance misuse) will be observed in the Canadian TBI population.
2. If the impaired brain functioning hypothesis is true, higher substance use rates should be observed in those with TBI relative to both those with a BSI and healthy controls. Additionally, negligible differences in substance use rates should be observed between the BSI and healthy control groups.

   If the general coping hypothesis is true, elevated substance use rates in both the TBI and the BSI groups should be observed relative to healthy controls. Additionally, negligible difference in substance use rates should be observed between the TBI and BSI groups.

If there is significantly greater substance use in the TBI group compared to the BSI and significantly greater substance use in the BSI group compared to the healthy control group, then there is evidence for both the impaired brain functioning and social coping hypothesis.

3. Individuals with a TBI will demonstrate poorer mental health outcomes as compared to non-injured controls. If general coping hypothesis is true, we would we expect to find similar prevalence estimates between the TBI and BSI group for poorer self-perceived mental health outcomes relative to non-injured controls. If those with a TBI have a significantly stronger relationship with poor mental health than those with a BSI and both those with a TBI or BSI have a significantly stronger relationship than the non-injured then there is evidence for both impaired brain functioning and the general coping hypotheses.

CHAPTER TWO: BACKGROUND INFORMATION

This section discusses the relevant literature pertaining to the relationship between TBI and substance use, with a focus on alcohol, to provide justification for this research project. This section begins with the definition of TBI as well as the incidence and prevalence of TBI in Canada, including a discussion of the most common mechanisms of injury. Following this is a description of the most commonly used TBI severity rating scales as well as the most common consequences of TBI, presented at both a personal and societal level. This section then discusses how substance use leads to TBI as well as how TBI can lead to substance use including a discussion of the most commonly misused substances. Next, it evaluates the influence of substance use on TBI outcomes and discusses the potential pathways between TBI and substance misuse; this includes the brain impairment hypothesis and the general coping hypothesis. Finally, this section discusses the relationship between substance use and mental health status in general and specific to the head injured population. This project aims to: quantify the association between substance use and TBI; identify the etiology of that relationship; and determine the extent of the association between TBI and self-reported perceived mental health status, presence of a mood disorder(s) as diagnosed by a health professional (i.e., depression/ bipolar disorder, mania or dysthymia), presence of an anxiety disorder(s) as diagnosed by a health professional, and self-perceived high stress.

2.1 TBI

The clinical case definition states that a TBI is a disruption in brain function and/or structure resulting from an external force (e.g., biomechanical force, acceleration/deceleration forces applied, and/or blast related forces). Therefore brain

injuries resulting from trauma during birth, ischemic and hemorrhagic strokes, and seizure disorders are not classified as TBI's. TBI can further be classified into two broad categories: primary and secondary injuries.[16] Primary injuries occur at the point of impact and secondary injuries are due to the body's response to the primary injury and are influenced by medical interventions.

2.1.1 Incidence and Prevalence of TBI

Traumatic Brain Injury (TBI) is an important public health problem worldwide. TBI has been referred to as the "silent epidemic" as the consequences felt by those suffering a TBI often consist of impairments in cognition and memory, both of which can be invisible deficits.[17] Globally, TBI directly affects over 10 million people per year leading to either mortality or hospitalization. Quantifying the magnitude of TBI is difficult on both a national and global scale for a variety of reasons. Firstly, mild TBI is difficult to capture as the likelihood of persons seeking medical attention is low; secondly TBI can be combined with other concurrent injuries and may be missed as a cause of death; and surveillance and reporting strategies are either non-existent or poor in many nations of the world.[17]

Estimates from 2002 hold TBI responsible for 4.5 million adult deaths worldwide.[18] What is more concerning is the global trend of increasing incidence of TBI. The World Health Organization projects that by 2020, TBI will be one of the leading causes of morbidity and mortality worldwide. By 2020, road traffic accidents, one of the major causes of TBI is expected to be the third leading cause of disease burden amongst all age categories.[19] In the United States, there are an estimated 1.4 million TBI-related deaths, hospitalizations, and emergency department visits (ED) per year. Of the 1.4

million, 1.1 million are treated and released from ED, 235,000 are hospitalized, and 50,000 die. Annually, an estimated 80,000 to 90,000 American TBI survivors suffer from permanent disability.

In Canada, during the years 2010-2011, there were 19,233 hospitalizations as a result of TBI, which equates to approximately 53 admissions per day and 9% of all trauma admissions.[20] A significant number of those admitted to hospital for TBI succumb to their injuries, which represents 10% of all admission deaths.[21] Adults aged 20 years and older accounted for 82% of admissions, with the elderly (60 and older) accounting for the largest proportion (i.e., 46%). Interestingly, Canadian trends showed a stark decrease in TBI-related hospital admissions from 1995 (25,665) to 2003-2004 (16,811) (However there has been a 46% increase from 2000-2001 to 2003-2004 for severe TBI). This trend reversed from 2003-2004 to 2010-2011 with an increase in TBI admissions of 2,422.

2.1.2 Mechanisms of TBI

Globally, close to 60% of all TBIs that lead to hospitalizations are due to road traffic accidents, 20% are due to falls, 10% are due to violence, and 10% are due to either work place accidents or sport-related injuries.[22] In Canada, 45% of TBI hospitalizations were due to falls, 36% to motor vehicle collisions, 9% to assaults, and 10% to 'other' causes. The most common mechanism for TBIs that lead to hospital admission in the elderly (>60 years) and children (0-19 years) were falls, 76% and 40%, respectively. The most common culprit for TBIs in Canadian adults (20-59 years) are road traffic accidents, followed by falls and violence.[21]

2.1.3 TBI Severity

Glasgow Coma Scale

The Glasgow Coma Scale (GCS) was developed in 1974 by Teasdale and Bennett of the Glasgow Neurological Institute. The GCS is still used today as a classification system for injury severity in head-injured patients. Loss of consciousness (LOC) is a common feature of head-injury; changes in level of consciousness as well as duration indicate the level of injury as well as the degree of expected recovery. The GCS takes into consideration three independent aspects of brain injured patient behaviour: the best motor response, best verbal response, and best eye opening response. The score ranges from 3 to 15, 3 being the worst and 15 the best. The eye response category has a range of 1-4, verbal response has a range 1-5, and motor response has a range of 1-6. A coma score of 13 or higher correlates with a "mild" brain injury, 9 to 12 is a "moderate" injury and 8 or less constitutes a "severe" brain injury.[23]

Injury Severity Score

The Injury Severity Score (ISS) is an injury scoring system based on anatomy and pathology. The ISS is calculated using the Abbreviated Injury Scale (AIS) handbook.[24] The AIS is an internationally recognized tool for ranking trauma severity. There are a total of 6 body systems that receive a score from 1 (minor) to 6 (fatal): the thorax, abdomen and visceral pelvis, head and neck, face, bony pelvis and extremities, and external structures. The ISS is the sum of squares of the three highest AIS scores which covers a range between 1 and 75; an ISS score over 15 is considered to be severe trauma.[25] For head injuries, ISSs are primarily based on Computerized Axial Tomography (CAT) images. The benefit of using ISS over GCS is that ISS can

accommodate patients who have been intubated whereas the GCS is not calculable in these situations.[26]

Trauma and Injury Severity Score (TRISS)

Introduced in 1981, the Trauma and Injury Severity Score (TRISS) is an index based on the ISS, the Revised Trauma Score (RTS) and the patient's age.[27] The RTS is the sum of the GCS, systolic blood pressure, and the respiratory rate. TRISS combines these three components in a manner that provides a powerful predictor of outcome in trauma patients.[28]

Scale Based on Medical Attention Received

This thesis will classify TBI severity (i.e., mild vs. moderate/severe) based on the whether or not medical attention was sought and received as the data set (CCHS 2009-2010) did not capture details of injury severity on a validated measure such as the Glasgow Coma Scale,[29] the Injury Severity Score[26,30] or the Trauma and Injury Severity Score.[27,28] Injuries of persons who did not report seeking medical attention in the 48 hours following the injury event will be classified as mild TBI. Those who reported seeking any degree of medical attention (i.e., family physician's office, emergency department, and hospital admission) within 48 hours of the injury event will be classified as moderate.

2.1.4 CONSEQUENCES OF TBI

Personal Consequences

There is a wide spectrum of potential personal consequences for persons who have suffered a traumatic brain injury. The deficits individuals face are difficult to predict as they depend on a variety of variables. Some of these are: severity of the injury, age,

sex, prior injuries (e.g., concussions), socio-economic status, and prior damage caused by other brain disorders (e.g., anoxia, fetal alcohol syndrome, and stroke). Specifically this section discusses neurological impairments (i.e., motor, sensory, and autonomic), cognitive impairments, personality and behavioural changes, and concludes with common lifestyle consequences.

Examples of neurological impairments resulting from TBI that involve motor function are difficulties with coordinated movements, achieving and/or maintaining balance, walking, and speaking. It is clear that moderate to severe versions of these impairments can greatly impact independence and the ability to attend school or maintain an occupation. This increases emotional and financial burden on patients and their families. Patients can also experience sensory deficits that may present in the form of reduction in taste sensitivity, touch, hearing, vision, smell, and sexual function. These specialized senses play a role in satisfaction; deficits in these areas can cause disruption in the patient's lifestyle. Insomnia and fatigue are other potential neurological consequences that can have wide reaching effects as alertness and productivity are required for everyday tasks and are inversely related to fatigue. There are a variety of medical complications that arise from neurological impairments. Some of these are: spasticity, post-traumatic epilepsy, and hydrocephalus.

The spectrum of cognitive impairments following TBIs is very large. Patients can experience a variety of memory impairments, difficulty learning new information, problems maintaining vigilance, a reduction in the speed and flexibility of thought processes, and impaired problem solving skills.[5] A 2010 study by Ord and colleagues examined problem solving ability in 109 patients with a mild TBI and 67 patients with

moderate to severe TBI using the Wisconsin Card Sorting Task (WCST), a validated measure of executive functioning. They found a severity-dependent relationship between TBI severity and performance on indices of the WCST: those with more severe TBI performed worse than controls whereas those with a mild TBI did not differ significantly from controls.[31] These abilities are all required gaining an education and performing adequately in an occupation; deficits such as these can cause financial hardships for patients and their families. Cognitive impairments as a result of TBIs can lead to a variety of language problems such as dysphasia, difficulty selecting words, as well as difficulties with reading and writing. It is important to note that injury severity and number of injuries has an influence on the likelihood and severity of experiencing cognitive deficits. The more injuries experienced, and the greater the severity of the injury, result in a higher likelihood of lasting cognitive deficits. For example, an individual who has experienced a single mild concussion is less likely to experience a lasting cognitive effect whereas an individual who has experienced multiple concussions of mild and moderate severity is more likely to experience a lasting cognitive effect. In conclusion, patients can experience impaired judgment and safety awareness which increases the likelihood of problematic behaviour increasing the probability of harm to others and themselves.

Personality and behavioural changes are also potential consequences of TBI. Patients can experience impaired social and coping skills in addition to reduced self-esteem. Altered emotional control manifested by poor management of frustration, decreased tolerance, and increased anger are also possible.[32] Baguley and colleagues followed 228 survivors of either moderate or severe TBI over a 5 year period with follow-ups occurring at 6, 24 and 60 months following discharge to investigate

aggressive behaviour. They found that regardless of follow-up interval, 25% were classified as aggressive using the Overt Aggression Scale,[33] indicating that aggressive behaviour can be a long-term problem following TBI. Patients can exhibit disinhibition and impulsivity which can result in rejection by peers and family members and consequent social isolation. Subsequent to TBI, a variety of psychiatric disorders can develop including depression, anxiety disorders, and substance use disorders.[32] For example, a study by Hibbard and colleagues reported that in a sample of 100 TBI survivors, the subset without an Axis I disorder prior to injury showed increased rates of substance use disorder and depression relative to community controls.[34]

There are a variety of lifestyle consequences due to the impairments described in this section. Common lifestyle consequences for TBI patients include inadequate academic achievement and unemployment, both of which can result in financial hardship.[5] Loss of pre-injury life roles and decreased independence can lead to difficulty maintaining relationships with others including marriage problems. A 1994 paper by Hallett and colleagues examined changes in adult life roles following severe TBI in 28 patients using a semi-structured interview and The Role Checklist. Hallet et al. found that the majority of role changes (71%) were role losses; role losses were most often experienced in roles such as worker, hobbyist, and friend.[35] The vast amount of adverse changes in the lives of some individuals who experience TBI is an unfortunate reality with significant consequences.

Societal Economic Consequences

The estimated annual total cost of TBI in the United States is over 37 billion dollars per year.[36] This estimate includes $4.5 billion in direct expenditures for hospital

care, extended care, and other medical care and services; $20.6 billion in work-related losses and disability; and $12.7 billion in lost income from premature death. A national United States survey estimated that over 350,000 persons each year did not seek medical attention following a brain injury. These types of injuries are often classified as mild or moderate; however, these non-treated injuries accounted for approximately half of the disability days attributed to brain injury.[37] Approximately 2% of the United States population is living with long-term disability resulting from a TBI which increases the burden on social support systems.[38] Unfortunately, Canadian data on economic consequences are not currently available.

2.2 TBI AND SUBSTANCE USE

Over 30 years of research has demonstrated that individuals with TBI are at substantial risk for substance misuse.[2] A well-developed section of the literature on TBI describes a strong association between TBI and substance misuse, with rates indicating that 50 to 60% of persons with TBI have significant issues with alcohol and/or other drugs.[7–10] Drugs are often involved at the time of injury .[39] The most common illicit drugs used at the time of injury are marijuana, cocaine, and methamphetamine.[39–42] There is also evidence for poly-substance use at the time of injury.[43] The prevalence of illicit drug use has shown to significantly decrease following TBI[6] whereas alcohol use does not display as steep of a decline as usage remains elevated as compared to the general population.[44] A recent study examined the rates of alcohol misuse of United States service members who suffered a mild TBI. The results showed a non-statistically significant difference in the rates of alcohol misuse between service members who experienced a TBI and non-injured service member controls (6.1% vs. 4.9%) with an

odds ratio of 1.24 with a 95% confidence interval of 0.90 to 1.70.[45] The United States service member based study suggests that TBI severity may have an influence on the association of TBI with alcohol use and misuse (i.e., the relation of TBI to alcohol use disorders may only be observed at more severe levels of TBI). Alternatively, this study may suggest that other comorbid health disorders should be controlled for if possible, as comorbidities may have an effect on alcohol use.

An interesting discussion is whether problem substance use precedes the injury event or is a consequence of injury. Equally interesting is whether alcohol acts as a protective factor versus alcohol exacerbating consequences of TBI. The next section will describe the studies pertinent to these issues as well as discuss the literature on the potential pathways between TBI and substance misuse.

2.2.1 Substance Use Preceding Injury

There is evidence for problem substance use preceding the injury event with negligible change in substance use patterns following injury. For example, studies have found that over 50% of people who experienced a TBI were intoxicated at the time of injury,[2,11,44] 44% to 79% of individuals with TBI demonstrated pre-injury alcohol misuse,[2]and 21% to 40% displayed pre-injury illicit drug misuse.[46,47] Interestingly, other studies have shown pre-injury alcohol misuse rates at a lower rate of 37%.[44,48]

Further, some studies suggest that substance use rates do not change following TBI. Heightened rates post injury have been explained by questionable study designs and methodological concerns such as: misuse of substance use terms (i.e., using substance use, misuse, and dependence interchangeably), and ill-defined subject samples (i.e., using

self-report and family member report to classify the presence and severity of TBI),[2,44,49] making the heightened association difficult to interpret.

2.2.2 Substance Use Following Injury

The literature also contains a body of evidence supporting the idea that substance use *increases* following TBI. A survey of health-maintenance organization enrollees found that TBI survivors with no prior evidence of mental illness or substance misuse-related service utilization in the year prior to injury had a 4.5 odds ratio of substance misuse within the first year post injury, dropping to 1.4 at 25–36 months post-injury.[50] Similar evidence exists from the New Haven NIMH Epidemiologic Catchment Area Study which examined 386 respondents who self-reported a severe TBI and found increased rates of drug misuse or dependence when compared to healthy controls even after controlling for pre-injury substance use disorder.[51]

There have been a few longitudinal studies examining alcohol use in TBI patients but these either had variable follow up intervals or significantly limited response rates at follow up.[52] A study by Kreutzer and colleagues documented a post TBI *decrease* in the rates of alcohol use. Pre-injury moderate to heavy drinking was found in 51% of the study sample (n=87) and pre-injury alcohol use was documented in 71%. The first follow-up interval occurred at an average of 8 months following injury, at this interval more patients (58% versus 27%) relative to pre-injury status were abstinent from alcohol consumption and only 25% were moderate to heavy drinkers. The second and final follow-up interval occurred at an average of 28 months following injury, they found 49% of the sample was abstinent and 35% were moderate or heavy drinkers.[44] A 1996 study by Kreutzer and colleagues used a longitudinal design to follow 73 TBI patients for four

years following injury; they found that frequency of drinking increased overall, younger patients had higher rates of drinking, and consumption rates were inversely associated with injury severity.[53]

2.2.3 Current State of the Literature Pertaining to TBI and Alcohol Use

The literature on alcohol misuse rates in the TBI population is substantial in size. I have described a sample of the literature in order to illustrate the opposing views of temporality between alcohol use and TBI. It is safe to say that a disproportionate number of people who experienced a TBI were under the influence of alcohol at the time of the incident or had a history of alcohol misuse prior to the incident. Alcohol use causes acute motor and decision making deficits, both of which can contribute to behaviors that may result in TBIs.

One of the major difficulties that arise when one interprets post-injury alcohol misuse rates and attempts to generalize findings to the population is the heterogeneity of the TBI population. Most studies have examined specific sub-samples of persons with TBI. For example, some studies were interested in only moderate to severe injury where others recruited patients who had suffered a mild TBI.[54] In addition to injury severity, studies have demonstrated a selection bias based on economic situation, psychological comorbidities, or a combination of both. A 2008 review by Graham and Cardon concludes that in spite of the heterogeneity of the TBI populations studied in the literature, there is a global pattern of decreased substance use post-injury. They explain that individuals who continue to misuse alcohol represent a high-risk group with complicated pre-injury histories and a compromised prognosis.[55]

A 2007 prospective study by Ponsford and colleagues examined alcohol use and misuse in 121 patients aged 16 and older who suffered a TBI that resulted in loss of consciousness. Ponsford found that 25% were consuming alcohol at a hazardous level at 2-years post injury,[52] a rate which is elevated compared to base rates of alcohol dependence in the general population of 12%.[56] Therefore, it is important to determine the effect alcohol misuse has on TBI outcomes and to determine the etiology of problem alcohol use in this population.

With attention to the examples I have illustrated above that represent evidence for both alcohol use declining following injury and disproportionate rates of problem alcohol relative to the general population. Based on my review of the literature, it is still up for debate whether or not TBI initiates or exacerbates problem alcohol use. I provide support for further exploration of the effect of TBI on rates of alcohol misuse in the following sections when the coping and brain impairment mechanisms for alcohol misuse following TBI are described.

2.2.4 The Effect of Alcohol on TBI Outcomes

A 2009 retrospective study conducted by De Guise and colleagues examined 60 persons with mild, moderate, and severe TBI in order to examine the difference in functional and neuro-behavioural outcomes in patients with and without a pre-injury history of alcohol misuse. They found that length of stay was greater for patients with a pre-injury history of alcohol misuse regardless of alcohol intoxication at the time of injury; however neuro-behavioural outcomes and global outcomes (i.e., Extended Glasgow Outcome Scale and Functional Independence Measure scale (FIM™) did not differ between persons with and without a pre-injury history of alcohol misuse.[57] The

Extended Glasgow Outcome Scale is a 7 point scale, a score of 0 or 1 corresponds to good recovery, 2 or 3 indicates moderate disability, 4 or 5 indicates total dependence in managing normal or modified environment, a score of 6 corresponds to a vegetative state and a score of 7 represents death.[57] The FIM™ is an 18-item 7-point scale, with higher values indicating more independence, it is important to note that the FIM™ has demonstrated ceiling effects.[58] This study utilized the global rating, and the physical cognitive ratings (i.e., social interaction, problem-solving, memory, expression, and comprehension), which are both composites of the global scale.[57]

In 1989, Sparadeo and colleagues showed that the effects of alcohol at the time of injury on early recovery of TBI was risk enhancing as persons with a positive BAC upon arrival to hospital experienced increased agitation, lower cognitive status at time of hospital discharge, as well as longer hospital stays.[59] They also demonstrated that higher BAC readings at the time of admission were associated with poorer performance on post-injury measures of memory and verbal learning.[59]

On the other hand, some evidence from both animal[60,61] and human clinical studies[62–64] suggests that persons under the influence of alcohol at the time of injury may experience a neuroprotective effect due to alcohol. A 2011 study by Berry and colleagues was conducted in order to identify the specific range of BAC that would provide a neuroprotective effect for patients with moderate to severe TBI. They used a retrospective study design that included 3794 moderate to severe TBI cases. As BAC levels increased [i.e., none (0 mg/dL), low (0-100 mg/dL), moderate (100-230 mg/dL), and high (≥230 mg/dL)], they found lower percentage of ICU admissions, shorter ICU and hospital length of stay durations, and an overall lower mortality rate.[63]

The literature has not come to consensus on the early effects of alcohol at time of injury. Various animal studies have provided evidence that low to moderate BAC levels may be protective[60,61,65–67] whereas larger doses may be harmful in terms of more brain edema and increased mortality.[66,68] In addition, there have been inconsistent results from human clinical studies; some have suggested that positive BAC at the time of injury has no effect on early outcomes such as mortality[69] whereas other have provided evidence that mild levels of alcohol are neuroprotective whereas high levels were associated with increased mortality.[65]

The literature on post-TBI alcohol use describes alcohol as detrimental to rehabilitation outcomes. This may result in decreased life satisfaction, increased risk for depression, as well as increased risk for seizures and re-injury.[7] A variety of studies have linked post-TBI alcohol use to increased rates of psychiatric disorders (including depression), increases in aggressive behaviour, higher arrest rates, lower return to work rates,[54,70] and suicide. Alcohol use following TBI can also lead to other medical complications such as liver and kidney dysfunction.[7]

Patients recovering from TBI are often prescribed medications to assist with complications that arose from their TBI. They are most often prescribed medications for depression and anxiety and drugs to minimize the incidence of seizures.[71] Alcohol use may create concerns for persons taking these medications.[72] It is plausible that the use of alcohol following TBI may reduce the likelihood of optimal recovery. The negative effects of alcohol use may extend to reduced overall future health and well-being of TBI survivors. However, in order to increase understanding, an empirical examination of the relationship between alcohol use and health among TBI survivors is warranted.

2.2.5 Brain Regions Affected By Alcohol Consumption and the Relationship With Incidence of TBI

Specific regions of the brain have heightened susceptibility to alcohol which results in motor, cognitive and sensory impairments that increase the likelihood of experiencing a TBI. When under the acute influence of alcohol there can be difficulty walking as well as maintaining and achieving balance due to effects on the cerebellum.[73] In addition to the cerebellum, the limbic system (i.e., hippocampus, amygdala, anterior cingulate gyrus, septal nuclei and striatum) is affected by acute alcohol use and results in both motor and memory impairments, again, which can increase the risk of experiencing a TBI. These motor difficulties increase the chance of experiencing a fall which subsequently increases the chance of experiencing a TBI.[73] Motor deficits are one of the prime causes behind the heightened danger of a collision among those who operate a motor vehicle whilst under the effects of alcohol,[2] which again increases the risk of experiencing a TBI. Acute cognitive effects due to alcohol occur in the realms of attention, such as reduced stimulus processing, and reduced executive functioning displayed by reduced working memory capacity.[74] In addition, alcohol depresses the behavioural inhibitory centers of the pre-fontal cortex and the limbic system which results in poor decision making, emotional impairments, and subsequent uncharacteristic behaviours which can increase the chances of experiencing a TBI.[75]

The chronic effects of excessive alcohol consumption can result in functional and structural abnormalities of the brain.[76] The brains of heavy consumers of alcohol atrophy according to the rate and amount of alcohol consumed over a life time.[77] Heavy alcohol consumers have been shown to have a significantly reduced white matter commissure which connects the left and right hemispheres of the brain (i.e., the corpus callosum).[78]

The corpus callosum is responsible for inter-hemispheric exchange of motor, sensory and cognitive information; therefore, a deficit in functioning can result in an increased chance of experiencing a TBI. The cerebellum is another brain region that has been shown to atrophy in heavy users of alcohol. This impairment results in motor and memory deficits which can increase the likelihood of experiencing a TBI.[79]

2.3 PROPOSED PATHWAYS BETWEEN TBI AND SUBSTANCE USE

Brain Impairment Hypothesis

As mentioned earlier, there is substantial heterogeneity in the TBI population. It is clear that many different areas of the brain can be affected in an individual with a TBI and the areas affected between individuals can vary greatly. However, it has been shown that there are commonalities in the white matter tracts[80] and cortical areas damaged[81] throughout the brain injured population.

Dopamine (DA) is an organic chemical compound belonging to the catecholamine family of compounds. In the brain, DA acts as a neurotransmitter which is involved in neuron to neuron signaling. Numerous studies have shown that DA is the major reward pathway neurotransmitter in the human brain. Currently DA is coined in the neuroscience literature as both the "pleasure molecule" and the "anti-stress molecule".[82] DA is released for virtually all perceivable pleasurable activities including sex, gaming, and listening to or playing music. It is suggested in the literature that low levels of DA and/or reduced DA function results in compulsive and addictive behaviors such as substance use/misuse.[82]

Taylor and colleagues have suggested that alcohol and other substance seeking behaviour among the head injured population may be due to organic brain syndromes that

result from TBI.[9] The main brain impairment hypothesis that will be discussed in this thesis is the reduced dopamine functioning hypothesis. However, it is important to note that there are also other potential mechanisms between brain injury and substance seeking behaviour. For example, damage to the orbitofrontal cortex results in reduced cognitive function. This can be exemplified by reduced inhibitions and increased impulsivity, which can both lead to substance seeking behaviour.[83] With respect to the reduced dopamine functioning hypothesis, it is first important to understand that dopaminergic neurocircuitry is recruited for both the natural reward pathway and for cueing and delivery of drugs.[11,12,84] For example, an animal study showed that controlled unilateral parietal lesions resulted in reduced release of striatal DA following stimulation of the medial forebrain bundle, as well as decreased DA transporter (DAT) expression in the ipsilateral striatum, and blunted ipsilateral DA clearance brain-wide.[13] Secondly, rat models have provided evidence of increased tyrosine hydroxylase activity following TBI;[85] tyrosine hydroxylase is a rate limiting step enzyme involved in catecholamine synthesis (DA). This is thought to act as a compensatory response to decreased levels of DA. Amphetamines as well as alcohol are known to naturally increase the expression of DA in the areas of the brain responsible for reward.[86] There is also evidence stemming from human brain imaging studies using single photon emission computer tomography (SPECT) for reduced DAT expression in TBI survivors.[87] This suggests that this group might be particularly motivated to engage in use of drugs that increase the expression of DA in brain reward centers.

Evidence for the brain impairment hypothesis in relation to reduced DA activity has also been brought forth via electrophysiological studies. Feedback-Related Negativity

(FRN) signals appear approximately 250 milliseconds after the sensation of a reward. It has been hypothesized that FRNs are a reflection of a dopaminergic negative feedback reinforcement-learning signal which is produced when real outcomes are worse than expected. More specifically, it has been hypothesized that FRN signals are generated when a punishment is relayed to the anterior cingulate cortex via the mesencephalic dopamine system.[88] Larson and colleagues examined reward context sensitivity and FRN in severely injured TBI patients and healthy controls. They found that brain injured individuals had significantly smaller signals compared to controls across both feedback conditions. Interestingly, blunted error-related negativity (ERN) and error positivity (pE) signals are also found in cocaine dependent patients,[89] and this also reflects blunted cortical error processing in fMRI studies of substance misusers.[90] Further, the control group showed significant differences in amplitude between non-reward and reward feedback conditions whereas the brain injured group did not. This study suggests that brain injured persons may have difficulty differentiating reward and non-reward contingencies. The TBI group had significantly larger FRN amplitudes in the low reward probability condition when positive feedback was given. This finding indicates a complete reversal in the direction of the reward-context effect on FRN signals in the TBI population compared to healthy controls which suggests impairment of DA related mechanisms in areas of the brain pertaining to reward pathways.

Psychological studies have examined the decision making processes of individuals who have suffered a TBI. TBI survivors show a preference for smaller but immediate rewards over larger and delayed rewards when compared to healthy controls in delayed-discounting choice tasks.[91] The preference for immediate rewards over

delayed rewards is also found in persons who have addictions to one or more of a variety of substances, including alcohol.[92] This suggests that TBI patients may have difficulty thinking about adverse long term consequences of substance use/misuse.

In conclusion, the research literature has provided evidence regarding the relationship between DA and brain reward pathways. Animal research has provided evidence that TBIs can lead to reductions in the functionality of DA. There is evidence for decreased striatal DA release, reduced functionality of crucial DA transporter proteins, as well as an increase in the production of DA building enzymes. The increase in DA building enzymes in those with TBI has been hypothesized to result from a feedback mechanism in response to reduced DA levels. Evidence from human electrophysiological studies has also provided evidence of impaired functioning in DA systems related to reward learning in those with TBI. Psychological research has demonstrated that TBI patients are more interested in rapid rewards, to the extent that they will overlook the cost of ramifications experienced in order to achieve the rapid reward. DA is known as the pleasure neurotransmitter. The use of alcohol has been shown to compensate for low DA levels in neural reward pathways, and hence the premise of the brain impairment hypothesis regarding heightened risk for substance use, misuse, and dependence following TBI.

Coping

The most disabling long term difficulties following TBI are emotional and social skill problems stemming from a lack of confidence, heightened anxiety, and depression.[93] These difficulties require the adoption of coping strategies. Coping has been defined as:

persistent cognitive and behavioural changes aimed to govern specific external and/or internal demands that are perceived as demanding or overwhelming.[93]

There is a strong association between post-traumatic stress disorder (PTSD) and TBI. Some of the key features of PTSD can lead to alcohol misuse because PTSD can cause neurological hyper-activation which increases adverse reactions to stress. This may lead to hyper-vigilance presenting with avoidance of others, places, or emotions that are related to the trauma. Based on this model by Ford and Russo, these behaviours can lead to substance use/misuse as TBI survivors attempt to alleviate stress and anxiety.[94] In addition, psychological research has also documented the link between TBI and hyper-cortical activation via the association of TBI and PTSD which may result in substance use behaviours including alcohol aimed at reducing stress and anxiety.

Similarly, clinicians have suggested that alcohol and illicit drug use serve as a means of reducing the emotional distress that frequently follows the onset of acquired disability such as a TBI.[95] A 2008 review on chronic pain following TBIs has suggested that novel or increased rates of alcohol and drug use following TBI may be a coping response mechanism for the psychosocial stressors that arise resulting from disability and/or pain.[15] Nampiaparampil and colleagues have also suggested that increased rates of drug or alcohol use may not be a consequence of proximal neurobiological sequelae of brain injury but rather a form of coping.[15]

Albert Bandura's Social Learning theory states that persons will carry out an action, in this case substance use, to obtain a desired reinforcement.[14] Farber and colleagues created and validated factors of positive reinforcement (e.g., social motives)

and of greater interest to TBI and alcohol/drug use, negative reinforcement (e.g., coping motives).[96]

Cooper (1994) expanded on learning theory by adding another dimension of substance use motives: the internal vs. external source of reinforcement dimension. She essentially created a 2x2 matrix of proximal drinking motives; this included 2 reinforcement factors as well as 2 sources for the reinforcement factors. The resulting *four motives* are called *social* (external, positive reinforcement), *enhancement* (internal, positive reinforcement), *conformity* (external, negative reinforcement), and *coping* (internal, negative reinforcement) (see appendix A). Social motives are the most common throughout all age groups,[97,98] and are associated with non-problematic, relatively light alcohol use.[97,99] Enhancement motives have been shown to be frequently associated with heavy and problem drinking across all age groups.[97,100,101] Conformity motives are usually studied with adolescents and have been shown to be associated with alcohol related problems[97,102,103] and positively associated with alcohol use but negatively associated with drinking levels in adolescents.[97] Significant positive associations have been found between coping motives and heavy drinking and alcohol related problems in comparison to social motives. Coping motives have been associated with heavy drinking[100,101] and alcohol related problems in adolescents,[104] adults,[97] and alcohol dependent drinkers.[105] A more recent study has suggested that coping motives should be further categorized into either 'coping-with-anxiety' or 'coping-with-depression'. Coping-with-depression motives are a predictor for drinking quantity as well as alcohol related drinking problems, whereas only coping-with-anxiety motives are related to alcohol problems when drinking levels are controlled for.

The main idea behind the *general coping hypotheses* is that some survivors of TBI are faced with novel difficulties in the realm of social and emotional skills and may subsequently seek substances to reduce anxiety and depression rooted from these social and emotional issues. The framework of learning theory provides evidence for this relationship. Because anxiety and depression are common consequences of TBI,[106] and because both anxiety and depression driven coping motives for drinking are strongly associated with problem drinking behavior,[97] it is possible that these coping motives may help to explain the elevated rates of alcohol and other substance misuse among those who have experienced a TBI.

2.4 SUBSTANCE USE AND THE ASSOCIATION WITH MENTAL HEALTH STATUS

The research literature has long documented a close relationship between psychiatric disorders and substance misuse. Evidence of this relationship has been provided in studies from many countries. Evidence from a population based study showed that 37% of persons with alcohol use disorders and 53% of persons with a non-alcohol substance use disorder had a comorbid psychological disorder.[107] The prevalence of comorbid psychiatric disorders is elevated in persons seeking addictions treatment with estimates between 47% and 67%.[108,109] The temporality of this relationship is complex as a psychiatric disorder can lead to substance use problems, and substance use can bring on and/or worsen mental health issues. In addition, other factors such as common genetic or personality factors can account for the relationship between substance misuse and psychiatric disorders.[110]

2.4.1 The Relationship Between TBI and Mental/ General Health

A variety of mental health issues have been revealed as potential consequences of TBIs. The most frequently diagnosed psychiatric disorder following TBIs is depression. Prevalence rate estimates for depression in the TBI population range from to 6% to 42%.[106] A large portion of the literature has focused on Major Depressive Disorder(MDD) which, according to the *Diagnostic and Statistical Manual of Mental Disorders, 4th edition* (DSM-IV), requires a duration of at least 2-weeks of 5 or more depressive symptoms.[111] Using this definition, it has been shown that approximately half of persons with a TBI have experienced MDD within the first year following their injury, even after controlling for pre-injury diagnosis.[112] Interestingly, the severity of the TBI is not correlated with the development or severity of depressive symptoms or diagnosis.[112–115] The consequences of depression following TBI can be severe, potentially leading to a decreased quality of life, unemployment, or even suicide.[116] Other common psychiatric consequences following TBI are anxiety disorders including: PTSD with a prevalence rates between 10% and 20% from 6-12 months following injury; generalized anxiety disorder (11%); agoraphobia (10%); social phobia (7%); and panic disorder (6%).[106]

2.5 OTHER COVARIATES ASSOCIATED WITH TBI

2.5.1 Race

In the United States, there is an interesting contrast in incidence rates of TBI between African Americans and Caucasians. Caucasians have an incidence rate of 399 per 100,000 whereas African Americans have a rate of 485 per 100,000.[117,118] Minority groups as a whole have a heightened prevalence of TBI. In 2002, over 33% of Americans with a TBI belonged to a minority group as compared to 28.6% of Americans without a TBI. In terms of post-injury recovery, some studies have shown similar patterns

between whites and minority groups in terms of impairment and activity. However, there is evidence that minority groups fare worse than whites in terms of social integration[119] at one year post-injury and employment[49] at both one and four year follow-up. This race-specific association has been hypothesized as a result of differences in SES between the two populations.[117,118] Multiple studies have shown that people with a TBI belonging to a minority group as compared to whites with a TBI have lower education levels and higher pre-injury rates of unemployment.[117]

2.5.2 Education and Income

Pre-injury education level has been shown to be a strong predictor of outcomes such as social-family functioning, cognitive, psychiatric, and vocational functioning.[120] In addition pre-injury education level is a strong predictor of vocational success following injury. I have included level of education as a covariate in this study based on the evidence of an association with TBI rehabilitation outcomes. I have also included total household income as a covariate because level of education is associated with higher income brackets.

2.5.3 Age

The literature has demonstrated older age as a risk factor for poorer outcomes for individuals who have experienced a TBI. Increased mortality and worse functional outcomes have been demonstrated in the elderly following TBI.[121,122] Interestingly, there is also evidence that age is not associated with outcomes following TBI.[123–125] I have included age as a covariate in this study based on the evidence of an association with TBI outcomes.

2.5.4 Sex

The literature provides evidence of sex-differences in terms of outcomes following TBI; however, the directionality is unclear. Evidence from animal studies have supported the premise that females experience better outcomes following TBI.[13] An explanation for this may lay in the hormonal differences between sexes, specifically the higher level of progesterone in women. Progesterone is dispersed throughout the brain and is thought to increase the survival and differentiation of neurons and glial cells.[126] A single-site double blinded study examined the effect of progesterone in patients who suffered a moderate to severe brain injury; this study found significantly decreased 30-day mortality and improved 30-day functional outcome scores for patients in the progesterone treatment arm as compared to a placebo control group.[127] On the other hand, there is some evidence for poorer outcomes among women in terms of morbidity and mortality.[128] Further, a variety of studies have reported no sex differences in terms of complication or outcomes.[129–131] An explanation for the uncertainty of the existence and/or direction of sex differences on TBI outcomes could lie in the differences in mode of injury and resulting injury severity between sexes, most importantly a trend for less severe TBI's among women.[132] I have included sex as a covariate in this study based on the evidence of association with TBI outcomes.

2.5.5 Mechanism of Injury

We have included a location/mechanism of injury for descriptive purposes.

2.5.6 Health Utilities Index

We have included the global Health Utilities Index (HUI) score for examination as a potential mediator between injury type and our outcomes of interest. The HUI is a classification system designed to provide comprehensive, reliable, responsive and valid

measures of health status and health related quality of life.[133] If the HUI were to behave as a mediator we would expect either a significant change in the effect size of the association between the independent variable and the dependent variable or a change in the direction or presence of the relationship.

CHAPTER THREE: METHODS

3.1 DATA

This study utilized individual level data from the 2009-2010 Canadian Community Health Survey (CCHS). The Canadian Institute for Health Information (CIHI), Statistics Canada, and Health Canada have collaborated to develop the CCHS, which is a national Canadian survey designed to be representative of the population. The 2009-2010 CCHS collected data from 124,188 Canadians in 12 two-month collecting periods with each interval being representative of the population of the 10 provinces. The sample from the territories was representative of their population after 12 months of data collection. The total sample is representative of 28,725,105 Canadians.

CCHS collects: socio-demographic measures, administrative data and a variety of other health related content. There is a common content section that is collected every cycle; another common content section collected every 2 years, an optional content component and a rapid response component. The entire interview process is estimated to take 40-45 minutes per individual interviewed.

The CCHS casts a wide net in terms of the target population. CCHS targets persons 12 years and older who reside in private dwellings in all of the ten provinces and three territories. Individuals living on Indian Reserves, Crown Lands, institutions or specific remote regions were not sampled in addition to full-time members of the Canadian Forces. The CCHS captures approximately 98% of the Canadian population that are 12 years or older.

To attain a representative sample, the CCHS target sample was divided among all provinces by health region (HR) according to population size. Within each province, the

sample was allocated among HRs proportionally to the square root of the estimated population in each HR. The 3 territories had different allocation strategies based on their population and available resources. Each province was divided into regions: major urban, cities, and rural areas. There was further stratification within each region based on geographic and/or socioeconomic strata. The CCHS used three sampling frames in order to select households: 49.5% of the sample of households was selected from an area frame, 49.5% were selected from a list frame of telephone numbers, and 1% was selected via a Random Digit Dialing sampling frame.

For the 2009-2010 CCHS, a total of 172,671 households were selected for interview, and 139,841 agreed to participate yielding a house-hold response rate of 81%. Of the 139,841 households, 124,870 individuals completed the survey yielding an individual-level response rate of 89.3%. The combined Canada-wise response rate for the 2009-2010 CCHS was 72.3%.

3.2 STUDY DESIGN

This is a cross-sectional study which examines differences in substance use, physical, and mental health outcomes across three subgroups of respondents. These three groups consist of one key exposure group and two control groups. All individuals included in the analysis were 12 years of age or older.

3.2.1 Exposure Variables

The main exposure variables that will be used throughout this study are injury status variables. This study will examine three injury status groups. The first are individuals who have experienced a TBI, the second are those who have experienced a BSI, and the third are those who have not experienced an injury.

The variable for exposure to injury is coded as INJ_01 in the 2009-2010 CCHS data file. The variable is measured by the question "Not counting repetitive strain injuries, in the past 12 months, were you injured?" The response categories include yes, no, don't know, and refusal.

The variable for injury type is coded as INJ_05 in the data file. The variable is assessed by the question "What type of injury did you have (for the most serious injury)? For example, a broken bone or burn." The response categories include: multiple injuries (exc. minor inj.), broken or fractured bones, burn/scald/chemical burn, dislocation, sprain or strain (incl. torn lig.), cut/ puncture/ animal bite, scrape(s)/bruise(s)/blister(s), concussion or other brain injury, poisoning (exc. food poisoning, poison ivy), injury to internal organs, other, not applicable, don't know, refusal, and not stated.

The variable for injury location is coded as INJ_06 in the data file. The variable is assessed by the question "What part of the body was injured (for the most serious injury)?" The response categories included: multiple sites, eyes, head, neck, shoulder/ upper arm, elbow/ lower arm, wrist, hand, hip, thigh, knee/ lower leg, ankle/ foot, upper back or upper spine, lower back or lower spine, chest (excl. back and spine), abdomen or pelvis (excl. back and spine), not applicable, don't know, refusal, and not stated.
Please see appendix B for detailed descriptions of all exposure variables.

3.2.2 Exposure Group

The exposure of interest is individuals who have experienced a TBI. In the 2009-2010 CCHS subjects were asked about the most serious injury that they experienced in the previous 12 months. Responses provided details on both the body part affected as well as the type of injury that occurred. For this project TBI will be classified as an injury

to the head which was specified as a concussion or other brain injury. We have included a combined head injury sub-group which includes those who responded that they have experienced a concussion or other brain injury and those that responded that the injury site was the head.

This study is utilizing self-report measures of TBI which has inherent differences to clinical measures of TBI. Self-report measures of TBI have been used in the literature; however, there is typically a stipulation for a loss of consciousness duration. Self-report measures of TBI, in theory, increase the likelihood of including misclassified cases of TBI which would result in conservative estimates of the associations with substance use/ misuse and mental health. Whereas a clinical diagnosis of TBI could exclude a good portion of those that are effected by TBI, as many of those with a TBI do not seek medical attention and are therefore not captured. Using a clinical diagnosis of TBI could also over-estimate the association of interest at a population level.[134] Since this is a population based study, and despite the heightened likelihood of misclassification of TBI when using self-report over clinical measures, we feel that capturing a wider spectrum of respondents (i.e., using a self-report measure) with a TBI is more useful for examining associations with substance use/ misuse and mental health among this population.

3.2.3 Control Groups

The first control group is non-head injured individuals with an injury type that is likely to be of a chronic nature, specifically, lower/ upper back/spinal injury. Lower back pain (LBP) is a common health problem in Canadians and throughout the world. The costs of LBP can be substantial; significant financial impacts are found on the level of individuals, their families, communities, government and industry.[135–137] Globally, LBP is

the number one cause of activity limitations and work absenteeism.[138] The course of LBP is increasingly considered as chronic and recurrent with the majority of cases never meeting 'true' remission, with the definition of true remission being no episodes following alleviation of symptoms from original onset.[139]

The lower back/ spine injury location is one of the most suitable injury types available in our data set (2009-2010 CCHS) in terms of the potential for chronicity of injury as well as the similarity of psychosocial consequences to TBI. We have included upper back/ spine injury with the lower back/ spine injury as the literature has often used spinal injury as a comparator injury type to TBI.[6,7,134] I am interested in chronicity and psychosocial consequences as these are factors that are related to the coping hypotheses for substance use.

The second control group is healthy controls who have not experienced any injury in the past 12 months. This group consists of a 10% random sample of all non-injured individuals.

3.3 MEASURES

This section will provide a description of the variables that will be included in the analysis of the relationship between TBI, alcohol, cigarette smoking, cannabis and other illicit drug use. All variables used in this study are from the 2009-2010 Canadian Community Health Survey. The variables included are divided into two categories, these are: outcome, as well as mediator and covariates.

3.3.1 Substance Use Outcome Variables

The main outcome variables that will be used throughout this study are measures of alcohol, tobacco, and illicit drug use behaviors. In addition, outcome measures on self-perceived mental health status are included.

Alcohol Measures

The measure of alcohol use captured those that did not drink, those that drank but did not binge drink, and those that binge drank. This measure stemmed from two separate questions in the CCHS. The first question is coded as ALC_1 in the data file. It is assessed using the question "During the past 12 months, have you had a drink of beer, wine, liquor or any other alcoholic beverage?" The response categories included: yes, no, don't know, refusal, and not stated. The second question is coded as ALC_3 in the data file. It is assessed using the question "How often in the past 12 months have you had 5 or more drinks on one occasion?" The response categories included: never, less than once a month, once a month, 2 to 3 times a month, once a week, more than once a week, not applicable, don't know, refusal, and not stated. From these two questions I created a categorical variable that captured non-drinkers, those that drank but did not binge and those who drank whilst bingeing.

Illicit Drug Use

This variable was created to measure the presence of illicit drug use. This measure is constructed from a series of questions asking about past 12 month's use of the following drugs: marijuana/ cannabis, ecstasy, cocaine/crack, amphetamines and hallucinogens/ PCP/ LSD. This variable is a dichotomous variable. The first dichotomy includes respondents who in the past 12 months prior to interview did not use any illicit drugs and the second dichotomy includes respondents that used at least 1 illicit drug.

Smoking Status

The measure for tobacco smoking status inquires about the type of smoker a respondent is. This variable is coded as SMK_202 in the data file. This question was asked of all respondents. It is assessed using the question "At the present time, do you smoke cigarettes daily, occasionally or not at all?" The response categories included: daily, occasionally, not at all, don't know, refusal and not stated. We dichotomized this variable to measure those that do not smoke compared to those that smoke (i.e., daily or occasionally).

3.3.2 Mental Health Outcomes/ Potential Mediator Variables

The first measure is self-perceived mental health. This variable acts as one of the mental health outcomes and is assessed as a mediator variable with the substance use/ misuse outcomes. This variable is coded GEN_02B in the data file. This variable is measured using the question "In general, would you say your mental health is: (Excellent, Very good, Good, Fair, Poor)?" The response categories included: excellent, very good, good, fair, poor, don't know, refusal, and not stated. We dichotomized this variable to measure poor/fair mental health versus good/very good/excellent mental health.

The second measure in this category is mood disorder. This variable is coded CCC_280 in the data file. This variable is measured using the question "Remember, we are interested in conditions diagnosed by a health professional. Do you have a mood disorder such as depression, bipolar disorder, mania, or dysthymia?" The response categories included: yes, no, don't know, refusal, and not stated. We dichotomized this variable to measure the existence or non-existence of mood disorders diagnosed by a health professional.

The third measure in this category is the presence of an anxiety disorder diagnosed by a health professional. This variable is coded CCC_290 in the data file. This variable is measured using the question "Do you have an anxiety disorder such as phobia, obsessive-compulsive disorder, or a panic disorder?" The response categories included: yes, no, don't know, refusal, and not stated. We dichotomized this variable to measure the existence or non-existence of an anxiety disorder.

The fourth measure in this category is perceived life stress. This variable acts as one of the mental health outcomes and is assessed as a mediator variable with the substance use/ misuse outcomes. This variable is coded GEN_07 in the data file. This variable is measured using the question "Thinking about the amount of stress in your life, would you say that most days are (not at all stressful, not very stressful, a bit stressful, quite a bit stressful, or extremely stressful)?" The response categories included: not at all stressful, not very stressful, a bit stressful, quite a bit stressful, extremely stressful, don't know, and refusal. We dichotomized this variable to measure low stress and high stress. Low stress included responses of not at all stressful and not very stressful whereas the high stress category includes those that responded that their life was: a bit stressful, quite a bit stressful, or extremely stressful.

3.3.3 Proxy Risk Taking (Wearing a Bicycle Helmet)

In order to examine whether TBI and injury involvement is part of a more general risk-taking profile, an additional outcome measure was included. This measure is adherence to bicycle helmet wearing. This variable will be used in the descriptive analysis between injury groups and as an outcome variable in a fully adjusted model- this variable will be utilized as a proxy for risk-taking behaviour. This variable is coded as

UPE_01 in the data file. This variable is measured by the question "When riding a bicycle, how often do you wear a helmet?" The response categories included: always, most of the time, rarely, or never. We operationalized this measure by creating a variable with a category for not applicable, a category for those that responded with always or most of the time and the last category for those that responded with rarely or never.

Please see appendix B for detailed descriptions of all variables.

3.3.4 Covariates

Variables that have been shown to relate, or are plausibly related, to the exposure (i.e., injury status) and/or outcome measures (i.e., alcohol use, illicit drug use, and self-perceived general and mental health) will be controlled for in the analyses. This includes variables related to: injury severity, location of injury occurrence, and socio-economic status.

Injury Measures

The first covariate that will be adjusted for is treatment by a medical professional. This is coded as INJ_13 in the data file. This variable is assessed using the question "Did you receive any medical attention for the injury (most serious injury) from a health professional in the 48 hours following the injury?" The response categories included: yes, no, not applicable, don't know, refusal, and not stated. We are not directly analyzing this variable but it is incorporated into the derived injury severity variable.

The second covariate that will be adjusted for is whether medical treatment was received at a doctor's office. This variable is coded INJ_14A in the data file. This variable is assessed using the question "Where did you receive treatment in the 48 hours (following injury)? Doctor's office." The response categories included: yes, no, not

applicable, don't know, and not stated. We are not directly analyzing this variable but it is incorporated into the derived injury severity variable.

The third covariate that will be adjusted for is whether medical treatment was received at a hospital emergency department. This variable is coded INJ_14B in the data file. This variable is measured using the question "Where did you receive treatment in the 48 hours (following injury)? Hospital emergency room." The response categories included: yes, no, not applicable, don't know, and not stated. We are not directly analyzing this variable but it is incorporated into the derived injury severity variable.

The fourth covariate that will be adjusted for is admission to hospital. This variable is coded INJ_15 in the data file. This variable is assessed using the question "Were you admitted to a hospital overnight?" The response categories included: yes, no, not applicable, don't know, and not stated. We are not directly analyzing this variable but it is incorporated into the derived injury severity variable.

A single dichotomous variable will be created from the measures mentioned above (i.e., INJ_13, INJ_14A, INJ_14B and INJ_15) as a means to classify injury severity. The first category will include those that responded that they did not seek any medical attention following injury, this will be deemed as mild injury. The second category will include persons that received medical attention as a result of injury, this will represent moderate injury severity. We are creating one category for those who suffered a mild injury and another category for those that experienced a moderate injury.

The fifth covariate that will be included is mechanism/ location of injury. This variable will be included in the descriptive analysis but not in the regression models. This variable is coded INJ_08 in the data file. This variable is measured in the context of the

most serious injury, it is asked as: "Where did the injury happen?" The response categories included: in a home or its surrounding area, residential institution, school/ college/ university, sports or athletics area of school, other sports or athletic areas, other institution, street/ highway/ sidewalk, commercial area, industrial or construction area, farm, countryside/ forest/ lake/ ocean, other, not applicable, don't know, refusal, and not stated. We recoded this variable to split the response options into 7 categories. Category 1 includes those that responded that their most serious injury occurred: in a home or its surrounding area or residential institution. Category 2 includes: school/ college/ university/ or street/ highway/ sidewalk. Category 3 includes: sports/ college/ university or other sports/ athletics areas. Category 4 includes those who were injured in a commercial area. Category 5 includes those that were injured: in an industrial/ construction area or a farm or in the country side/ forest/ lake/ ocean. Category 6 included those that responded with not applicable or don't know or refusal, or not stated.

Socio-demographic Status Measures

The first variable that will be adjusted for is the sex of the respondent. This variable is coded DHH_SEX in the 2009-2010 CCHS data file. This variable was evaluated by the interviewer but if the interviewer was unable or uncertain of the respondents sex, they inquired using the question "Is respondent male or female?"

The second variable that will be adjusted for is the age of the respondent. This variable is coded DHH_AGE in the data file. This variable was derived from day of birth, month of birth, and year of birth. We recoded this variable to measure youth, young adults, middle aged adults, and seniors. Youth were classified as 12-17 years, young

adults were classified as ages 18-40 years, middle aged as 41-60 years, and seniors were classified as 61 years and above.

The third variable that will be adjusted for is total household income. This variable is coded INCDHH in the data file. This is a derived variable based on four variables coded in the data file as INC_3, INC_5A, INC_5B, and INC_5C. These variables are assessed by the following questions or statements: "What is your best estimate of the total income, before taxes and deductions, of all household members from all sources in the past 12 months?", "What is your best estimate of the total household income received by all household members, from all sources, before taxes and deductions, in the past 12 months?", "Please stop me when I have read the category which applies to your household". Categories for this derived variable include: no income, less than $5,000, $5000 to $9,999, $10000 to $14,999, $15000 to $19,999, $20,000 to $29,999, $30,000 to $39,999, $40,000 to $49,9999, $50,000 to $59,999, $60,000 to $69,999, $70,000 to $79,999, $80,000 to $89,999, $90,000 to $99,999, $100,000 or more, and not stated. We recoded this variable to measure poverty, low income, moderate income, and high income. Poverty was defined as an income below $19,999, low income was classified as earnings greater than $19,999 but less than $30,000, moderate income was classified as income greater than $30,000 but less than $60,000, and high income was classified as $60,000 and above per year.[140]

The fourth variable that will be adjusted for is highest level of education. This variable is coded EDUDR10 in the data file. This is a derived variable based on four variables EDU_1, EDU_2, EDU_3, and EDU_4. These variables are assessed using the following questions or statements: "What is the highest grade of elementary or high

school you ever completed?", "Did you graduate from high school (secondary school)?", Have you received any other education that could be counted towards a degree, certificate or diploma from an educational institution?", and "What is the highest degree, certificate or diploma have you obtained?". Categories for this derived variable include: grade 8 or lower, grade 9-10, grade 11-13, secondary school graduate, some post-secondary, trades certificate or diploma, diploma/ certificate- college/ cegep, univ. certificate below bachelor's level, bachelor's degree, univ. degree or cert. above bac. level, and not stated. We recoded this variable to measure low education, moderate education, high education, and advanced education. Low education was classified as less than high school diploma (i.e., less than secondary school graduate), moderate education was classified as high school graduate (i.e., secondary school),high education was classified as any education greater then high school but less than a bachelor's degree (i.e., trade certificate or diploma or college certificate/ diploma/ cegep or a university certificate below bachelor's levels), and advanced education was defined as a university certificate at or above the bachelor's level (i.e., bachelor's degree and/or university degree above bachelor's level).[141]

The fifth variable that will be adjusted for is province of residence. This variable is coded GEO_PRV in the data file. This variable is included to control for provincial trends.

The final variable that will be adjusted for is cultural or racial origin. This variable is coded SDCDCGT in the data file. This derived variable is based on thirteen variables SDC_43A, SDC_43B, SDC_43C, SDC_43D, SDC_43E, SDC_43F, SDC_43G, SDC_43H, SDC_43I, SDC_43J, SDC_43K, SDC_43L, and SDC_43M. Categories for

this derived variable are: White, black, Korean, Filipino, Japanese, Chinese, south Asian, Southeast Asian, Arab, west Asian, Latin American, other racial or cultural origin, multiple racial/ cultural origins, not applicable, and not stated. Categories will be collapsed into a dichotomy of white versus all other cultures or racial origins. We dichotomized this variable to measure whites versus all minorities.

Mediators (Mental Health and HUI)

Three variables are included in the analysis to assess mediating effects between injury type and both substance use/ misuse and mental health outcomes. The first mediator is included to control for the effects of disability on substance use and mental health, measured with the Health Utilities Index (HUI). The Health Utilities Index is coded as HUIDHSI in the data file. This variable is derived based on the responses for each component of the HUI, in this data set these components were represented by the following variables: HUIDVIS, HUIDHER, HUIDSPE, HUIDMOB, HUIDDEX, HUIDEMO, HUIDCOG, and HUPDPAD. The index score ranges from a -0.335 to 1.0, smaller scores represent worse health related quality of life whereas greater scores represent better. We divided the index score range into quartiles based on cut-points calculated from the distribution of responses from the entire sample; therefore, we created a Health Utilities Index variable with four categories. In summary, we are using the HUI as a marker for overall functioning as we felt overall level of functioning may confound our findings regarding the association of TBI and substance use or mental health.

The second and third mediators are drawn from the mental health measures described above, stress and general mental health, and are used to assess mediation between injury status and substance use outcomes.

Please see appendix B for detailed descriptions of all variables.

3.4 ANALYSIS

3.4.1 Descriptive Statistics

Analysis of the data will include an exploration of descriptive statistics such as frequency distributions, medians, and means. We will look at injury group differences among all outcome measures as well as injury group differences among covariates.

3.4.2 Regression Models

In order to explore the relationship between TBI and substance use outcomes, a series of regression models will be conducted.

Substance use outcomes

Logistic and multinomial regression models will be employed depending on whether the outcome variable of interest is dichotomous, or has more than two categories without a rank order (i.e., logistic regression for dichotomous variables, and multinomial regression for variables with greater than 2 categories.

Mental health outcomes

I use logistic regression modeling for all mental health outcome measures as they are collapsed into dichotomous variables.

Modeling

To begin, we created unadjusted models to examine inherent differences between the groups (i.e., head injured, back/ spine injured, and non-injured) on all outcomes of interest (i.e., substance use and mental health), this will be called **model A.**

Secondly, we tested for mediation. A mediator variable is a variable that plays an important role guiding the relationship between an independent variable and a dependent variable. We created **models B and C** in order to test for mediation.

- **Model B** is the same as model A except it includes the Health Utilities Index variable.
- **Model C** is also similar to model A except it includes the stress and general mental health variables.

Next, we introduced the previously described covariates (appendix B) into the models as a means to control for their effects in explaining relations between exposure and outcome variable's; these were included in the fully adjusted models, **model D.**

- **Model D**
  - The fully adjusted models for the *substance use outco*mes consisted of the following control variables: stress, self-perceived general mental health, province, sex, income, minority status, injury severity, age, HUI, and education.
  - The fully adjusted models for the *mental health outcomes* are similar to the full model for the substance use outcomes except they do not include any mental health covariates.

In order to test for interactions we examined differences across sex and age in terms of exposure and outcomes. Based on the results of models A, B, and D as well as models A, C and D we assessed whether the Health Utilities Index alone or stress and general mental health mediate the relationship between injury type and our outcomes of interest (i.e., substance use and mental health measures).

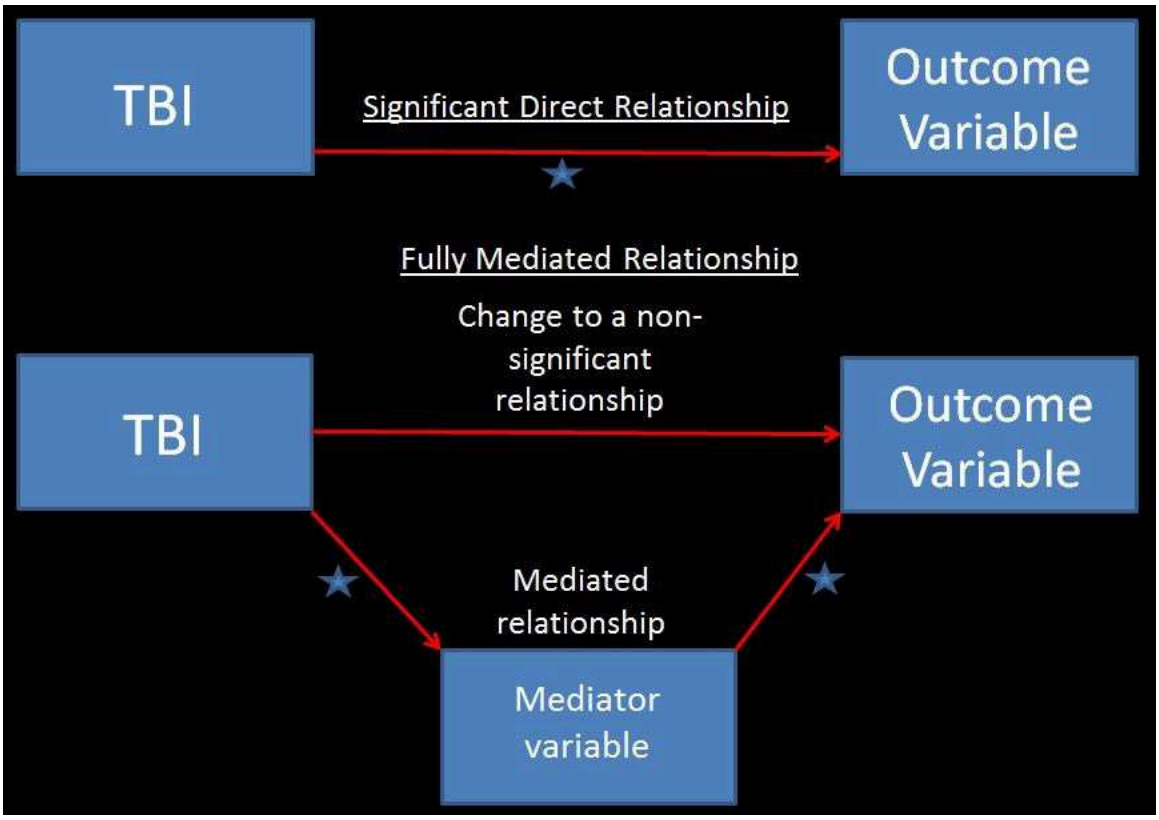

Figure 1. Mechanism of an example mediator variable

All analyses will utilize the bootstrap weights provided with the CCHS data to produce reliable estimates weighted to be representative of the Canadian population. All analyses employ the survey commands (svy) in Stata to address the stratified, complex sampling design of the data.

Statistical significance for all analyses was set at a 2-sided alpha level of P=0.05, unless otherwise stated. All data analyses were completed using the software statistical package STATA version 11.1 SE.

3.4.3 Ethics

The protocol for this study was reviewed and approved by the Dalhousie University Research Ethics Board.

3.4.4 Results

The following three chapters describe the association between injury groups and demographic variables as well as other covariates. In addition, these chapters examine the associations between TBI and mental health and substance use outcomes. Due to the large number of variables included in the analysis, these sections will comment only on demographics and covariates that differ from what has been shown to be expected in the literature. The combined injury group, those that declared they had an injury to the head and those that declared they experienced a concussion or other brain injury, will not be discussed, except for instances where associations differ significantly from the TBI group.

CHAPTER FOUR: RESULTS- INJURY GROUPS DEMOGRAPHICS AND COVARIATES

This first section provides a descriptive overview of the study population (demographics and injury measures) stratified by injury group (i.e., TBI, BSI, Combined, and Non-injured). All results are presented in tables 4.1 and 4.2 at the end of the chapter.

Beginning with sex, the TBI and the combined injury group had the greatest proportion of males (62%) followed by the BSI group (56%), and the non-injured group (52%). With regards to age, the TBI group had the greatest proportion of respondents below the age of 25 (49%) followed by the combined injury group (41%), the BSI group (41%), and the non-injured group (19%). Minority group membership was low, overall, with 15% of the TBI group, 16% of the combined injury group, 14% of the BSI group and 22% of the non-injured group reporting belonging to a minority group.

With regards to education, about 30% of the TBI group had an education level less than a high school diploma, whereas 54% had a Trade/ Diploma or a University level degree. The combined injury group had similar levels of education as the TBI group as almost 30% had an education below the level of a high school diploma and 54% had a Trade/ Diploma or a University level degree. Only 14% of the BSI group had an education level below that of a high school diploma, whereas 69.4% of this group had a Trade/ Diploma or a University level degree. The non-injured group was more similar to the BSI group than the TBI and combined injury groups in terms of education as 62% of respondents had an education level beyond a high school diploma, only 21% did not attain a high school diploma.

Turning to income, 45% of the TBI groups were in the high income bracket, with 17% belonging to the low income or poverty brackets. Again, the combined injury group

showed similar numbers to the TBI group with 44% belonging to high income and 17% belonging to the low income or poverty brackets. Almost 58% of the BSI group reported an income within the range of the high income bracket, whereas only 11% reported an income within the poverty or low income brackets. About 46% of the non-injured group was from the high income bracket and only 13% fell within the poverty or low income brackets.

Looking specifically at the location/ activity at the time of injury, what was most prominent for the TBI group was an injury whilst playing sports (38%), followed by an injury occurring at school (19%), and at home (17%). The most prominent location/ activity at the time of injury for the combined injury group was playing sports (28%), followed by: an injury occurring at home (25%), and an injury occurring at school or a street/ sidewalk/ highway (19%). The most common location at the time of injury for the BSI group was at home (45%) followed by: a street or public space (14%) and whilst playing sports (13%). With regard to severity of injury (i.e., whether or not medical attention was received) 81% of the TBI group, 80% of the combined injury, and 50% of the BSI group received medical attention.

With regard to the global HUI score, almost one third (32%) of the TBI group fell and 32% of the combined injury group were in the lowest quartile for overall health and well-being. About 27% of the BSI group and 21% of the non-injured group fell within this quartile.

Finally, I ran a series of regression models with injury type as the dependent variable and each covariate as the independent variable (Table 4.3). With the non-injured group as the reference category regressions revealed significant differences in quartile 3

and 4 of the HUI for the TBI and BSI groups, and quartiles 2,3, and 4 for the Combined Head Injury Group. Next, looking at sex, the TBI, BSI, and Combined Head Injury groups were all significantly more likely to consist of males relative to the non-injured group. Moving to age, the TBI and Combined Head injury groups were significantly younger than the non-injured group. Relative to the non-injured group the BSI group was significantly less likely to not have an education below the level of a high school diploma, more likely to be White as well as more likely to have a high household income. Both the TBI and Combined Head Injury group were significantly more likely to have received medical attention following injury relative to the BSI group. Lastly, in terms of the location that the injury occurred relative to the BSI group, the TBI and Combined Head Injury Group was significantly more likely to experience their injury whilst playing sports.

Table 4.1.Demographics by injury group (sample weights and bootstrapping methods applied (N and percent))

Total CCHS sample (n= 124,870)		Traumatic Brain Injury (N=339)		Combined Head Injury (N=807)		Back/ Spinal Injury (N=2790)		Non-Injured (N=10627)	
Demographic variables		*N*	Percent	*N*	Percent	*N*	Percent	*N*	Percent
Sex	Male	209	61.6	500	61.9	1572	56.4	5147	48.4
	Female	130	38.4	307	38.1	1218	43.6	5480	51.6
Age	12-17	80	23.7	177	22.0	169	6.1	842	7.9
	18-25	87	25.6	155	19.2	316	11.3	1180	11.1
	26-40	57	16.8	152	18.9	808	29.0	2513	23.7
	41-60	81	23.9	186	23.0	1137	40.7	3809	35.8
	61+	34	10.0	137	16.9	361	12.9	2284	21.5
Income	Poverty	31	9.2	71	8.8	132	4.7	773	7.3
	Low	27	8.1	60	7.5	165	5.9	664	6.2
	Middle	56	16.6	184	22.8	563	20.2	2369	22.3
	High	153	45.1	353	43.7	1615	57.9	4862	45.8
	Not Stated	72	21.1	139	17.2	316	11.3	1960	18.4
Education	< High School	101	29.7	244	30.2	379	13.6	2191	20.6
	High School	48	14.2	112	13.9	417	15.0	1613	15.2
	Trade/ Diploma	133	39.1	318	39.4	1278	45.8	4321	40.7
	Bachelor's Degree and above	52	15.3	119	14.7	660	23.6	2243	21.1
	Not Stated	6	1.6	14	1.7	56	2.0	257	2.4
Ethnicity	White	289	85.4	675	83.7	2393	85.8	8334	78.4
	Any Minority	49.5618	14.6	132	16.3	397	14.2	2293	21.6

Table 4.2 Covariates by injury group (sample weights and bootstrapping methods applied (N and percent)).

Total CCHS sample (n= 124,870)		Traumatic Brain Injury (N=339)		Combined Head Injury (N=807)		Back/ Spinal Injury (N=2790)		Non-Injured (N=10627)	
Covariates		*N*	Percent	*N*	Percent	*N*	Percent	*N*	Percent
Health Utilities Index	Quartile 1	110	32.4	258	32.0	756	27.1	2189	20.6
	Quartile 2	90	26.5	212	26.3	790	28.3	2635	24.8
	Quartile 3	55	16.2	128	15.8	569	20.4	2763	26.0
	Quartile 4	85	25.0	209	25.9	678	24.3	3039	28.6
Injury Mechanism	Home	57	16.7	199	24.7	1258	45.1	-	-
	School	64	19.0	153	18.9	259	9.3	-	-
	Sports	130	38.4	228	28.2	349	12.5	-	-
	Street/ public space	25	7.4	73	9.0	399	14.3	-	-
	Industrial/ occupation	18	5.2	40	4.9	117	4.2	-	-
	Other	41	12.1	102	12.7	299	10.7	-	-
	Don’t know	4	1.3	13	1.6	112	4.0	-	-
Injury Severity	No Medical Attention	65	19.3	165	20.5	403	49.8	-	-
	Medical Attention	274	80.7	642	79.5	404	50.2	-	-

Table 4.3 Multinomial Logistic Regression of Injury status by each covariate (RRR's and 95% CI's presented; sample weights and bootstrapping methods applied)

Covariate		TBI (Non-injured as referent)	Combined (Non-injured as referent)	BSI (Non-injured as referent)
HUI	Quartile 2	0.68 (0.41-1.13)	0.68 (0.51-0.92)**	0.87 (0.69-1.08)
	Quartile 3	0.40 (0.24-0.66)***	0.39 (0.26-0.60)***	0.60 (0.50-0.71)***
	Quartile 4	0.56 (0.34-0.92)**	0.58 (0.40-0.85)***	0.65 (0.54-0.77)***
Sex	Female	0.59 (0.42-0.83)***	0.58 (0.44-0.75)***	0.73 (0.64-0.83)***
Age	12-17	1.30 (0.79-2.16)	1.60 (1.11-2.31)**	0.75 (0.56-1.00)*
	18-40	-	-	-
	41-60	0.31 (0.17-0.57)***	0.46 (0.30-0.70)***	1.20 (0.93-1.56)
	61+	0.29 (0.17-0.49)***	0.37 (0.26-0.53)***	1.12 (0.89-1.40)
	Not stated	0.20 (0.11-0.37)***	0.46 (0.31-0.66)	0.59 (0.44-0.80)***
Education	< than High School	1.54 (0.52-4.50)	1.60 (0.91-2.79)	0.67 (0.48-0.94)**

Covariate		TBI (Non-injured as referent)	Combined (Non-injured as referent)	BSI (Non-injured as referent)
	High School	-	-	-
	Trade/ Diploma	1.03 (0.49-2.13)	1.06 (0.64-1.74)	1.14 (0.84-1.55)
	University Degree	0.77 (0.23-2.59)	0.76 (0.36-1.63)	1.14 (0.92-1.41)
	Not Stated	0.72 (0.21-2.43)	0.78 (0.40-1.54)	0.84 (0.49-1.44)
Income (Household)	< $19,999	0.98 (0.43-2.24)	1.01 (0.54-1.90)	0.69 (0.50-0.95)**
	$20,000 - $29,999	-	-	-
	$30,000- $59,999	0.58 (0.21-1.58)	0.85 (0.49-1.48)	0.96 (0.73-1.25)
	≥ $60,000	0.76 (0.33-1.78)	0.80 (0.45-1.42)	1.34 (1.04-1.72)**
	Not Stated	0.89 (0.40-1.96)	0.78 (0.44-1.40)	0.65 (0.47-0.90)**
Race	White	1.61 (0.78-3.32)	1.41 (0.84-2.37)	1.66 (1.23-2.24)***
Injury Severity ***(BSI as referent)***	Medical Attention Received	4.14 (2.81-6.09)***	3.84 (2.91-5.08)***	-

Covariate		TBI (Non-injured as referent)	Combined (Non-injured as referent)	BSI (Non-injured as referent)
Place of Injury ***(BSI as referent)***	Home and Surrounding Area	0.35 (0.18-0.67)***	0.49 (0.33-0.73)***	-
	School/ College/ Street/ Highway/ Sidewalk/ Other	-	-	-
	Sports	2.91 (1.86-4.56)***	2.03 (1.43-2.89)***	-
Note. *p<.10; **p<.05; ***p<.01				

CHAPTER FIVE: RESULTS- MENTAL HEALTH OUTCOMES

This chapter describes the results of analysis of all mental health outcomes by injury group; this includes self-perceived general mental health, mood disorder(s), anxiety disorder(s), and stress. The results include descriptive findings regarding differences in mental health outcomes across injury groups. This is followed by an overview of the logistic regression models of each mental health outcome on injury groups, the HUI mediator, and other covariates. As a reminder, model A is an unadjusted model looking at injury groups, model B is the same as model A except it includes the global HUI variable, and model D is the fully adjusted model. All results are presented in tables 5.1 through 5.17 located at the end of the chapter.

5.1 DESCRIPTIVE STATISTICS OF MENTAL HEALTH OUTCOMES BY GROUP

Below are the descriptive results for each mental health outcome by injury group. See table 5.1 at the end of the chapter for a display of these results.

5.1.1 Self-reported Mental Health

There was little variation in self-reported mental health across groups. Similar proportions of the TBI group (9.4%) and Combined Head Injury group (8.3%) reported having poor/ fair mental health. A lower percentage (6%) of the BSI group and the non-injured group (5.2%) reported having poor/ fair mental health.

5.1.2 Mood Disorder

Approximately 10% of the TBI group and 9% of the Combined Head Injury group declared that they had a mood disorder that was diagnosed by a health

professional. The BSI group had a similar percent (9%), while the non-injured group had lower percentages of respondents declaring they had a mood disorder, at 6%.

5.1.3 Anxiety

With respect to anxiety disorder, about 9% of respondents from the TBI group and 8% from the Combined Head Injury group, and 8% of the BSI group reported that they suffered from an anxiety disorder, as diagnosed by a health professional. The non-injured group had lower percentages of respondents declaring they suffered from an anxiety disorder, at 5%.

5.1.4 Stress

Finally, approximately 70% of the TBI group, 66% of the Combined Head Injury group, and 72% of the BSI group reported that their lives were a bit, quite a bit, or extremely stressful. Conversely, 64% of the non-injured random sample responded that their lives were a bit, quite a bit or extremely stressful.

5.2 REGRESSION MODELING

See table 5.2 through 5.17 at the end of the chapter for a display of these results.

5.2.1 Self-reported Mental Health

As Tables 5.2 and 5.3 indicate, there was a non-significant association between poor/ fair mental health across injury group, with the TBI and BSI groups exhibited similar odds relative to the non-injured group. Interestingly, when the combined injury group was substituted for the TBI group (Table 5.4), individuals with a head injury had a significantly higher odds (1.65; 95% CI: 1.00-2.70) of reporting poor or fair mental health. In the mediator model (model B), however, the association became non-significant, suggesting that HUI may account for differences in self-reported mental

health between injury groups as those with a combined injury had a significantly poorer HUI rating. The non-significant association persisted in the full adjusted model (D).

5.2.2 Mood Disorder

Tables 5.6 to 5.9 provide results for the presence of a mood disorder across injury groups. Relative to non-injured controls (Tables 5.6 and 5.7); persons with a TBI did not demonstrate a significantly higher likelihood of having a mood disorder in models A, B and D. However, the BSI group demonstrated a significant increased odds of having a mood disorder (OR 1.50; 95% CI: 1.19-1.88) in model A and (OR 1.31; 95% CI: 1.03-1.67) in Model B. This association was not present in model D. While HUI was significantly associated with having a mood disorder, it did not act as a mediator of the relationship between BSI and mood disorder. In terms of other covariates, mood disorders were more likely in females, older adults, and white respondents, and less likely in higher income individuals. These patterns were similar when TBI was replaced with the combined head injury measure (Tables 5.8 and 5.9).

5.2.3 Anxiety Disorder

Turning to Table 5.10, relative to the non-injured controls, those with a TBI had significantly increased odds of having an anxiety disorder in models A (OR 1.94; 95% CI: (1.11-3.38), B (OR 1.62; 95% CI: 0.94-2.79) and D (OR1.83; 95% CI: 0.92-3.67). Models B and D demonstrated a non- significant trend at an alpha level of $p<0.10$ where models A was significant at a $p<0.05$ level. There was also a significant gender interaction as only females with a TBI, but not males with a TBI, had a significantly increased odds of having a diagnosed anxiety disorder (Model D; (OR 2.06; 95% CI: 0.88-4.84, $P<0.10$). The BSI group also had a significantly increased odds of an anxiety

disorder in models A (OR 1.68; 95% CI: 1.30-2.15), B (OR 1.50; 95% CI: 1.17-1.92), and D (OR 1.59; 95% CI: 1.19-2.14).There was no significant difference between the TBI and BSI groups (Table 5.11) in terms of having a mood disorder. While the HUI was strongly associated with the presence of a mood disorder, given the persistence of the association in Model B, HUI did not act as a mediator between injury and the presence of an anxiety disorder. White respondents were more likely to have an anxiety disorder, whereas those in the highest income group were less likely to have an anxiety disorder. These associations were consistent when the Combined Head Injury group was substituted for the TBI group in the analysis (Tables 5.12 and 5.13).

5.2.4 Life-Stress

The final mental health measure was self-reported stress, dichotomized to measure high stress. Relative to the non-injured group (Table 5.14), the BSI group demonstrated a strong ($p<0.01$) association with high level of life stress, where they reported significant greater odds of having high stress in models A (OR: 1.44, 95% CI: 1.23-1.68) and B (OR: 1.38, 95% CI: 1.18-1.61). There was no association between having a TBI or Combined Head Injury and stress. Stress levels were strongly associated with HUI (i.e., stress is associated with poorer global ratings of the HUI), though no mediation of the association between BSI and high stress was observed. In terms of other covariates, low stress levels were experienced by the very young, and seniors, and was less likely among those with a Bachelor's degree or above and among White respondents. Results were consistent for Tables 5.15 and 5.16

Table 5.1 Mental health outcomes by injury group (sample weights and bootstrapping methods applied (N and percent))

Total CCHS sample (n= 124,870)		Traumatic Brain Injury (N=339)		Combined Head Injury (N=807)		Back/ Spinal Injury (N=2790)		Non-Injured (N=10627)	
Mental health variables		*N*	Percent	*N*	Percent	*N*	Percent	*N*	Percent
Self-reported Mental Health	Poor/ fair	32	9.4	67	8.3	167	6.0	553	5.2
	Good/ very good/ excellent	307	90.6	740	91.7	2623	94.0	10074	94.8
Mood Disorder	No	304	89.8	735	91.1	2531	90.7	9947	93.6
	Yes	35	10.2	72	8.9	259	9.3	680	6.4
Anxiety	No	308	90.8	746	92.5	2564	91.9	10096	95.0
	Yes	31	9.2	61	7.6	226	8.1	531	5.0
Stress	Not at all stressful/ not very stressful	103	30.3	275	34.1	795	28.5	3879	36.5
	A bit/ quite a bit/ extremely stressful	236	69.7	532	65.9	1995	71.5	6748	63.5

Table 5.2 Logistic Regression of poor/ fair Mental Health on TBI and BSI injury status (ORs and 95% CIs presented; sample weights and bootstrapping methods applied)

Variables	Model A OR	Model B OR	Model C OR	Model D OR
Injury Type [Non-injured as reference]				
TBI	1.88 (0.71-4.98)	1.36 (0.55-3.38)		1.65 (0.59-4.48)
BSI	1.16 (0.86-1.57)	0.93 (0.67-1.28)		0.97 (0.64-1.46)
Injury severity [no medical attention as reference]				
Medical attention received				0.95 (0.60-1.50)
Health Utilities Index [quartile 1 as reference]				
Quartile 2		0.16 (0.12-0.23)***		0.20 (0.14-0.29)***
Quartile 3		0.06 (0.04-0.09)***		0.07 (0.04-0.12)***
Quartile 4		0.09 (0.05-0.14)***		0.10 (0.06-0.19)***
Sex [Male as reference]				
Female				0.95 (0.75-1.19)
Age (years) [18-25 as reference]				
12-17				0.51 (0.25-1.03)*
26-40				1.92 (1.10-3.32)**
41-60				2.12 (1.22-3.67)***
60+				0.90 (0.51-1.58)
Income [low as reference]				

Variables	Model A OR	Model B OR	Model C OR	Model D OR
Poverty				1.10 (0.60-1.99)
Middle				0.35 (0.21-0.60)***
High				0.31 (0.21-0.46)***
Not Stated				0.39 (0.20-0.74)***
Education [high school as reference]				
<High School				1.77 (0.99-3.15)*
Trade/ Diploma				1.00 (0.72-1.42)
Bachelor's Degree and Above				0.97 (0.62-1.49)
Not Stated				8.52 (2.77-26.20)***
Ethnicity [minority as reference]				
White				1.19 (0.80-1.78)
Province				1.01 (0.98-1.01)
F-statistic	F (2, 498) = 2.46	F (5,495) =64.61		F (21,479) = 24.34

Note. OR= odds ratio. *p.10; **p<.05; ***p<.01

Table 5.3 Logistic Regression of self-reported poor/ fair Mental Health on TBI and Non-injured injury status (ORs and 95% CIs presented; sample weights and bootstrapping methods applied)

Variable	Model A OR	Model B OR	Model C OR	Model D OR
Injury Type [BSI as reference]				
TBI	1.62 (0.51-5.13)	1.47 (0.49-4.41)		1.70 (0.55-5.28)
Non-injured	0.86 (0.64-1.17)	1.08 (0.78-1.50)		1.03 (0.68-1.55)
Injury severity [no medical attention as reference]				
Medical attention received				0.95 (0.60-1.50)
Health Utilities Index [quartile 1 as reference]				
Quartile 2		0.16 (0.12-0.23)***		0.20 (0.14-0.29)***
Quartile 3		0.06 (0.04-0.09)***		0.07 (0.04-0.12)***
Quartile 4		0.09 (0.05-0.14)***		0.10 (0.06-0.19)***
Sex [Male as reference]				
Female				0.94 (0.75-1.19)
Age (years) [18-25 as reference]				
12-17				0.51 (0.25-1.03)*
26-40				1.92 (1.10-3.32)**
41-60				2.12 (1.22-3.67)***
60+				0.90 (0.51-1.58)
Income [low as reference]				
Poverty				1.10 (0.60-2.00)
Middle				0.35 (0.21-0.60)***

Variable	Model A OR	Model B OR	Model C OR	Model D OR
High				0.31 (0.21-0.46)***
Not Stated				0.39 (0.20-0.74)***
Education [high school as reference]				
<High School				1.77 (0.99-3.15)*
Trade/ Diploma				1.01 (0.72-1.42)
Bachelor's Degree and Above				0.97 (0.62-1.49)
Not Stated				8.52 (2.77-26.21)***
Ethnicity [minority as reference]				
White				1.19 (0.80-1.78)
Province				1.00 (1.00-1.01)
F-statistic	F (2,498) = 2.46	F (5,495) =64.61		F (21,479) = 24.34

Note. OR= odds ratio. *p<.10; **p<.05; ***p<.01

Table 5.4 Logistic Regression of self-reported poor/ fair Mental Health on Combined and BSI injury status (ORs and 95% CIs presented; sample weights and bootstrapping methods applied)

Variable	Model A OR	Model B OR	Model C OR	Model D OR
Injury Type [Non-injured as reference]				
Combined	1.65 (1.00-2.70)**	1.23 (0.75-2.00)		1.41 (0.76-2.62)
BSI	1.16 (0.86-1.57)	0.93 (0.67-1.29)		0.96 (0.66-1.39)
Injury severity [no medical attention as reference]				
Medical attention received				1.00 (0.64-1.55)
Health Utilities Index [quartile 1 as reference]				
Quartile 2		0.17 (0.12-0.24)***		0.20 (0.14-0.29)***
Quartile 3		0.06 (0.04-0.09)***		0.08 (0.05-0.12)***
Quartile 4		0.09 (0.06-0.15)***		0.11 (0.06-0.21)***
Sex [Male as reference]				
Female				0.93 (0.73-1.18)
Age (years) [18-25 as reference]				
12-17				0.53 (0.26-1.05)*
26-40				1.78 (1.05-3.02)**
41-60				1.99 (1.18-3.35)**
60+				0.86 (0.50-1.48)
Income [low as reference]				
Poverty				1.09 (0.60-1.99)
Middle				0.35 (0.21-0.59)***
High				0.29 (0.20-0.43)***

Variable	Model A OR	Model B OR	Model C OR	Model D OR
Not Stated				0.37 (0.19-0.74)***
Education [high school as reference]				
<High School				1.69 (0.95-3.03)*
Trade/ Diploma				0.99 (0.72-1.38)
Bachelor's Degree and Above				0.92 (0.59-1.44)
Not Stated				8.25 (2.62-25.99)***
Ethnicity [minority as reference]				
White				1.14 (0.78-1.68)
Province				1.00 (1.00-1.02)
F-statistic	F (2,498) = 2.87	F (5,495) = 58.11		F (21,479) = 26.18

Note. OR= odds ratio. *p<.10; **p<.05; ***p<.01

Table 5.5 Logistic Regression of self-reported poor/ fair Mental Health on combined and non-injured injury status (ORs and 95% CIs presented; sample weights and bootstrapping methods applied)

Variable	Model A OR	Model B OR	Model C OR	Model D OR
Injury Type [BSI as reference]				
Combined	1.42 (0.77-2.64)	1.32 (0.73-2.36)		1.47 (0.76-2.82)
Non-injured	0.86 (0.64-1.17)	1.07 (0.78-1.49)		1.04 (0.72-1.50)
Injury severity [no medical attention as reference]				
Medical attention received				1.00 (0.64-1.55)
Health Utilities Index [quartile 1 as reference]				
Quartile 2		0.17 (0.12-0.24)***		0.20 (0.14-0.29)***
Quartile 3		0.06 (0.04-0.09)***		0.08 (0.05-0.12)***
Quartile 4		0.09 (0.06-0.15)***		0.11 (0.06-0.21)***
Sex [Male as reference]				
Female				0.93 (0.73-1.18)
Age (years) [18-25 as reference]				
12-17				0.53 (0.26-1.08)*
26-40				1.78 (1.05-3.02)**
41-60				1.99 (1.18-3.35)**
60+				0.86 (0.50-1.48)
Income [low as reference]				
Poverty				1.09 (0.60-1.99)
Middle				0.35 (0.21-0.59)***
High				0.29 (0.20-0.43)***

Variable	Model A OR	Model B OR	Model C OR	Model D OR
Not Stated				0.37 (0.19-0.74)***
Education [high school as reference]				
<High School				1.69 (0.95-3.03)*
Trade/ Diploma				0.99 (0.72-1.38)
Bachelor's Degree and Above				0.92 (0.59-1.44)
Not Stated				8.25 (2.62-25.99)***
Ethnicity [minority as reference]				
White				1.14 (0.78-1.68)
Province				1.01 (1.00-1.02)
F-statistic	F (2,498) = 2.87	F (5,495) =58.11		F (21,479) = 26.18

Note. OR= odds ratio. *p<.10; **p<.05; ***p<.01

Table 5.6 Logistic Regression of having a Mood Disorder(s) on TBI and BSI injury status (ORs and 95% CIs presented; sample weights and bootstrapping methods applied)

Variables	Model A OR	Model B OR	Model C OR	Model D OR
Injury Type [Non-injured as reference]				
TBI	1.66 (0.80-3.41)	1.32 (0.60-2.93)		1.45 (0.58-3.65)
BSI	1.50 (1.19-1.88)***	1.31 (1.03-1.67)**		1.21 (0.84-1.74)
Injury severity [no medical attention as reference]				
Medical attention received				1.05 (0.70-1.59)
Health Utilities Index [quartile 1 as reference]				
Quartile 2		0.36 (0.26-0.48)***		0.39 (0.28-0.54)***
Quartile 3		0.16 (0.11-0.23)***		0.16 (0.11-0.24)***
Quartile 4		0.17 (0.12-0.23)***		0.18 (0.13-0.25)***
Sex [Male as reference]				
Female				1.80 (1.42-2.27)***
Age (years) [18-25 as reference]				
12-17				0.25 (0.11-0.57)***
26-40				1.61 (1.07-2.42)**
41-60				1.60 (1.05-2.43)**
60+				0.66 (0.44 -0.98)**
Income [low as reference]				
Poverty				1.19 (0.60-2.37)
Middle				0.55 (0.30-1.02)*

Variables	Model A OR	Model B OR	Model C OR	Model D OR
High				0.44 (0.28-0.69)***
Not Stated				0.43 (0.27-0.68)***
Education [high school as reference]				
<High School				0.99 (0.61-1.59)
Trade/ Diploma				0.87 (0.61-1.23)
Bachelor's Degree and Above				0.87 (0.61-1.23)
Not Stated				1.87 (0.62-5.61)
Ethnicity [minority as reference]				
White				1.69 (1.10-2.61)**
Province				1.00 (1.00-1.02)**
F-statistic	F (2,498) = 7.99	F (5,495) = 44.05		F (21,479) = 18.84

Note. OR= odds ratio. *p<.10; **p<.05; ***p<.01

Table 5.7 Logistic Regression of having a Mood Disorder(s) on TBI and non-injured injury status (ORs and 95% CIs presented; sample weights and bootstrapping methods applied)

Variable	Model A OR	Model B OR	Model C OR	Model D OR
Injury Type [BSI as reference]				
TBI	1.11 (0.50-2.44)	1.01 (0.42-2.44)		1.20 (0.43-3.30)
Non-injured	0.67 (0.53-0.84)***	0.77 (0.60-0.97)**		0.83 (0.57-1.19)
Injury severity [no medical attention as reference]				
Medical attention received				1.05 (0.70-1.59)
Health Utilities Index [quartile 1 as reference]				
Quartile 2		0.36 (0.26-0.48)***		0.39 (0.28-0.54)***
Quartile 3		0.16 (0.11-0.23)***		0.16 (0.11-0.24)***
Quartile 4		0.17 (0.12-0.23)***		0.18 (0.13-0.25)***
Sex [Male as reference]				
Female				1.80 (1.42-2.27)***
Age (years) [18-25 as reference]				
12-17				0.25 (0.11-0.57)***
26-40				1.61 (1.07-2.42)**
41-60				1.60 (1.05-2.43)**
60+				0.66 (0.44-0.98)**
Income [low as reference]				
Poverty				1.19 (0.60-2.37)

Variable	Model A OR	Model B OR	Model C OR	Model D OR
Middle				0.55 (0.30-1.02)*
High				0.44 (0.28-0.69)***
Not Stated				0.43 (0.27-0.68)***
Education [high school as reference]				
<High School				0.99 (0.61-1.59)
Trade/ Diploma				0.87 (0.61-1.23)
Bachelor's Degree and Above				0.87 (0.61-1.23)
Not Stated				1.87 (0.62-5.61)
Ethnicity [minority as reference]				
White				1.69 (1.10-2.61)
Province				1.01 (1.01-1.02)**
F-statistic	F (2, 498) = 7.99	F (5,495) = 44.05		F (21,479) = 18.84

Note. OR= odds ratio. *p<.10;
****p<.05; ***p<.01**

Table 5.8 Logistic Regression of having a Mood Disorder(s) on Combined and BSI injury status (ORs and 95% CIs presented; sample weights and bootstrapping methods applied)

Variable	Model A OR	Model B OR	Model C OR	Model D OR
Injury Type [Non-injured as reference]				
Combined	1.42 (0.84-2.40)	1.14 (0.62-2.06)		1.23 (0.68-2.25)
BSI	1.50 (1.19-1.88)***	1.31 (1.03-1.66)**		1.19 (0.82-1.73)
Injury severity [no medical attention as reference]				
Medical attention received				1.09 (0.73-1.63)
Health Utilities Index [quartile 1 as reference]				
Quartile 2		0.36 (0.26-0.50)***		0.40 (0.28-0.57)***
Quartile 3		0.16 (0.11-0.22)***		0.16 (0.11-0.24)***
Quartile 4		0.17 (0.12-0.23)***		0.19 (0.13-0.26)***
Sex [Male as reference]				
Female				1.77 (1.42-2.22)***
Age (years) [18-25 as reference]				
12-17				0.25 (0.11-0.56)***
26-40				1.60 (1.05-2.42)**
41-60				1.66 (1.09-2.53)**
60+				0.67 (0.45-1.00)**
Income [low as reference]				
Poverty				1.18 (0.61-2.31)

Variable	Model A OR	Model B OR	Model C OR	Model D OR
Middle				0.56 (0.31-1.01)*
High				0.42 (0.27-0.67)***
Not Stated				0.43 (0.26-0.72)***
Education [high school as reference]				
<High School				0.97 (0.61-1.54)
Trade/ Diploma				0.91 (0.65-1.26)
Bachelor's Degree and Above				0.90 (0.64-1.27)
Not Stated				1.88 (0.64-5.55)
Ethnicity [minority as reference]				
White				1.71 (1.12-2.63)**
Province				1.01 (1.00-1.01)**
F-statistic	F (2, 498) = 7.79	F (5,495) = 45.66		F (21,479) =19.18

Note. OR= odds ratio. *p<.10; **p<.05; ***p<.01

Table 5.9 Logistic Regression of having a Mood Disorder(s) on combined and non-injured injury status (ORs and 95% CIs presented; sample weights and bootstrapping methods applied)

Variable	Model A OR	Model B OR	Model C OR	Model D OR
Injury Type [BSI as reference]				
Combined	0.95 (0.52-1.72)	0.87 (0.44-1.73)		1.04 (0.51-2.11)
Non-injured	0.67 (0.53-0.84)***	0.77 (0.60-0.97)**		0.84 (0.58-1.23)
Injury severity [no medical attention as reference]				
Medical attention received				1.09 (0.73-1.63)
Health Utilities Index [quartile 1 as reference]				
Quartile 2		0.36 (0.26-0.50)***		0.40 (0.28-0.57)***
Quartile 3		0.16 (0.11-0.22)***		0.16 (0.11-0.24)***
Quartile 4		0.17 (0.12-0.23)***		0.19 (0.13-0.26)***
Sex [Male as reference]				
Female				1.77 (1.42-2.22)***
Age (years) [18-25 as reference]				
12-17				0.25 (0.11-0.56)***
26-40				1.60 (1.05-2.42)**
41-60				1.66 (1.09-2.53)**
60+				0.67 (0.45-1.00)**
Income [low as reference]				
Poverty				1.18 (0.61-2.31)

Variable	Model A OR	Model B OR	Model C OR	Model D OR
Middle				0.56 (0.31-1.01)*
High				0.42 (0.27-0.67)***
Not Stated				0.43 (0.26-0.72)***
Education [high school as reference]				
<High School				0.97 (0.61-1.54)
Trade/ Diploma				0.91 (0.65-1.26)
Bachelor's Degree and Above				0.90 (0.64-1.27)
Not Stated				1.88 (0.64-5.55)
Ethnicity [minority as reference]				
White				1.71 (1.12-2.63)**
Province				1.01 (1.00-1.01) **
F-statistic	F (2,498) = 7.79	F (5,495) = 45.66		F (21,479) =19.18

Note. OR= odds ratio. *p<.10; **p<.05; ***p<.01

Table 5.10 Logistic Regression of Anxiety Disorder on TBI and BSI injury status (ORs and 95% CIs presented; sample weights and bootstrapping methods applied)

Variables	Model A OR	Model B OR	Model C OR	Model D OR
Injury Type [Non-injured as reference]				
TBI	1.94 (1.11-3.38)**	1.62 (0.94-2.79)*		1.83 (0.92-3.67)*
BSI	1.68 (1.30-2.15)***	1.50 (1.17-1.92)***		1.59 (1.19-2.14)***
Injury severity [no medical attention as reference]				
Medical attention received				0.98 (0.65-1.48)
Health Utilities Index [quartile 1 as reference]				
Quartile 2		0.39 (0.28-0.56)***		0.42 (0.29-0.62)***
Quartile 3		0.23 (0.14-0.38)***		0.28 (0.17-0.46)***
Quartile 4		0.23 (0.16-0.32)***		0.25(0.18-0.36)***
Sex [Male as reference]				
Female				1.81 (1.43-2.30)***
Age (years) [18-25 as reference]				
12-17				0.57 (0.32-1.01)*
26-40				1.20 (0.78-1.86)
41-60				1.17 (0..78-1.73)
60+				0.46 (0.26-0.82)***
Income [low as reference]				
Poverty				1.52-0.97-2.38)*
Middle				0.77 (0.51-1.17)
High				0.58 (0.39-0.84)***
Not Stated				0.72 (0.44-1.17)

Variables	Model A OR	Model B OR	Model C OR	Model D OR
Education [high school as reference]				
<High School				1.46 (0.96-2.22)*
Trade/ Diploma				0.89 (0.64-1.22)
Bachelor's Degree and Above				0.69 (0.45-1.05)
Not Stated				3.95 (1.63-9.57)***
Ethnicity [minority as reference]				
White				1.59 (1.10-2.30)***
Province				0.99 (0.99-1.00)
F-statistic	F (2, 498) =11.56	F (5, 495) = 16.40		F (21,479) = 11.81

Note. OR= odds ratio. *p<.10; **p<.05; ***p<.01

Table 5.11 Logistic Regression of Anxiety Disorder on TBI and non-injured injury status (ORs and 95% CIs presented; sample weights and bootstrapping methods applied)

Variable	Model A OR	Model B OR	Model C OR	Model D OR
Injury Type [BSI as reference]				
TBI	1.16 (0.62-2.16)	1.08 (0.59-1.96)		1.15 (0.60-2.19)
Non-injured	0.60 (0.46-0.77)***	0.67 (0.52-0.85)***		0.63 (0.47-0.84)***
Injury severity [no medical attention as reference]				
Medical attention received				0.98 (0.65-1.48)
Health Utilities Index [quartile 1 as reference]				
Quartile 2		0.39 (0.28-0.56)***		0.42 (0.29-0.62)***
Quartile 3		0.23 (0.14-0.38)***		0.28 (0.17-0.46)***
Quartile 4		0.23 (0.16-0.33)***		0.25 (0.18-0.36)***
Sex [Male as reference]				
Female				1.81 (1.43-2.30)***
Age (years) [18-25 as reference]				
12-17				0.57 (0.32-1.01)*
26-40				1.20 (0.78-1.86)
41-60				1.17 (0.78-1.73)
60+				0.46 (0.26-0.82)***
Income [low as reference]				
Poverty				1.52 (0.97-2.38)*
Middle				0.77 (0.51-1.17)
High				0.58 (0.39-0.84)***
Not Stated				0.72 (0.44-1.17)

Variable	Model A OR	Model B OR	Model C OR	Model D OR
Education [high school as reference]				
<High School				1.46 (0.96-2.22)*
Trade/ Diploma				0.89 (0.65-1.22)
Bachelor's Degree and Above				0.69 (0.45-1.05)*
Not Stated				3.95 (0.47-0.84)***
Ethnicity [minority as reference]				
White				1.59 (1.10-2.30)***
Province				1.00 (0.99-1.00)
F-statistic	F (2,498) = 11.56	F (5,495) = 16.40		F (21,479) = 11.81

Note. OR= odds ratio. *p<.10; **p<.05; ***p<.01

Table 5.12 Logistic Regression of Anxiety Disorder on Combined and BSI injury status (ORs and 95% CIs presented; sample weights and bootstrapping methods applied)

Variable	Model A OR	Model B OR	Model C OR	Model D OR
Injury Type [Non-injured as reference]				
Combined	1.56 (1.10-2.23)**	1.30 (0.91-1.86)		1.44 (0.90-2.33)
BSI	1.68 (1.30-2.15)***	1.50 (1.17-1.93)***		1.54 (1.15-2.07)***
Injury severity [no medical attention as reference]				
Medical attention received				1.04 (0.71-1.54)
Health Utilities Index [quartile 1 as reference]				
Quartile 2		0.39 (0.27-0.57)***		0.43 (0.29-0.64)***
Quartile 3		0.23 (0.14-0.38) ***		0.27 (0.16-0.46)***
Quartile 4		0.27 (0.16-0.33)***		0.25 (0.17-0.36)***
Sex [Male as reference]				
Female				1.85 (1.48-2.32)***
Age (years) [18-25 as reference]				
12-17				0.54 (0.31-0.94)**
26-40				1.16 (0.77-1.76)
41-60				1.14 (0.79-1.65)
60+				0.48 (0.27-0.85)**

Variable	Model A OR	Model B OR	Model C OR	Model D OR
Income [low as reference]				
Poverty				1.47 (0.95-2.30)*
Middle				0.75 (0.50-1.10)
High				0.57 (0.40-0.83)***
Not Stated				0.71 (0.45-1.10)
Education [high school as reference]				
<High School				1.45 (0.96-2.19)*
Trade/ Diploma				0.90 (0.66-1.22)
Bachelor's Degree and Above				0.71 (0.47-1.07)*
Not Stated				4.07 (1.73-9.56)***
Ethnicity [minority as reference]				
White				1.60 (1.12-2.28)**
Province				0.99 (0.99-1.00)
F-statistic	F (2,498) = 10.06	F (5, 495) = 14.02		F (21, 479) = 12.49

Note. OR= odds ratio. *p<.10; **p<.05; ***p<.01

Table 5.13 Logistic Regression of Anxiety Disorder on combined and non-injured injury status (ORs and 95% CIs presented; sample weights and bootstrapping methods applied)

Variable	Model A OR	Model B OR	Model C OR	Model D OR
Injury Type [BSI as reference]				
Combined	0.93 (0.62-1.40)	0.87 (0.59-1.29)		0.93 (0.61-1.43)
Non-injured	0.60 (0.46-0.77)***	0.67 (0.52-0.85)***		0.65 (0.48-0.87)***
Injury severity [no medical attention as reference]				
Medical attention received				1.04 (0.71-1.54)
Health Utilities Index [quartile 1 as reference]				
Quartile 2		0.39 (0.27-0.57)***		0.43 (0.29-0.64)***
Quartile 3		0.23 (0.14-0.38)***		0.27 (0.16-0.46)***
Quartile 4		0.23 (0.16-0.33)***		0.25 (0.17-0.36)***
Sex [Male as reference]				
Female				1.85 (1.49-2.32)***
Age (years) [18-25 as reference]				
12-17				0.54 (0.31-0.94)**
26-40				1.16 (0.77-1.76)
41-60				1.14 (0.79-1.65)
60+				0.48 (0.27-0.85)***
Income [low as reference]				
Poverty				1.47 (0.95-2.30)*

Variable	Model A OR	Model B OR	Model C OR	Model D OR
Middle				0.75 (0.50-1.10)
High				0.57 (0.40-0.83)***
Not Stated				0.71 (0.45-1.10)
Education [high school as reference]				
<High School				1.45 (0.96-2.19)*
Trade/ Diploma				0.90 (0.66-1.22)
Bachelor's Degree and Above				0.71 (0.47-1.07)*
Not Stated				4.07 (1.73-9.56)***
Ethnicity [minority as reference]				
White				1.60 (1.12-2.28)
Province				0.99 (0.99-1.00)
F-statistic	F (2,498) = 10.06	F (5,495) = 14.02		F (21, 479) = 12.49

Note. OR= odds ratio. *p<.10;
****p<.05; ***p<.01**

Table 5.14 Logistic Regression of High Stress (i.e., a bit stressful, quite a bit stressful, or extremely stressful) on TBI and BSI injury status (ORs and 95% CIs presented; sample weights and bootstrapping methods applied)

Variables	Model A OR	Model B OR	Model C OR	Model D OR
Injury Type [Non-injured as reference]				
TBI	1.32 (0.91-1.91)	1.23 (0.84-1.81)		1.13 (0.68-1.90)
BSI	1.44 (1.23-1.68)***	1.38 (1.18-1.61)***		1.09 (0.89-1.35)
Injury severity [no medical attention as reference]				
Medical attention received				1.18 (0.91-1.53)
Health Utilities Index [quartile 1 as reference]				
Quartile 2		0.78 (0.65-0.94)***		0.63 (0.53-0.75)***
Quartile 3		0.55 (0.47-0.65)***		0.45 (0.37-0.53)***
Quartile 4		0.60 (0.51-0.70)***		0.43 (0.35-0.53)***
Sex [Male as reference]				
Female				1.16 (1.03-1.30)
Age (years) [18-25 as reference]				
12-17				0.51 (0.38-0.69)***
26-40				1.27 (1.01-1.59)**
41-60				1.06 (0.81-1.39)
60+				0.34 (0.27-0.43)***
Income [low as reference]				
Poverty				1.08 (0.79-1.48)
Middle				0.99 (0.78-1.25)

Variables	Model A OR	Model B OR	Model C OR	Model D OR
High				0.98 (0.78-1.23)
Not Stated				1.12 (0.84-1.50)
Education [high school as reference]				
<High School				0.88 (0.66-1.17)
Trade/ Diploma				1.17 (0.97-1.43)
Bachelor's Degree and Above				1.37 (1.13-1.67)***
Not Stated				1.98 (1.00-3.91)**
Ethnicity [minority as reference]				
White				1.29 (1.07-1.55)***
Province				1.00 (1.00-1.00)
F-statistic	F (2,498) =10.65	F (5,495) = 16.80		F (21,479) = 25.83

Note. OR= odds ratio. *p<.10; **p<.05; ***p<.01

Table 5.15 Logistic Regression of High Stress (i.e., a bit stressful, quite a bit stressful, or extremely stressful) on TBI and non-injured injury status (ORs and 95% CIs presented; sample weights and bootstrapping methods applied)

Variable	Model A OR	Model B OR	Model C OR	Model D OR
Injury Type [BSI as reference]				
TBI	0.92 (0.64-1.31)	0.89 (0.62-1.29)		1.04 (0.66-1.62)
Non-injured	0.69 (0.60-0.81)***	0.72 (0.62-0.85)***		0.91 (0.74-1.13)
Injury severity [no medical attention as reference]				
Medical attention received				1.18 (0.91-1.53)
Health Utilities Index [quartile 1 as reference]				
Quartile 2		0.78 (0.65-0.94)***		0.63 (0.53-0.74)***
Quartile 3		0.55 (0.47-0.65)***		0.44 (0.37-0.53)***
Quartile 4		0.59 (0.51-0.70)***		0.43 (0.35-0.53)***
Sex [Male as reference]				
Female				1.16 (1.03-1.30)**
Age (years) [18-25 as reference]				
12-17				0.51 (0.38-0.69)***
26-40				1.27 (1.01-1.59)**
41-60				1.06 (0.81-1.39)
60+				0.34 (0.27-0.43)***
Income [low as reference]				
Poverty				1.08 (0.79-1.48)
Middle				0.99 (0.78-1.25)
High				0.98 (0.78-1.23)
Not Stated				1.12 (0.84-1.50)
Education [high school as reference]				
<High School				0.88 (0.66-1.17)
Trade/ Diploma				1.17 (0.97-1.43)
Bachelor's Degree and Above				1.37 (1.13-1.67)***

Variable	Model A OR	Model B OR	Model C OR	Model D OR
Not Stated				1.98 (1.00-3.91)**
Ethnicity [minority as reference]				
White				1.29 (1.07-1.55)***
Province				1.00 (1.00-1.00)
F-statistic	F (2,498) = 10.65	F (5, 495) = 16.80		F (21,479) = 25.83

Note. OR= odds ratio. *p<.10;
****p<.05; ***p<.01**

Table 5.16 Logistic Regression of High Stress (i.e., a bit stressful, quite a bit stressful, or extremely stressful) on Combined and BSI injury status (ORs and 95% CIs presented; sample weights and bootstrapping methods applied)

Variable	Model A OR	Model B OR	Model C OR	Model D OR
Injury Type [Non-injured as reference]				
Combined	1.11 (0.89-1.38)	1.03 (0.82-1.30)		1.00 (0.73-1.36)
BSI	1.44 (1.26-1.68)	1.38 (1.18-1.61)***		1.09 (0.89-1.33)
Injury severity [no medical attention as reference]				
Medical attention received				1.19 (0.93-1.50)
Health Utilities Index [quartile 1 as reference]				
Quartile 2		0.77 (0.64-0.93)***		0.62 (0.52-0.74)***
Quartile 3		0.55 (0.47-0.65)***		0.45 (0.38-0.53)***
Quartile 4		0.60 (0.51-0.70)***		0.43 (0.35-0.52)***
Sex [Male as reference]				
Female				1.15 (1.03-1.28)**
Age (years) [18-25 as reference]				
12-17				0.54 (0.40-0.71)***
26-40				1.30 (1.04-1.63)**
41-60				1.08 (0.83-1.42)
60+				0.35 (0.28-1.14)***
Income [low as reference]				
Poverty				1.09 (0.81-1.48)
Middle				0.99 (0.79-1.23)
High				0.99 (0.79-1.24)

Variable	Model A OR	Model B OR	Model C OR	Model D OR
Not Stated				1.12 (0.85-1.49)
Education [high school as reference]				
<High School				0.87 (0.66-1.14)
Trade/ Diploma				1.17 (0.96-1.42)
Bachelor's Degree and Above				1.38 (1.14-1.69)***
Not Stated				1.91 (0.99-3.70)*
Ethnicity [minority as reference]				
White				1.26 (1.05-1.51)**
Province				1.00 (1.00-1.00)
F-statistic	F (2,498) = 10.73	F (5,495)= 18.02		F (21,479) =26.94

Note. OR= odds ratio. *p<.10; **p<.05; ***p<.01

Table 5.17 Logistic Regression of High Stress (i.e., a bit stressful, quite a bit stressful, or extremely stressful) on combined and non-injured injury status (ORs and 95% CIs presented; sample weights and bootstrapping methods applied)

Variable	Model A OR	Model B OR	Model C OR	Model D OR
Injury Type [BSI as reference]				
Combined	0.77 (0.60-0.99)**	0.75 (0.58-0.96)**		0.91 (0.70-1.20)
Non-injured	0.69 (0.60-0.81)***	0.72 (0.62-0.85)***		0.92 (0.75-1.12)
Injury severity [no medical attention as reference]				
Medical attention received				1.19 (0.93-1.51)
Health Utilities Index [quartile 1 as reference]				
Quartile 2		0.77 (0.64-0.93)***		0.62 (0.52-0.74)***
Quartile 3		0.55 (0.47-0.65)***		0.45 (0.38-0.53)***
Quartile 4		0.60 (0.51-0.70)***		0.43 (0.35-0.52)***
Sex [Male as reference]				
Female				1.15 (1.03-1.28)**
Age (years) [18-25 as reference]				
12-17				0.54 (0.40-0.71)***
26-40				1.30 (1.04-1.63)**
41-60				1.08 (0.83-1.42)
60+				0.35 (0.28-0.44)***
Income [low as reference]				
Poverty				1.09 (0.81-1.48)
Middle				0.99 (0.79-1.23)
High				0.99 (0.79-1.24)
Not Stated				1.12 (0.85-1.49)

Variable	Model A OR	Model B OR	Model C OR	Model D OR
Education [high school as reference]				
<High School				0.87 (0.66-1.14)
Trade/ Diploma				1.17 (0.96-1.42)
Bachelor's Degree and Above				1.38 (1.14-1.69)***
Not Stated				1.91 (0.99-3.70)*
Ethnicity [minority as reference]				
White				
Province				
F-statistic	F (2,498) = 10.73	F (5,495) = 18.02		F (21,479) = 26.94

Note. OR= odds ratio. *p<.10;
****p<.05; ***p<.01**

CHAPTER SIX: RESULTS- SUBSTANCE USE OUTCOMES + RISK MARKER

This chapter describes the results for all substance use outcomes by injury group; this includes cigarette smoking, drinking, and illicit drug use. This section will also examine the risk marker variable (i.e., bicycle helmet wearing adherence). Secondly, this section describes the results of the regression models comparing the differences between groups in terms of the strength of association with the above substance use and risk-taking outcomes; this includes the results of the examination of mediator variables (i.e., HUI, and stress and self- perceived mental health). As a reminder, model A is an unadjusted model, model B is the same as model A except it includes the global HUI variable, model C is similar to model A except it includes stress and self-perceived mental health, and model D is the fully adjusted model. All substance use outcomes were run with all four models, only model A and B were used with the risk marker outcome. All results are presented in tables 6.0 through 6.16 located at the end of the chapter.

6.1 DESCRIPTIVE STATISTICS OF SUBSTANCE USE OUTCOMES BY GROUP

See table 6.0 at the end of the chapter for a display of these results.

6.1.1 Cigarette Smoking

Smoking varied across groups with one-fifth of the TBI and non-injured groups reporting being a current smoker. Persons with a back or spinal injury had the highest proportion of smokers (25%), followed by the Combined Head Injury group (23%).

6.1.2 Illicit Drugs

Approximately 13% of the TBI group and 9.9% of the Combined Head Injury Group declared that they had consumed an illicit drug within the past 12 months of

interview. The BSI group and the non-injured group had lower percentages of respondents declaring they had used an illicit drug, 6% and 5% respectively.

6.1.3 Alcohol Use and Binge Drinking

Both alcohol use and binge drinking varied across injury groups. The TBI group and the Combined Head Injury Group reported the lowest proportion of drinkers (i.e., drinking without bingeing) (71% and 72%), whereas the BSI group had the highest proportion (85%). Approximately 47% of the TBI group had reported at least 1 episode of binge drinking (i.e., 5 drinks or more in one sitting) in the past year, compared to 45% of the Combined Head Injury Group. Binge drinking was reported by 48% of the BSI group and by 36% of the non-injured group.

6.1.4 Risk Marker- Bicycle Helmet Wearing Adherence

The measure of bicycle helmet use as a proxy measure of risk taking behaviour can be conceptualized as follows. The highest risk is associated with bicycling without a helmet; moderate risk is bicycling with a helmet, while the lowest risk is associated with not bicycling at all. Given this stratification, approximately one third (35.1% and 32.7%) of the TBI and Combined Head Injury groups bicycle without a helmet, compared to approximately one quarter (23%) of the BSI group, and one-fifth (20.3%) of the non-injured group.

6.2 REGRESSION MODELING

See tables 6.1 through 6.24 at the end of the chapter for a display of these results.

6.2.1 Cigarette Smoking

Tables 6.1 through 6.4 provide results for cigarette smoking. Relative to the non-injured group, there was no significant association between TBI and being a current

smoker (Table 6.1), whereas the BSI group had a significantly higher odds of being a current smoker in model A (OR 1.34; 95% CI: 1.14-1.56), model B (OR 1.30; 95% CI: 1.11-1.52) and model C (OR 1.30; 95% CI: 1.10-1.54). However, this association became non-significant in the fully adjusted model (model D). HUI, poor mental health, and high stress, were strongly associated with being a regular smoker; however, there was no evidence of mediation for these three measures. In terms of other covariates, female respondents, youth (under 17) and seniors were least likely to be smokers, as where those of higher education and income. Conversely, White respondents were more likely to be regular smokers than minority respondents. These findings were consistent when the Combined Head Injury group was included (Table 6.3).

There were also differences between injury groups in terms of smoking status (Table 6.2). Relative to the BSI group, those with a TBI had a significantly lower odds of being a regular smoker (OR 0.75; 95% CI: 0.64-0.87), though only in model A. Given that this finding became non-significant in models B and C, this suggests the presence of mediation.

6.2.2 Illicit Drugs

Tables 6.5 through 6.8 describe the results for illicit drug use. Relative to the non-injured control group (Table 6.5), persons with a TBI had a significantly increased odds of past-year illicit drug use in all four models [models A (OR 2.92; 95% CI: 1.52-5.64, $p<0.01$), B (OR 2.80; 95% CI: 1.45-5.42, $p<0.01$), C (OR 2.78; 95% CI: 1.43-5.38, $p<0.02$) and model D (OR 2.36; 95% CI: 1.16-4.78, $p<0.05$).] The BSI group demonstrated a non-significant trend (OR: 1.38, 95% CI: 0.97-1.96) with illicit drug use in model A. HUI was not related to illicit drug use, while those reporting fair/poor

general mental health were more likely to use illicit drugs. There was no evidence of mediation for these measures. In terms of other covariates, the odds of illicit drug use was higher in White respondents, and lower for females and all age groups relative to 18-25 year olds.

Relative to the BSI group (Table 6.6), those with a TBI demonstrated a non-significant trend of increased odds of consuming illicit drugs in model A (OR 2.12; 95% CI: 0.98-4.58), model B (OR 2.10; 95% CI: 0.96-4.59) and model C (OR 2.09; 95% CI: 0.99-4.40); the association demonstrated a non-significant trend in the fully adjusted model (D). These results were consistent when the Combined Head Injury group was included in the analysis (Tables 6.7 and 6.8).

6.2.3 Alcohol Use and Binge Drinking

Tables 6.9 to 6.16 examine alcohol use without bingeing (i.e., being a drinker and not bingeing) and binge drinking. Relative to the non-injured group (Table 6.9), those with a TBI had a significantly lower odds of being a drinker without bingeing [model A (RRR0.56; 95% CI: 0.36-0.87), model B (RRR 0.59; 95% CI: 0.38-0.92), model C (RRR 0.53; 95% CI: 0.38-0.92]. Interestingly this association diminished to non-significance after adjusting for covariates, as evidenced by model D. Conversely, the BSI group had a significantly increased odds of drinking in all models [model A (RRR 1.55; 95% CI: 1.20-1.99), model B (RRR 1.59; 95% CI: 1.25-2.04), model C (RRR1.49; 95% CI: 1.19-1.86) and model D (RRR 1.62; 95% CI: 1.17-2.24). Relative to the BSI group (Table 6.10), those with a TBI had a significantly lower odds of being a drinker without bingeing [model A (RRR 0.36; 95% CI: 0.23-0.56), model B (RRR 0.37; 95% CI: 0.24-

0.58), model C (RRR 0.36; 95% CI: 0.23-0.56), and model D (RRR 0.54; 95% CI: 0.34-0.87)].

Looking at binge drinking (Table 6.13), relative to the non-injured group, those with a TBI had a significantly increased odds of binge drinking in three of the four models [model A (RRR 2.07; 95% CI: 1.41-3.04), model B (RRR 2.11; 95% CI: 1.44-3.10), and model C (RRR 2.06; 95% CI: 1.39-3.05). Staying with binge drinking, the BSI injury group had a significantly increased odds of binge drinking in all models [model A (RRR 1.45; 95% CI: 1.24-1.70), model B (RRR 1.48; 95% CI: 1.24-1.76), model C (RRR 1.28; 95% CI: 1.03-1.58), and model D (RRR 1.28; 95% CI: 1.03-1.58).Relative to the BSI group (Table 6.14), those with a TBI had a significantly higher odds of binge drinking in model A (RRR 1.42; 95% CI: 0.93-2.18) and model C (RRR 1.44; 95% CI: 0.94-2.21), though this relationship was non-significant in the fully adjusted model (model D).Findings were similar when TBI was replaced by the Combined Head Injury Group, the only difference being that relative to the BSI injury group those within the Combined Injury Group had a significantly elevated odds of binge drinking (Table 6.16) only in model A (RRR 1.22; 95% CI: 0.79-1.90), the unadjusted model.

Drinking without bingeing and binge drinking was more common among older adults, those who were well-off and had higher levels of education, and among White respondents. While there were significant associations between all three mediator variables with both drinking and binge drinking, there was no evidence for mediation.

6.2.4 Risk Marker- Bicycle Helmet Wearing Adherence

The final analysis looks at bicycling and helmet using as a proxy measure of risk taking (Tables 6.17 to 6.24). Relative to the non-injured group, the TBI group was

significantly more likely to bicycle whilst wearing a helmet than to not bicycle at all (Table 6.17). This effect was significant in model A (RRR 2.27; 95% CI: 1.52-3.37) and model D (RRR 1.47; 95% CI: 0.93-2.34; $p<0.10$). Similarly, the BSI group were significantly more likely to bicycle with a helmet than to not bicycle at all, but only in model A (RRR: 1.35, 95% CI: 1.15-1.59). Interestingly, the TBI and the BSI group significantly differed in the magnitude of the positive association with bicycling using a bicycle helmet as the TBI group had a RRR of 1.68 (95% CI: 1.13-2.49) in model A with the BSI group as the referent (Table 6.18) meaning that the TBI group were more likely to cycle with a helmet than not cycle at all, compared to the BSI group.

Looking at bicycling without wearing a helmet (Table 6.21), relative to the non-injured group, those with a TBI and a BSI did not differ from the non-injured group in both the unadjusted (model A) and fully adjusted model (model D). There was also no difference in helmet use between the TBI and BSI groups (Table 6.22). These associations remained the same when the Combined Injury Group was substituted for the TBI group (Tables 6.23 and 6.24).

Table 6.0 Substance use outcomes by injury group (sample weights and bootstrapping methods applied (N and percent))

Total CCHS sample (n= 124,870)		Traumatic Brain Injury (N=339)		Combined Head Injury (N=807)		Back/ Spinal Injury (N=2790)		Non-Injured (N=10627)	
Substance use		*N*	Percent	*N*	Percent	*N*	Percent	*N*	Percent
Binge Drinking	Don't drink	97	28.7	221	27.4	427	15.3	2699	25.4
	Drink but don't binge	84	24.7	223	27.7	1016	36.4	4145	39.0
	Binge	158	46.7	362	44.9	1348	48.3	3783	35.6
Illicit use in past 12 months	No	297	87.5	726	90.0	2614	93.7	10128	95.3
	Yes	42	12.5	80	9.9	176	6.3	499	4.7
Cigarette Smoking	No	273	80.4	621	77.0	2093	75.0	8502	80.0
	Yes	66	19.6	186	23.0	698	25.0	2125	20.0
Risk Marker (cycle helmet usage)	Not Applicable	134	39.6	367	45.5	1557	55.8	6599	62.1
	Always	86	25.3	176	21.8	594	21.3	1870	17.6
	Rarely	119	35.1	264	32.7	639	22.9	2157	20.3

Table 6.1 Logistic Regression of Smoking cigarettes on TBI and BSI injury status (ORs and 95% CIs presented; sample weights and bootstrapping methods applied)

Variables	Model A OR	Model B OR	Model C OR	Model D OR
Injury Type [Non-injured as reference]				
TBI	0.97 (0.63-1.49)	0.92 (0.59-1.43)	0.91 (0.58-1.44)	0.71 (0.38-1.33)
BSI	1.34 (1.14-1.56)***	1.30 (1.11-1.52)***	1.30 (1.10-1.54)***	1.16 (0.84-1.60)
Injury severity [no medical attention as reference]				
Medical attention received				1.06 (0.75-1.49)
Health Utilities Index [quartile 1 as reference]				
Quartile 2		0.76 (0.63-0.93)***		0.81 (0.64-1.01)*
Quartile 3		0.61 (0.50-0.74)***		0.74 (0.57-0.95)**
Quartile 4		0.71 (0.59-0.86)***		0.75 (0.61-0.93)***
Sex [Male as reference]				
Female				0.59 (0.52-0.67)***
Age (years) [18-25 as reference]				
12-17				0.15 (0.10-023)***
26-40				1.03 (0.80-1.33)
41-60				0.82 (0.65-1.03)*
60+				0.29 (0.22-0.39)***
Income [low as reference]				
Poverty				1.13 (0.81-1.57)
Middle				0.88 (0.61-1.27)
High				0.56 (0.44-0.72)***
Not Stated				0.59 (0.44-0.80)***
Education [high school as reference]				
<High School				1.28 (0.95-1.73)
Trade/ Diploma				0.83 (0.69-0.98)**

Variables	Model A OR	Model B OR	Model C OR	Model D OR
Bachelor's Degree and Above				0.28 (0.20-0.40)***
Not Stated				1.53 (0.67-3.49)
Ethnicity [minority as reference]				
White				1.58 (1.22-2.05)***
Mental Health [poor/ fair as reference]				
Good/ very good/ excellent			0.48 (0.37-0.61)***	0.65 (0.50-0.85)***
Stress [High as reference]				
Low			0.78 (0.66-0.92)***	0.90 (0.76-1.07)
Province				0.99 (0.99-1.00)***
F-statistic	F (2,498) =6.67	F (5,495) = 8.56	F (4,496) = 18.48	F (23,477) = 22.35

Note. OR= odds ratio. *p<.10;
****p<.05; ***p<.01**

Table 6.2 Logistic Regression of Smoking cigarettes on TBI and non-injured injury status (ORs and 95% CIs presented; sample weights and bootstrapping methods applied)

Variable	Model A OR	Model B OR	Model C OR	Model D OR
Injury Type [BSI as reference]				
TBI	0.75 (0.64-0.87)***	0.71 (0.44-1.15)	0.70 (0.42-1.17)	0.61 (0.29-1.29)
Non-injured	0.73 (0.46-1.16)	0.77 (0.66-0.90)***	0.77 (0.65-0.91)***	0.86 (0.63-1.18)
Injury severity [no medical attention as reference]				
Medical attention received				1.06 (0.75-1.49)
Health Utilities Index [quartile 1 as reference]				
Quartile 2		0.76 (0.63-0.93)***		0.81 (0.64-1.01)*
Quartile 3		0.61 (0.50-0.74)***		0.74 (0.57-0.95)**
Quartile 4		0.71 (0.59-0.86)***		0.75 (0.61-0.93)***
Sex [Male as reference]				
Female				0.59 (0.52-0.67)***
Age (years) [18-25 as reference]				
12-17				0.15 (0.10-0.23)***
26-40				1.03 (0.80-1.33)
41-60				0.82 (0.65-1.03)*
60+				0.29 (0.22-0.39)***
Income [low as reference]				
Poverty				1.13 (0.81-1.57)
Middle				0.88 (0.61-1.27)
High				0.56 (0.44-0.72)***
Not Stated				0.59 (0.44-0.80)***
Education [high school as reference]				
<High School				1.28 (0.95-1.73)
Trade/ Diploma				0.83 (0.69-098)**
Bachelor's Degree and Above				0.28 (0.20-0.40)***

Variable	Model A OR	Model B OR	Model C OR	Model D OR
Not Stated				1.53 (0.67-3.49)
Ethnicity [minority as reference]				
White				1.58 (1.22-2.05)***
Mental Health [poor/ fair as reference]				
Good/ very good/ excellent			0.48 (0.37-0.61)***	0.65 (0.50-0.85)***
Stress [High as reference]				
Low			0.78 (0.66-0.92)***	0.90(0.76-1.07)
Province				0.99 (0.99-1.00)***
F-statistic	F (2,498) = 6.67	F (5,495) = 8.56	F (4,496) = 18.48	F (23,477) = 22.35

Note. OR= odds ratio. *p<.10;
****p<.05; ***p<.01**

Table 6.3 Logistic Regression of Smoking cigarettes on Combined and BSI injury status (ORs and 95% CIs presented; sample weights and bootstrapping methods applied)

Variable	Model A OR	Model B OR	Model C OR	Model D OR
Injury Type [Non-injured as reference]				
Combined	1.19 (0.88-1.61)	1.12 (0.84-1.50)	1.15 (0.84-1.56)	1.00 (0.68-1.49)
BSI	1.34 (1.14-1.57)***	1.30 (1.11-1.52)***	1.30 (1.09-1.54)***	1.18 (0.87-1.59)
Injury severity [no medical attention as reference]				
Medical attention received				1.03 (0.75-1.40)
Health Utilities Index [quartile 1 as reference]				
Quartile 2		0.75 (0.62-0.91)***		0.80 (0.64-1.00)**
Quartile 3		0.61 (0.50-0.74)***		0.74 (0.58-0.95)***
Quartile 4		0.70 (0.59-0.84)***		0.75 (0.61-0.91)
Sex [Male as reference]				
Female				0.60 (0.53-0.68)***
Age (years) [18-25 as reference]				
12-17				0.14 (0.09-0.22)***
26-40				1.05 (0.81-1.36)
41-60				0.83 (0.66-1.04)
60+				0.29 (0.21-0.38)***
Income [low as reference]				
Poverty				1.16 (0.84-1.59)
Middle				0.93 (0.63-1.37)
High				0.58 (0.45-0.75)***
Not Stated				0.61 (0.45-0.82)***
Education [high school as reference]				
<High School				1.31 (0.98-1.76)*
Trade/ Diploma				0.82 (0.69-0.98)**
Bachelor's Degree and Above				0.28 (0.20-0.39)***

Variable	Model A OR	Model B OR	Model C OR	Model D OR
Not Stated				1.52 (0.67-3.45)
Ethnicity [minority as reference]				
White				1.60 (1.24-2.06)***
Mental Health [poor/ fair as reference]				
Good/ very good/ excellent			0.48 (0.38-0.61)***	0.66 (0.51-0.85)***
Stress [High as reference]				
Low			0.77 (0.66-0.91)***	0.90 (0.76-1.06)
Province				0.99 (0.99-1.00)**
F-statistic	F (2,498) = 6.67	F (5,495) = 8.44	F (4,496) = 20.08	F (23,477) = 23.99

Note. OR= odds ratio. *p<.10;
****p<.05; ***p<.01**

Table 6.4 Logistic Regression of Smoking cigarettes on combined and non-injured injury status (ORs and 95% CIs presented; sample weights and bootstrapping methods applied)

Variable	Model A OR	Model B OR	Model C OR	Model D OR
Injury Type [BSI as reference]				
Combined	0.89 (0.67-1.19)	0.87 (0.66-1.15)	0.88 (0.66-1.18)	0.85 (0.62-1.18)
Non-injured	0.75 (0.64-0.87)***	0.77 (0.66-0.90)***	0.77 (0.65-0.91)***	0.85 (0.63-1.15)
Injury severity [no medical attention as reference]				
Medical attention received				1.03 (0.75-1.40)
Health Utilities Index [quartile 1 as reference]				
Quartile 2		0.75 (0.62-0.91)***		0.80 (0.64-1.00)**
Quartile 3		0.61 (0.50-0.74)***		0.74 (0.58-0.95)**
Quartile 4		0.70 (0.59-0.84)***		0.75 (0.61-0.91)***
Sex [Male as reference]				
Female				0.60 (0.53-0.68)***
Age (years) [18-25 as reference]				
12-17				0.14 (0.09-0.22)***
26-40				1.05 (0.81-1.36)
41-60				0.83 (0.66-1.04)
60+				0.29 (0.21-0.38)***
Income [low as reference]				
Poverty				1.16 (0.85-1.59)
Middle				0.93 (0.63-1.37)
High				0.58 (0.45-0.75)***
Not Stated				0.61 (0.45-0.82)***
Education [high school as reference]				
<High School				1.31 (0.98-1.76)*
Trade/ Diploma				0.82 (0.69-0.98)**
Bachelor's Degree and Above				0.28 (0.20-0.39)**

Variable	Model A OR	Model B OR	Model C OR	Model D OR
Not Stated				1.52 (0.67-3.45)
Ethnicity [minority as reference]				
White				1.60 (1.24-2.06)***
Mental Health [poor/ fair as reference]				
Good/ very good/ excellent			0.48 (0.38-0.61)***	0.66 (0.51-0.85)***
Stress [High as reference]				
Low			0.77 (0.66-0.91)***	0.90 (0.76-1.06)
Province				0.99 (0.99-1.00)
F-statistic	F (2,498) = 6.67	F (5, 495) = 8.44	F (4,496) = 20.08	F (23,477) = 23.99

Note. OR= odds ratio. *p<.10;
****p<.05; ***p<.01**

Table 6.5 Logistic Regression of Illicit Drug usage on TBI and BSI injury status (ORs and 95% CIs presented; sample weights and bootstrapping methods applied)

Variables	Model A OR	Model B OR	Model C OR	Model D OR
Injury Type [Non-injured as reference]				
TBI	2.92 (1.52-5.64)***	2.80 (1.45-5.42)***	2.78 (1.43-5.38)***	2.36 (1.16-4.78)**
BSI	1.38 (0.97-1.96)*	1.33 (0.93-1.91)	1.33 (0.94-1.88)	1.45 (0.91-2.30)
Injury severity [no medical attention as reference]				
Medical attention received				0.64 (0.37-1.12)
Health Utilities Index [quartile 1 as reference]				
Quartile 2		1.25 (0.83-1.89)		1.08 (0.72-1.60)
Quartile 3		0.61 (0.40-0.94)**		0.70 (0.45-1.09)
Quartile 4		0.94 (0.66-1.33)		0.66 (0.43-1.00)**
Sex [Male as reference]				
Female				0.57 (0.43-0.75)***
Age (years) [18-25 as reference]				
12-17				0.45(0.23-0.91)**
26-40				0.37 (0.26-0.52)***
41-60				0.15 (0.08-0.28)***
60+				0.04 (0.02-0.11)***
Income [low as reference]				
Poverty				1.68 (0.88-3.23)
Middle				0.75 (0.28-2.00)
High				0.63 (0.24-1.62)
Not Stated				0.67 (0.24-1.89)
Education [high school as reference]				
<High School				0.96 (0.58-1.59)
Trade/ Diploma				0.92 (0.65-1.30)

Variables	Model A OR	Model B OR	Model C OR	Model D OR
Bachelor's Degree and Above				1.20 (0.77-1.88)
Not Stated				1.69 (0.27-10.52)
Ethnicity [minority as reference]				
White				2.05 (1.34-3.13)***
Mental Health [poor/ fair as reference]				
Good/ very good/ excellent			0.59 (0.36-0.95)*	0.59 (0.37-0.96)**
Stress [High as reference]				
Low			0.82 (0.47-1.46)	0.96 (0.60-1.53)
Province				0.99 (0.98-0.99)***
F-statistic	F (2,498) = 7.20	F (5,495) = 4.79	F (4,496) = 5.84	F (23,476) = 8.09

Note. OR= odds ratio. *p<.10; **p<.05; ***p<.01

Table 6.6 Logistic Regression of Illicit Drug usage on TBI and non-injured injury status (ORs and 95% CIs presented; sample weights and bootstrapping methods applied)

Variable	Model A OR	Model B OR	Model C OR	Model D OR
Injury Type [BSI as reference]				
TBI	2.12 (0.98-4.58)*	2.10 (0.96-4.59)*	2.09 (0.99-4.40)*	1.63 (0.82-3.12)
Non-injured	0.73 (0.51-1.03)*	0.75 (0.52-1.08)	0.75 (0.53-1.06)	0.69 (0.43-1.10)
Injury severity [no medical attention as reference]				
Medical attention received				0.64 (0.37-1.12)
Health Utilities Index [quartile 1 as reference]				
Quartile 2		1.25 (0.83-1.89)		1.08 (0.72-1.61)
Quartile 3		0.61 (0.40-0.93)**		0.70 (0.45-1.09)
Quartile 4		0.94 (0.66-1.33)		0.66 (0.43-0.99)*
Sex [Male as reference]				
Female				0.57 (0.43-0.75)***
Age (years) [18-25 as reference]				
12-17				0.45 (0.23-0.91)**
26-40				0.37 (0.26-0.52)***
41-60				0.15 (0.08-0.28)***
60+				0.04 (0.02-0.11)***
Income [low as reference]				
Poverty				1.68 (0.88-3.23)
Middle				0.75 (0.28-2.00)
High				0.63 (0.24-1.63)
Not Stated				0.67 (0.24-1.88)
Education [high school as reference]				
<High School				0.96 (0.58-1.59)
Trade/ Diploma				0.92 (0.65-1.30)

Variable	Model A OR	Model B OR	Model C OR	Model D OR
Bachelor's Degree and Above				1.20 (0.77-1.88)
Not Stated				1.69 (0.27-10.52)
Ethnicity [minority as reference]				
White				2.05 (1.34-3.13)***
Mental Health [poor/ fair as reference]				
Good/ very good/ excellent			0.59 (0.36-0.95)**	0.59 (0.37-0.96)**
Stress [High as reference]				
Low			0.82 (0.47-1.46)	0.96 (0.60-1.54)
Province				0.99 (0.98-0.99)***
F-statistic	F (2,498) = 7.20	F (5,495) = 4.79	F (4,496) = 5.84	F (23,476) = 8.09

Note. OR= odds ratio. *p<.10;
****p<.05; ***p<.01**

Table 6.7 Logistic Regression of Illicit Drug usage on Combined and BSI injury status (ORs and 95% CIs presented; sample weights and bootstrapping methods applied)

Variable	Model A OR	Model B OR	Model C OR	Model D OR
Injury Type [Non-injured as reference]				
Combined	2.25 (1.43-3.57)***	2.15 (1.37-3.38)***	2.24 (1.40-3.56)***	2.00 (1.12-3.56)**
BSI	1.38 (0.97-1.96)*	1.33 (0.93-1.91)	1.33 (0.94-1.88)	1.44 (0.92-2.25)
Injury severity [no medical attention as reference]				
Medical attention received				0.65 (0.40-1.06)*
Health Utilities Index [quartile 1 as reference]				
Quartile 2		1.21 (0.81-1.80)		1.01 (0.68-1.51)
Quartile 3		0.58 (0.38-0.89)**		0.68 (0.44-1.05)*
Quartile 4		0.94 (0.67-1.32)		0.66 (0.44-0.97)**
Sex [Male as reference]				
Female				0.57 (0.44-0.74)***
Age (years) [18-25 as reference]				
12-17				0.44 (0.22-0.86)**
26-40				0.37 (0.27-0.52)***
41-60				0.15 (0.08-0.27)***
60+				0.04 (0.02-0.11)***
Income [low as reference]				
Poverty				1.75 (0.91-3.35)*
Middle				0.79 (0.30-2.09)
High				0.66 (0.26-1.68)
Not Stated				0.72 (0.26-1.98)
Education [high school as reference]				
<High School				0.94 (0.57-1.53)
Trade/ Diploma				0.88 (0.63-1.24)
Bachelor's Degree and Above				1.14 (0.73-1.78)
Not Stated				1.59 (0.26-9.87)

Variable	Model A OR	Model B OR	Model C OR	Model D OR
Ethnicity [minority as reference]				
White				2.07 (1.35-3.17)***
Mental Health [poor/ fair as reference]				
Good/ very good/ excellent			0.58 (0.37-0.90)**	0.60 (0.38-0.94)**
Stress [High as reference]				
Low			0.81 (0.46-1.44)	0.95 (0.60-1.50)
Province				0.99 (0.98-0.99)***
F-statistic	F (2,498) = 7.57	F (5,495) = 4.98	F (4,496) = 6.68	F (23,476) = 8.24

Note. OR= odds ratio. *p<.10;
****p<.05; ***p<.01**

Table 6.8 Logistic Regression of Illicit Drug usage on Combined and Non-injured injury status (ORs and 95% CIs presented; sample weights and bootstrapping methods applied)

Variable	Model A OR	Model B OR	Model C OR	Model D OR
Injury Type [BSI as reference]				
Combined	1.64 (0.92-2.90)*	1.61 (0.91-2.85)*	1.68 (0.96-2.94)*	1.39 (0.86-2.25)
Non-injured	0.73 (0.51-1.03)*	0.75 (0.52-1.08)	0.75 (0.53-1.06)	0.70 (0.44-1.09)
Injury severity [no medical attention as reference]				
Medical attention received				0.65 (0.40-1.06)*
Health Utilities Index [quartile 1 as reference]				
Quartile 2		1.21 (0.81-1.80)		1.01 (0.68-1.50)
Quartile 3		0.58 (0.38-0.89)**		0.68 (0.44-1.05)*
Quartile 4		0.94 (0.67-1.32)		0.66 (0.44-0.97)**
Sex [Male as reference]				
Female				0.57 (0.44-0.74)***
Age (years) [18-25 as reference]				
12-17				0.44 (0.22-0.86)**
26-40				0.38 (0.27-0.52)***
41-60				0.15 (0.08-0.27)***
60+				0.04 (0.02-0.11)***
Income [low as reference]				
Poverty				1.75 (091-3.35)*
Middle				0.79 (0.30-2.08)
High				0.66 (0.26-1.68)
Not Stated				0.72 (0.26-1.98)
Education [high school as reference]				
<High School				0.94 (0.57-1.53)
Trade/ Diploma				0.88 (0.63-1.24)
Bachelor's Degree and Above				1.14 (0.73-1.78)
Not Stated				1.59 (0.26-9.87)

Variable	Model A OR	Model B OR	Model C OR	Model D OR
Ethnicity [minority as reference]				
White				2.07 (1.35-3.17)***
Mental Health [poor/ fair as reference]				
Good/ very good/ excellent			0.58 (0.37-0.90)**	0.60 (0.38-0.94)**
Stress [High as reference]				
Low			0.81 (0.46-1.44)	0.95 (0.60-1.50)
Province				0.99 (0.98-0.99)***
F-statistic	F (2,498) = 7.57	F (5,495) = 4.98	F (4,496) =6.68	F (23,476) = 8.24

Note. OR= odds ratio. *p.10;
****p<.05; ***p<.01**

Table 6.9 Multinomial logistic regression of drinking alcohol [not drinking as reference] on TBI and BSI Injury status (RRRs and 95% CIs presented; sample weights and bootstrapping methods applied)

Variable	Drink But don't Binge			
	Model A RRR	Model B RRR	Model C RRR	Model D RRR
Injury Type [Non-injured as reference]				
TBI	0.56 (0.36-0.87) ***	0.59 (0.38-0.92)**	0.53 (0.34-0.83)***	0.88 (0.51-1.50)
BSI	1.55 (1.20-1.99)***	1.59 (1.25-2.04)***	1.49 (1.19-1.86)***	1.62 (1.17-2.24)***
Injury severity [no medical attention as reference]				
Medical attention received				0.72 (0.48-1.08)
Health Utilities Index [quartile 1 as reference]				
Quartile 2		1.25 (1.04-1.50)**		1.18 (0.94-1.50)
Quartile 3		1.65 (1.26-2.17)***		1.22 (0.89-1.67)
Quartile 4		1.04 (0.85-1.29)		1.05 (0.85-1.30)
Sex [Male as reference]				
Female				1.05 (0.89-1.25)
Age (years) [18-25 as reference]				
12-17				0.33 (0.20-0.54)***
26-40				1.13 (0.71-1.78)
41-60				1.19 (0.80-1.77)
60+				1.50 (1.03-2.17)**
Income [low as reference]				
Poverty				0.72 (0.54-0.97)**
Middle				1.29 (1.02-1.65)**
High				1.49 (1.09-2.03)**
Not Stated				1.28 (0.86-1.92)
Education [high school as reference]				
<High School				0.67 (0.52-0.86)***

Trade/ Diploma				1.29 (0.99-1.65)*
Bachelor's Degree and Above				1.97 (1.47-2.65)***
Not Stated				0.85 (0.37-1.95)
Ethnicity [minority as reference]				
White				3.30 (2.55-4.26)***
Mental Health [poor/ fair as reference]				
Good/ very good/ excellent			1.65 (1.26-2.15)***	1.35 (1.01-1.81)**
Stress [High as reference]				
Low			0.72 (0.56-0.92)***	1.35 (1.01-1.81)**
Province				1.00 (0.99-1.00)
F-statistic	F (4,496) = 26.21	F (10,490) = 17.72	F (8,492) = 25.66	F (46,454) = 38.08

Note. RRR= Relative Risk Ratio. * P<.10
****p<.05; ***p<.01**

Table 6.10 Multinomial logistic regression of drinking alcohol [not drinking as reference] on TBI and Non-injured Injury status (RRRs and 95% CIs presented; sample weights and bootstrapping methods applied)

Variable	Drink But don't Binge			
	Model A RRR	Model B RRR	Model C RRR	Model D RRR
Injury Type [BSI as reference]				
TBI	0.36 (0.23-0.56)***	0.37 (0.24-0.58)***	0.36 (0.23-0.56)***	0.54 (0.34-0.87)**
Non-injured	0.65 (0.50-0.83)***	0.63 (0.49-0.80)***	0.67 (0.54-0.84)***	0.62 (0.45-0.85)***
Injury severity [no medical attention as reference]				
Medical attention received	0.72 (0.48-1.08)			0.72 (0.48-1.08)
Health Utilities Index [quartile 1 as reference]				
Quartile 2		1.25 (1.04-1.50)**		1.18 (0.94-1.50)
Quartile 3		1.65 (1.26-2.17)***		1.22 (0.89-1.67)
Quartile 4		1.04 (0.85-1.29)		1.05 (0.85-1.29)
Sex [Male as reference]				
Female				1.05 (0.89-1.25)
Age (years) [18-25 as reference]				
12-17				0.33 (0.20-0.54)***
26-40				1.13 (0.71-1.78)
41-60				1.19 (0.80-1.77)
60+				1.49 (1.03-2.17)**

Variable	Drink But don't Binge			
	Model A RRR	Model B RRR	Model C RRR	Model D RRR
Income [low as reference]				
Poverty				0.72 (0.54-0.97)**
Middle				1.29 (1.02-1.65)**
High				1.49 (1.09-2.03)**
Not Stated				1.28 (0.86-1.91)
Education [high school as reference]				
<High School				0.67 (0.52-0.86)***
Trade/ Diploma				1.29 (0.99-1.65)*
Bachelor's Degree and Above				1.97 (1.47-2.65)***
Not Stated				0.85 (0.37-1.95)
Ethnicity [minority as reference]				
White				3.30 (2.56-4.26) ***
Mental Health [poor/ fair as reference]				
Good/ very good/ excellent			1.65 (1.26-2.15)***	1.35 (1.01-1.81)**
Stress [High as reference]				
Low			0.72 (0.56-0.92)***	0.76 (0.60-0.97)**
Province				(0.99-1.00)
F-statistic	F (4,496) = 26.21	F (10,490) = 17.72	F (8,492) = 25.66	F (46,454)= 38.08

Variable	Drink But don't Binge			
	Model A RRR	Model B RRR	Model C RRR	Model D RRR

Note. RRR= Relative Risk Ratio. * P<.10 **p<.05; ***p<.01

Table 6.11 Multinomial logistic regression of drinking alcohol [not drinking as reference] on Combined and BSI Injury status (RRRs and 95% CIs presented; sample weights and bootstrapping methods applied)

Variable	Drink But don't Binge			
	Model A RRR	Model B RRR	Model C RRR	Model D RRR
Injury Type [Non-injured as reference]				
Combined	0.66 (0.49-0.88)***	0.69 (0.51-0.93)**	0.62 (0.46-0.84)***	0.93 (0.61-1.41)
BSI	1.55 (1.20-2.00)***	1.59 (1.24-2.03)***	1.49 (1.19-1.86)***	1.52 (1.13-2.04)***
Injury severity [no medical attention as reference]				
Medical attention received				0.81 (0.57-1.16)
Health Utilities Index [quartile 1 as reference]				
Quartile 2			1.26 (1.05-1.50)**	1.21 (0.97-1.51)*
Quartile 3			1.65 (1.26-2.15)***	1.22 (0.89-1.24)
Quartile 4			1.03 (0.84-1.27)	1.04 (0.84-1.27)
Sex [Male as reference]				
Female				1.06 (0.90-1.24)
Age (years) [18-25 as reference]				
12-17				0.33 (0.20-0.53)***
26-40				1.10 (0.70-1.73)
41-60				1.19 (0.80-1.77)
60+				1.50 (1.04-2.17)**
Income [low as reference]				

Variable	Drink But don't Binge			
	Model A RRR	Model B RRR	Model C RRR	Model D RRR
Poverty				0.73 (0.55-0.98)**
Middle				1.32 (1.04-1.68)**
High				1.47 (1.07-2.03)**
Not Stated				1.25 (0.84-1.86)
Education [high school as reference]				
<High School				0.67 (0.53-0.85)***
Trade/ Diploma				1.28 (0.99-1.65)*
Bachelor's Degree and Above				1.98 (1.48-2.66)***
Not Stated				0.85 (0.37-1.93)
Ethnicity [minority as reference]				
White				3.24 (2.49-4.22)***
Mental Health [poor/ fair as reference]				
Good/ very good/ excellent			1.66 (1.28-2.17)***	1.36 (1.02-1.81)**
Stress [High as reference]				
Low			0.73 (0.57-0.94)**	0.77 (0.61-0.98)**
Province				1.00 (0.99-1.00)
F-statistic	F (4,496) = 25.01	F (10,490) = 18.46	F (8,492)= 25.76	F (46,454) = 38.60

Variable	Drink But don't Binge			
	Model A RRR	Model B RRR	Model C RRR	Model D RRR

Note. RRR= Relative Risk Ratio. * P<.10 **p<.05; ***p<.01

Table 6.12 Multinomial logistic regression of drinking alcohol [not drinking as reference] on Combined and Non-injured Injury status (RRRs and 95% CIs presented; sample weights and bootstrapping methods applied)

Variable	Drink But don't Binge			
	Model A RRR	Model B RRR	Model C RRR	Model D RRR
Injury Type [BSI as reference]				
Combined	0.42 (0.30-0.60)***	0.43 (0.30-0.62)***	0.42 (0.29-0.60)***	0.61 (0.42-0.89)***
Non-injured	0.64 (0.50-0.83)***	0.63 (0.49-0.80)***	0.67 (0.54-0.84)***	0.66 (0.49-0.88)***
Injury severity [no medical attention as reference]				
Medical attention received				0.81 (0.57-1.16)
Health Utilities Index [quartile 1 as reference]				
Quartile 2		1.26 (1.05-1.50)**		1.21 (0.97-1.51)*
Quartile 3		1.65 (1.26-2.15)***		1.22 (0.89-1.66)
Quartile 4		1.03 (0.84-1.27)		1.04 (0.84-1.28)
Sex [Male as reference]				
Female				3.24 (2.49-4.22)***
Age (years) [18-25 as reference]				
12-17				0.33 (0.20-0.53)***
26-40				1.10 (0.69-1.73)
41-60				1.19 (0.80-1.77)
60+				1.50 (1.04-2.17)**

Variable	Drink But don't Binge			
	Model A RRR	Model B RRR	Model C RRR	Model D RRR
Income [low as reference]				
Poverty				0.73 (0.55-0.98)**
Middle				1.32 (1.04-1.68)**
High				1.47 (1.07-2.03)**
Not Stated				1.25 (0.84-1.86)
Education [high school as reference]				
<High School				0.67 (0.53-0.85)***
Trade/ Diploma				1.28 (0.99-1.65)*
Bachelor's Degree and Above				1.98 (1.47-2.66)***
Not Stated				0.85 (0.37-1.93)
Ethnicity [minority as reference]				
White				3.24 (2.49-4.22)***
Mental Health [poor/ fair as reference]				
Good/ very good/ excellent			1.66 (1.28-2.17)***	1.36 (1.02-1.81)**
Stress [High as reference]				

Variable	Drink But don't Binge			
	Model A RRR	Model B RRR	Model C RRR	Model D RRR
Low			0.73 (0.57-0.94)**	0.77 (0.61-0.98)**
Province				1.00 (0.99-1.00)
F-statistic	F (4,496) = 25.01	F (10,490) = 18.46	F (8,492) = 25.76	F (46, 454) = 38.60

Note. RRR= Relative Risk Ratio.
*** P<.10 **p<.05; ***p<.01**

Table 6.13 Multinomial logistic regression of binge drinking [drinking as reference] on TBI and BSI Injury status (RRRs and 95% CIs presented; sample weights and bootstrapping methods applied)

Variable	Binge Drinking			
	Model A RRR	Model B RRR	Model C RRR	Model D RRR
Injury Type [Non-injured as reference]				
TBI	2.07 (1.41-3.04)***	2.11 (1.44-3.10)***	2.06 (1.39-3.05)***	1.46 (0.87-2.43)
BSI	1.45 (1.24-1.70)***	1.48 (1.24-1.76)***	1.43 (1.23-1.66)***	1.28 (1.03-1.58)**
Injury severity [no medical attention as reference]				
Medical attention received				0.88 (0.67-1.16)
Health Utilities Index [quartile 1 as reference]				
Quartile 2		1.59 (1.26-2.02)***		1.19 (0.96-1.44)
Quartile 3		1.06 (0.87-1.30)		0.98 (0.80-1.20)
Quartile 4		1.80 (1.34-2.41)***		1.10 (0.90-1.35)
Sex [Male as reference]				
Female				0.37 (0.31-0.43)***
Age (years) [18-25 as reference]				
12-17				0.26 (0.14-0.47)***
26-40				0.44 (0.32-0.59)***
41-60				0.21 (0.16-0.27)***
60+				0.06 (0.04-0.09)***
Income [low as reference]				
Poverty				1.24 (0.84-1.81)
Middle				1.21 (0.93-1.57)
High				1.58 (1.21-2.06)***
Not Stated				1.05 (0.77-1.43)
Education [high school as reference]				
<High School				0.97 (0.72-1.81)

Variable	Binge Drinking			
	Model A RRR	Model B RRR	Model C RRR	Model D RRR
Trade/ Diploma				1.00 (0.80-1.25)
Bachelor's Degree and Above				0.63 (0.46-0.88)***
Not Stated				1.28 (0.50-3.28)
Ethnicity [minority as reference]				
White				1.77 (1.33-2.36)***
Mental Health [Good/ very good/ excellent as reference]				
poor/ fair			1.28 (0.95-1.73)	1.05 (0.77-1.44)
Stress [High as reference]				
Low			1.33 (1.09-1.64)***	1.12 (0.96-1.30)
Province				0.99 (0.99-1.00)
F-statistic	F (4,496) = 26.21	F (10,490) = 17.72	F (8,492) = 25.66	F (46,454) = 38.08

Note. RRR= Relative Risk Ratio. * P<.10 **p<.05; ***p<.01

Table 6.14 Multinomial logistic regression of binge drinking [drinking as reference] on TBI and Non-injured Injury status (RRRs and 95% CIs presented; sample weights and bootstrapping methods applied)

Variable	Binge Drinking			
	Model A RRR	Model B RRR	Model C RRR	Model D RRR
Injury Type [BSI as reference]				
TBI	1.42 (0.93-2.18)*	1.43 (0.92-2.23)	1.44 (0.94-2.21)*	1.14 (0.70-1.86)
Non-injured	0.69 (0.59-0.81)***	0.68 (0.57-0.81)***	0.70 (0.60-0.81)***	0.78 (0.63-0.97)**
Injury severity [no medical attention as reference]				
Medical attention received				0.88 (0.67-1.16)
Health Utilities Index [quartile 1 as reference]				
Quartile 2		1.59 (1.26-2.02)***		1.19 (0.96-1.48)
Quartile 3		1.06 (0.87-1.30)		0.98 (0.80-1.20)
Quartile 4		1.80 (1.34-2.41)***		1.10 (0.90-1.35)
Sex [Male as reference]				
Female				0.37 (0.31-0.43)***
Age (years) [18-25 as reference]				
12-17				0.26 (0.14-0.47)***
26-40				0.44 (0.32-0.59)***
41-60				0.21 (0.16-0.27)***
60+				0.06 (0.04-0.09)***
Income [low as reference]				
Poverty				1.24 (0.84-1.81)

Variable	Binge Drinking			
	Model A RRR	Model B RRR	Model C RRR	Model D RRR
Middle High Not Stated				1.21 (0.93-1.57) 1.58 (1.21-2.06)*** 1.05 (0.77-1.43)
Education [high school as reference]				
<High School				0.97 (0.72-1.31)
Trade/ Diploma				1.00 (0.80-1.25)
Bachelor's Degree and Above				0.63 (0.46-0.88)***
Not Stated				1.28 (0.50-3.28)
Ethnicity [minority as reference]				
White				1.77 (1.33-2.36)***
Mental Health [Good/ very good/ excellent as reference]				
poor/ fair			1.28 (0.95-1.73)	1.05 (0.77-1.44)
Stress [High as reference]				
Low			1.33 (1.08-1.64)***	1.12 (0.96-1.30)
Province				0.99 (0.99-1.00)**
F-statistic	F (4,496) = 26.21	F (10,490) = 17.72	F (8,492) = 25.66	F (46, 454) = 38.08

Note. RRR= Relative Risk Ratio.
*** P<.10 **p<.05; ***p<.01**

Table 6.15 Multinomial logistic regression of binge drinking [drinking as reference] on Combined and BSI Injury status (RRRs and 95% CIs presented; sample weights and bootstrapping methods applied)

Variable	Binge Drinking			
	Model A RRR	Model B RRR	Model C RRR	Model D RRR
Injury Type [Non-injured as reference]				
Combined	1.78 (1.28-2.56)***	1.80 (1.25-2.60) ***	1.84 (1.25-2.71)***	1.42 (0.97-2.06)*
BSI	1.45 (1.24-1.70)***	1.47 (1.24-1.76)***	1.43 (1.23-1.66)***	1.25 (1.02-1.54)**
Injury severity [no medical attention as reference]				
Medical attention received				0.91 (0.70-1.19)
Health Utilities Index [quartile 1 as reference]				
Quartile 2		1.57 (1.24-1.99)***		1.17 (0.95-1.44)
Quartile 3		1.03 (0.85-1.26)		0.97 (0.80-1.19)
Quartile 4		1.75 (1.29-2.38)***		1.07 (0.88-1.31)
Sex [Male as reference]				
Female				0.36 (0.31-0.42)***
Age (years) [18-25 as reference]				
12-17				0.28 (0.15-0.52)***
26-40				0.44 (0.32-0.60)***
41-60				0.21 (0.16-0.27)***
60+				0.06 (0.04-0.08)***
Income [low as reference]				
Poverty				1.21 (0.84-1.74)

Variable	Binge Drinking			
	Model A RRR	Model B RRR	Model C RRR	Model D RRR
Middle High Not Stated				1.18 (0.90-1.53) 1.54 (1.18-2.00)*** 1.01 (0.74-1.38)
Education [high school as reference]				
<High School				0.94 (0.70-1.27)
Trade/ Diploma				0.96 (0.77-1.21)
Bachelor's Degree and Above				0.60 (0.44-0.83)***
Not Stated				1.24 (0.48-3.16)
Ethnicity [minority as reference]				
White				1.73 (1.32-2.26))***
Mental Health [Good/ very good/ excellentas reference]				
poor/ fair			1.23 (0.92-1.65)	1.01 (0.74-1.37)
Stress [High as reference]				
Low			1.36 (1.12-1.64)***	1.14 (0.99-1.31)*
Province				0.99 (0.99-1.00)**
F-statistic	F (4,496) = 25.01	F (10,490) = 18.46	F (8,492) = 25.76	F (46, 454) = 38.60

Note. RRR= Relative Risk Ratio. * P<.10
****p<.05; ***p<.01**

Table 6.16 Multinomial logistic regression of binge drinking [drinking as reference] on Combined and Non-injured Injury status (RRRs and 95% CIs presented; sample weights and bootstrapping methods applied)

Variable	Binge Drinking			
	Model A RRR	Model B RRR	Model C RRR	Model D RRR
Injury Type [BSI as reference]				
Combined	1.22 (0.79-1.90)***	1.22 (0.77-1.95)	1.29 (0.82-2.03)	1.13 (0.77-1.65)
Non-injured	0.69 (0.59-0.81)	0.68 (0.57-0.81)***	0.70 (0.60-0.82)***	0.80 (0.65-0.98)**
Injury severity [no medical attention as reference]				
Medical attention received				0.91 (0.70-1.19)
Health Utilities Index [quartile 1 as reference]				
Quartile 2		1.57 (1.24-1.99)***		1.17 (0.95-1.44)
Quartile 3		1.03 (0.85-1.26)		0.97 (0.80-1.19)
Quartile 4		1.75 (1.29-2.38)***		1.07 (0.88-1.31)
Sex [Male as reference]				
Female				0.36 (0.31-0.42)
Age (years) [18-25 as reference]				
12-17				0.28 (0.15-0.52)***
26-40				0.44 (0.32-0.60)***
41-60				0.21 (0.16-0.27)***
60+				0.06 (0.04-0.08)***

Variable	Binge Drinking			
	Model A RRR	Model B RRR	Model C RRR	Model D RRR
Income [low as reference]				
Poverty				1.21 (0.84-1.74)
Middle				1.18 (0.90-1.53)
High				1.54 (1.18-2.00)***
Not Stated				1.01 (0.74-1.38)
Education [high school as reference]				
<High School				0.94 (0.70-1.27)
Trade/ Diploma				0.96 (0.77-1.21)
Bachelor's Degree and Above				0.60 (0.44-0.83)***
Not Stated				1.24 (0.48-3.16)
Ethnicity [minority as reference]				
White				1.73 (1.32-2.26)***
Mental Health [Good/ very good/ excellent as reference]				
poor/ fair			1.23 (0.92-1.65)	1.01 (0.75-1.37)
Stress [High as reference]				
Low			1.36 (1.12-1.64)***	1.14 (0.99-1.31)*

Variable	Binge Drinking			
	Model A RRR	Model B RRR	Model C RRR	Model D RRR
Province				0.99 (0.99-1.00)**
F-statistic	F (4,496) = 25.01	F (10,490) = 18.46	F (8,492) = 25.76	F (46,454) = 38.60

**Note. RRR= Relative Risk Ratio. *
P<.10 **p<.05; ***p<.01**

Table 6.17 Multinomial logistic regression of bicycling with a helmet [does not cycle as reference] on TBI and BSI Injury status (RRRs and 95% CIs presented; sample weights and bootstrapping methods applied)

Variable	Wears a helmet			
	Model A RRR	Model B RRR	Model C RRR	Model D RRR
Injury Type [Non-injured as reference]				
TBI	2.27 (1.52-3.37)**			1.47 (0.93-2.34)*
BSI	1.35 (1.15-1.59)**			1.10 (0.86-1.39)
Injury severity [no medical attention as reference]				
Medical attention received				1.17 (0.87-1.59)
Health Utilities Index [quartile 1 as reference]				
Quartile 2				1.49 (1.12-1.99)**
Quartile 3				1.66 (1.13-2.45)*
Quartile 4				2.53 (1.98-3.24)**
Sex [Male as reference]				
Female				0.67 (0.57-0.78)**
Age (years) [18-25 as reference]				
12-17				10.17 (6.05-17.10)**
26-40				0.85 (0.61-1.17)
41-60				0.80 (0.55-1.18)
60+				0.35 (0.24-0.52)**
Income [low as reference]				
Poverty				0.83 (0.55-1.26)
Middle				0.88 (0.59-1.30)
High				1.49 (1.03-2.15)
Not Stated				1.14 (0.79-1.66)
Education [high school as reference]				
<High School				0.95 (0.68-1.34)
Trade/ Diploma				1.89 (1.48-2.41)**
Bachelor's Degree and Above				4.58 (3.07-6.82)**

Variable	Wears a helmet			
	Model A RRR	Model B RRR	Model C RRR	Model D RRR
Not Stated				0.48 (0.06-4.06)
Ethnicity [minority as reference]				
White				3.02 (1.96-4.65)**
Mental Health [poor/ fair as reference]				
Good/ very good/ excellent				1.59 (0.92-2.72)
Stress [High as reference]				
Low				0.91 (0.77-1.07)
Province				1.00 (1.00-1.01)***
F-statistic	F (4,496) = 11.24			F (46,454) = 28.82

Note. RRR= Relative Risk Ratio. *p<.05;
****p<.01**

Table 6.18 Multinomial logistic regression of bicycling with a helmet [does not cycle as reference] on TBI and Non-injured Injury status (RRRs and 95% CIs presented; sample weights and bootstrapping methods applied)

Variable	Wears a helmet			
	Model A RRR	Model B RRR	Model C RRR	Model D RRR
Injury Type [BSI as reference]				
TBI	1.68 (1.13-2.49)***			1.34 (0.89-2.03)
Non-injured	0.74 (0.63-0.87)***			0.91 (0.72-1.16)
Injury severity [no medical attention as reference]				
Medical attention received				1.18 (0.87-1.59)
Health Utilities Index [quartile 1 as reference]				
Quartile 2				1.50 (1.13-1.99)***
Quartile 3				1.67 (1.14-2.45)***
Quartile 4				2.54 (1.98-3.24)***
Sex [Male as reference]				
Female				0.67 (0.58-0.78)***
Age (years) [18-25 as reference]				
12-17				10.17 (6.05-17.10)***
26-40				0.85 (0.61-1.17)
41-60				0.80 (0.55-1.18)
60+				0.35 (0.24-0.52)***
Income [low as reference]				
Poverty				0.83 (0.55-1.26)
Middle				0.88 (0.59-1.30)
High				1.49 (1.03-2.14)**

Variable	Wears a helmet			
	Model A RRR	Model B RRR	Model C RRR	Model D RRR
Not Stated				1.14 (0.79-1.66)
Education [high school as reference]				
<High School Trade/ Diploma Bachelor's Degree and Above Not Stated				0.96 (0.68-1.34 1.88 (1.48-2.41)*** 4.65 (3.12-6.94)*** 0.48 (0.72-1.16)
Ethnicity [minority as reference]				
White				3.02 (1.96-4.65)***
Mental Health [poor/ fair as reference]				
Good/ very good/ excellent				1.59 (0.92-2.72)*
Stress [High as reference]				
Low				0.91 (0.77-1.08)
Province				1.00 (1.00-1.01)***
F-statistic	F (4,496) = 11.24			F (46,454) = 28.82

**Note. RRR= Relative Risk Ratio. *
P<.10 **p<.05; ***p<.01**

Table 6.19 Multinomial logistic regression of bicycling with a helmet [Does not cycle as reference] on Combined and BSI Injury status (RRRs and 95% CIs presented; sample weights and bootstrapping methods applied)

Variable	Wears a helmet			
	Model A RRR	Model B RRR	Model C RRR	Model D RRR
Injury Type [Non-injured as reference]				
Combined	1.69 (1.25-2.30)***			1.24 (0.80-1.90)
BSI	1.35 (1.15-1.59)***			1.08 (0.86-1.37)
Injury severity [no medical attention as reference]				
Medical attention received				1.22 (0.92-1.62)
Health Utilities Index [quartile 1 as reference]				
Quartile 2				1.54 (1.17-2.01)**
Quartile 3				1.75 (1.20-2.53)**
Quartile 4				2.61 (2.05-3.33)**
Sex [Male as reference]				
Female				0.67 (0.58-0.78)***
Age (years) [18-25 as reference]				
12-17				10.04 (6.05-16.68)
26-40				0.83 (0.61-1.15)***
41-60				0.79 (0.55-1.15)***
60+				0.35 (0.24-0.51)
Income [low as reference]				

Variable	Wears a helmet			
	Model A RRR	Model B RRR	Model C RRR	Model D RRR
Poverty				0.85 (0.56-1.28)
Middle				0.95 (0.64-1.40)
High				1.51 (1.05-2.17)**
Not Stated				1.16 (0.81-1.62)
Education [high school as reference]				
<High School				1.00 (0.72-1.41)
Trade/ Diploma				1.95 (1.53-2.50)***
Bachelor's Degree and Above				4.84 (3.18-7.37)***
Not Stated				0.64 (0.20-2.02)
Ethnicity [minority as reference]				
White				3.07 (1.98-4.74)***
Mental Health [poor/ fair as reference]				
Good/ very good/ excellent				1.56 (0.94-2.60)*
Stress [High as reference]				
Low				0.94 (0.80-1.10)
Province				1.00 (1.00-1.01)***
F-statistic	F (4,496) = 12.55			F (46,454) = 29.91

Note. RRR= Relative Risk Ratio. * P<.10
****p<.05; ***p<.01**

Table 6.20 Multinomial logistic regression of bicycling with a helmet [does not cycle as reference] on Combined and Non-injured Injury status (RRRs and 95% CIs presented; sample weights and bootstrapping methods applied)

Variable	Wears a helmet			
	Model A RRR	Model B RRR	Model C RRR	Model D RRR
Injury Type [Non-injured as reference]				
Combined	1.25 (0.91-1.72)			1.14 (0.78-1.68)
Non-injured	0.74 (0.63-0.87)***			0.92 (0.73-1.16)
Injury severity [no medical attention as reference]				
Medical attention received				1.22 (0.92-1.61)
Health Utilities Index [quartile 1 as reference]				
Quartile 2				1.54 (1.17-2.01)***
Quartile 3				1.75 (1.21-2.53)***
Quartile 4				2.61 (2.03-3.33)***
Sex [Male as reference]				
Female				0.67 (0.58-0.78)***
Age (years) [18-25 as reference]				
12-17				10.05 (6.05-16.68)***
26-40				0.83 (0.61-1.15)
41-60				0.79 (0.55-1.15)
60+				0.35 (0.24-0.51)***
Income [low as reference]				
Poverty				0.85 (0.56-1.28)
Middle				0.95 (0.64-1.40)

Variable	Wears a helmet			
	Model A RRR	Model B RRR	Model C RRR	Model D RRR
High				1.51 (1.05-2.17)**
Not Stated				1.16 (0.81-1.68)
Education [high school as reference]				
<High School				1.00 (0.72-1.40)
Trade/ Diploma				1.95 (1.53-2.50)***
Bachelor's Degree and Above				4.84 (3.18-7.37)***
Not Stated				0.64 (0.20-2.02)
Ethnicity [minority as reference]				
White				3.07 (1.98-4.74)***
Mental Health [poor/ fair as reference]				
Good/ very good/ excellent				1.56 (0.94-2.60)*
Stress [Low as reference]				
High				0.94 (0.80-1.10)
Province				1.01 (1.00-1.01)***
F-statistic	F (4, 496) = 12.55			F (46,454) = 29.91

Note. RRR= Relative Risk Ratio. * P<.10
****p<.05; ***p<.01**

Table 6.21 Multinomial logistic regression of bicycling without a helmet [bicycling with a helmet as reference] on TBI and BSI Injury status (RRRs and 95% CIs presented; sample weights and bootstrapping methods applied)

Variable	Without a helmet			
	Model A RRR	Model B RRR	Model C RRR	Model D RRR
Injury Type [Non-injured as reference]				
TBI	1.20 (0.68-2.11)			1.29 (0.70-2.40)
BSI	0.93 (0.77-1.12)			0.99 (0.76-1.29)
Injury severity [no medical attention as reference]				
Medical attention received				0.82 (0.59-1.15)
Health Utilities Index [quartile 1 as reference]				
Quartile 2				0.76 (0.57-1.00)*
Quartile 3				0.79 (0.53-1.16)
Quartile 4				0.57 (0.43-0.75)***
Sex [Male as reference]				
Female				0.69 (0.58-0.82)
Age (years) [18-25 as reference]				
12-17				0.28 (0.18-0.44)***
26-40				0.76 (0.55-1.04)*
41-60				0.52 (0.38-0.72)***
60+				0.48 (0.33-0.69)***
Income [low as reference]				
Poverty				1.11 (0.64-1.94)
Middle				1.06 (0.71-1.58)
High				0.73 (0.49-1.08)
Not Stated				0.76 (0.47-1.23)
Education [high school as reference]				
<High School				0.90 (0.61-1.33)
Trade/ Diploma				0.61 (0.45-0.83)***
Bachelor's Degree and Above				0.21 (0.13-0.34)***

Variable	Without a helmet			
	Model A RRR	Model B RRR	Model C RRR	Model D RRR
Not Stated				3.85 (0.97-15.36)*
Ethnicity [minority as reference]				
White				0.64 (0.48-0.85)***
Mental Health [Good/ very good/ excellentas reference]				
poor/ fair				0.82 (0.48-1.41)
Stress [High as reference]				
Low				1.04 (0.85-1.28)
Province				0.98 (0.97-0.98)***
F-statistic	F (4,496) = 11.24			F (46, 453) = 28.79

Note. RRR= Relative Risk Ratio. *p<.05;p<.01**

Table 6.22 Multinomial logistic regression of bicycling without a helmet [bicycling with a helmet as reference] on TBI and Non-injured Injury status (RRRs and 95% CIs presented; sample weights and bootstrapping methods applied)

Variable	Without a helmet			
	Model A RRR	Model B RRR	Model C RRR	Model D RRR
Injury Type [BSI as reference]				
TBI	1.29 (0.73-2.27)			1.31 (0.77-2.26)
Non-injured	1.08 (0.89-1.30)			1.01 (0.77-1.32)
Injury severity [no medical attention as reference]				
Medical attention received				0.82 (0.59-1.15)
Health Utilities Index [quartile 1 as reference]				
Quartile 2				0.76 (0.57-1.00)*
Quartile 3				0.79 (0.53-1.16)
Quartile 4				0.57 (0.43-0.75)***
Sex [Male as reference]				
Female				0.69 (0.58-0.82)***
Age (years) [18-25 as reference]				
12-17				0.28 (0.18-0.44)***
26-40				0.76 (0.55-1.04)*
41-60				0.52 (0.38-0.72)***
60+				0.48 (0.33-0.69)***
Income [low as reference]				
Poverty				1.11 (0.64-1.94)
Middle				1.06 (0.71-1.58)
High				0.73 (0.49-1.08)

Variable	Without a helmet			
	Model A RRR	Model B RRR	Model C RRR	Model D RRR
Not Stated				0.76 (0.47-1.23)
Education [high school as reference]				
<High School Trade/ Diploma Bachelor's Degree and Above Not Stated				0.90 (0.61-1.33) 0.61 (0.45-0.83)*** 0.21 (0.13-0.36)*** 3.85 (0.97-15.36)*
Ethnicity [minority as reference]				
White				0.64 (0.48-0.85)***
Mental Health [Good/ very good/ excellentas reference]				
poor/ fair				0.82 (0.48-1.41)
Stress [High as reference]				
Low				1.04 (0.85-1.28)
Province				0.98 (0.97-0.98)***
F-statistic	F (4,496) = 11.24			F (46,453) = 28.79

Note. RRR= Relative Risk Ratio. * P<.10
****p<.05; ***p<.01**

Table 6.23 Multinomial logistic regression of bicycling without a helmet [bicycling with a helmet as reference] on Combined and BSI Injury status (RRRs and 95% CIs presented; sample weights and bootstrapping methods applied)

Variable	Without a helmet			
	Model A RRR	Model B RRR	Model C RRR	Model D RRR
Injury Type [Non-injured as reference]				
Combined	1.30 (0.43-0.80)			1.31 (0.83-2.06)
BSI	0.93 (0.77-1.12)			0.97 (0.75-1.26)
Injury severity [no medical attention as reference]				
Medical attention received				0.86 (0.62-1.16)
Health Utilities Index [quartile 1 as reference]				
Quartile 2				0.76 (0.58-1.00)**
Quartile 3				0.77 (0.53-1.12)
Quartile 4				0.55 (0.43-0.72)***
Sex [Male as reference]				
Female				0.69 (0.58-0.81)***
Age (years) [18-25 as reference]				
12-17				0.31 (0.21-0.47)***
26-40				0.79 (0.58-1.08)
41-60				0.54 (0.40-0.74)***
60+				0.49 (0.34-0.70)***
Income [low as reference]				
Poverty				1.10 (0.66-1.83)
Middle				0.95 (0.65-1.40)

Variable	Without a helmet			
	Model A RRR	Model B RRR	Model C RRR	Model D RRR
High				0.69 (0.47-1.00)*
Not Stated				0.71 (0.44-1.14)
Education [high school as reference]				
<High School				0.86 (0.58-1.27)
Trade/ Diploma				0.59 (0.43-0.80)***
Bachelor's Degree and Above				0.20 (0.12-0.33)***
Not Stated				2.78 (0.77-10.11)
Ethnicity [minority as reference]				
White				0.59 (0.45-0.78)***
Mental Health [Good/ very good/ excellentas reference]				
poor/ fair				0.80 (0.49-1.33)
Stress [High as reference]				
Low				1.09 (0.90-1.33)
Province				0.98 (0.97-0.98)***
F-statistic	F (4, 496)= 12.55			F (46, 454) = 29.91

Note. RRR= Relative Risk Ratio. * P<.10
****p<.05; ***p<.01**

Table 6.24 Multinomial logistic regression of bicycling without a helmet [bicycling with a helmet as reference] on Combined and Non-injured Injury status (RRRs and 95% CIs presented; sample weights and bootstrapping methods applied)

Variable	Without a helmet			
	Model A RRR	Model B RRR	Model C RRR	Model D RRR
Injury Type [Non-injured as reference]				
Combined	1.40 (0.94-2.08)			1.35 (0.91-2.00)
Non-injured	1.08 (0.89-1.30)			1.03 (0.79-1.34)
Injury severity [no medical attention as reference]				
Medical attention received				0.59 (0.45-1.14)
Health Utilities Index [quartile 1 as reference]				
Quartile 2				0.76 (0.58-1.00)**
Quartile 3				0.77 (0.53-1.12)
Quartile 4				0.55 (0.43-0.72)***
Sex [Male as reference]				
Female				0.69 (0.58-0.81)***
Age (years) [18-25 as reference]				
12-17				0.31 (0.21-0.47)***
26-40				0.79 (0.58-1.08)
41-60				0.54 (0.40-0.74)***
60+				0.49 (0.34-0.70)***
Income [low as reference]				
Poverty				1.10 (0.66-1.83)
Middle				0.95 (0.65-1.40)

Variable	Without a helmet			
	Model A RRR	Model B RRR	Model C RRR	Model D RRR
High				0.69 (0.47-1.00)*
Not Stated				0.71 (0.44-1.14)
Education [high school as reference]				
<High School				0.86 (0.58-1.27)
Trade/ Diploma				0.59 (0.43-0.80)***
Bachelor's Degree and Above				0.20 (0.12-0.33)***
Not Stated				2.78 (0.77-10.11)
Ethnicity [minority as reference]				
White				0.59 (0.45-0.78)***
Mental Health [Good/ very good/ excellentas reference]				
poor/ fair				0.80 (0.48-1.33)
Stress [High as reference]				
Low				1.09 (0.90-1.33)
Province				0.98 (0.97-0.98)
F-statistic	F (4,496) = 12.55			F (46, 454) = 29.91

Note. RRR= Relative Risk Ratio. * P<.10
****p<.05; ***p<.01**

CHAPTER SEVEN: DISCUSSION

The purpose of this thesis was to examine a representative sample of Canadians 12 years and older who had experienced a TBI in the previous year, with the goal of understanding whether these individuals, relative to those experiencing other injuries or no injuries, had elevated rates of substance use/ misuse and poor mental health. Existing literature has demonstrated high rates of alcohol misuse and illicit drug use among persons who have experienced a TBI, both prior to injury and following injury. Most studies that have demonstrated disproportionate (to the general population) rates of alcohol misuse and illicit drug use following TBI[50] have employed clinical samples of TBI survivors.[44,52,53] Clinical samples likely capture fewer mild TBI cases and more moderate and severe injuries which may result in inflation of estimates. Moreover, while an association exists between TBI and substance use/misuse following injury, it is less clear which mechanisms foster this relationship.

The remainder of this chapter will review the main findings from this thesis and connect them to the existing literature, particularly as it relates to whether the dopamine brain impairment hypothesis and/ or the social coping hypothesis help us to understand associations between TBI and substance use and mental health. To better assess thesis findings it is important to first restate the main research questions. These include:

1. To what extent do persons with a TBI engage in alcohol and other drug use?
2. Can either the general coping hypothesis or the impaired brain functioning hypothesis help to explain substance use patterns among those with an injury?
3. To what extent is TBI associated with poor mental health outcomes?

This chapter will analyze the findings from the previous three chapters (5 through 7) as they pertain to the above study questions, and discuss how these findings fit within the current body of knowledge pertaining to TBI and substance use/misuse and mental health. To begin, this section will discuss the findings pertaining to the mental health outcomes (i.e., mood disorders, stress, perceived general mental health, and anxiety). Secondly, I will discuss the findings relating to the substance use outcomes (i.e., cigarette smoking, alcohol binge drinking, and illicit drug use) and the risk-taking measure (helmet use). The third section will be a brief summary of how the findings from this study relate to the dopamine brain impairment hypothesis and the social coping hypothesis for substance use/ misuse among those with TBI. In the next section, I will present and discuss the strengths and limitations of the methods and results of this project. In conclusion, I will provide a succinct summary of the potential implications of the findings for public health policy as well as describe areas for future research.

7.1 ASSOCIATIONS BETWEEN TBI AND MENTAL HEALTH FOLLOWING INJURY

Mental health was captured in this thesis employing four self-report measures. Poor/fair general mental health status, the presence of an anxiety disorder, the presence of a mood disorder, and high or elevated life stress.

7.1.1 Associations with General Mental Health

Descriptive analysis revealed that more of the TBI group (9.4%) reported having poor/ fair mental health than the BSI (6%) and non-injured (5.2%) groups. However, statistical models, both unadjusted and fully adjusted did not provide evidence of any significant associations between TBI or BSI and fair/poor general mental health. This

finding is slightly perplexing, especially for the TBI group, as existing literature has shown strong evidence for poorer overall mental health among those that have experienced a TBI.[112–115] However, it may be the very imprecise nature of our general mental health question that also explains the lack of association between those with a TBI and general mental health. TBI may affect specific mental processes and the non-selective nature of the general mental health question does not test for such associations; those who may have had a specific mental health issue may not feel that a lone mental health problem warrants a poor overall rating of mental health well-being.

7.1.2 Associations with Mood Disorders

The second outcome that will be discussed is the self-report measure of having a mood disorder as diagnosed by a health professional. Mood disorders are psychiatric disorders that fall under the spectrums of depressive disorders, bipolar disorders, substance induced mood disorders, and mood disorders due to other medical/ psychiatric condition(s).[142] We found that both the TBI and BSI groups had slightly higher proportions of respondents reporting that they had a mood disorder than was present in the non-injured group (i.e., 10.2%, 9.3%, and 6.4%, respectively). Examination of the regression analysis, again, demonstrated that those with a TBI were not more likely than non-injured individuals to have a mood disorder. Some evidence of an association was present for those with a BSI in the unadjusted models but not in the adjusted model. Moreover, when comparing the likelihood of a mood disorder between the TBI and the BSI group we found no significant difference in any of the models. Considering the premise of the social coping hypothesis, if supported, one would expect that both the TBI and BSI group would show similar and significant associations with having a mood

disorder, such as depression. For example, it has been shown that approximately half of those that suffer a TBI experience a major depressive disorder within a year of injury,[112] this study as well as others have shown that the relationship between depression and TBI stands independent of injury severity.[113–115] It may also be due to the fact that we do not know exactly how much time has passed since the onset of injury; potentially, we may have a significant proportion of the TBI group whom reported injuries that occurred relatively recently which would decrease the likelihood of them yet facing social adjustment difficulties which have been shown to be a precursor to mood disorder(s).[93,95]

7.1.3 Associations with Anxiety Disorders

The third mental health outcome analyzed in this study was the presence of an anxiety disorder as diagnosed by a health professional. Our analysis showed that the TBI and the BSI groups had similar proportions of respondents reporting having an anxiety disorder (9.2% and 8.1%, respectively) which were both greater than the non-injured group (6.4%). Evidence form the regression models showed that both the TBI and BSI group had a significantly higher likelihood of having an anxiety disorder when compared to those without an injury. This relationship held true in all models. We found a significant interaction of sex, as only females with a TBI had statistically significant elevated rates of having at least one anxiety disorder. We then looked to see how the relationship with having a diagnosed anxiety disorder differed between the TBI and BSI groups; we found that there was no significant difference in the rates of anxiety disorder between those with a TBI and those with a BSI. These findings, that both TBI and BSI are significantly associated with having an anxiety disorder, confirm existing evidence,[5] pointing out that changing life circumstances, like those associated with experiencing a

TBI (or BSI), can bring on feelings of anxiety. Anxiety is associated with a lower sense of well-being and has been hypothesized to be related to increased problem-focused behaviour.[143] Although a variety of studies have demonstrated significant association between TBI and anxiety,[106,112] the causal mechanism is unknown.[143]

7.1.4 Associations with Life Stress

The final mental health outcome addressed was self-perceived life stress. This variable was dichotomized to capture those who are living with a high stress level which included those that rated their life stress as a bit, quite a bit, or extremely stressful.

The descriptive analysis showed that the TBI and BSI groups had similar proportions of respondents that fell into the high life stress category (69.7% and 71.5%, respectively) whereas the non-injured group had a lower proportion of respondents with life stress in the high category (63.5%).

Evidence from the regression models showed that those with a TBI were no more likely to have a high stress life than those who did not have an injury in the past 12 months. This finding was contrary to what has been observed in the literature as Ponsford and colleagues have demonstrated that those with a TBI experience elevated life stress.[144] In addition, dopamine has been coined as the neural anti-stress molecule.[82] Considering the dopamine brain impairment hypothesis, which premises on dopamine impairment in the reward pathways of the brain, we would expect elevated stress levels amongst those with a TBI. Those with a TBI have heightened rates of post-traumatic stress disorder,[94] relative to the general population, which has been shown to cause elevated cortical activation resulting in more adverse reactions to life stress. We expected to see the TBI group demonstrate elevated life stress. Intuitively, one would expect that adapting to a

new lifestyle, especially one that is more difficult, would bring on feelings of stress. We may not have found an association between those with a TBI and stress due to the measure of stress in the CCHS and the subsequent manner in which this measure was operationalized. The stress variable was collapsed into a dichotomous variable to represent low and high stress, this manner of classification may not be precise enough to find the association that we expected.

Interestingly, BSI demonstrated a significant association with having high life stress as compared to the non-injured group in the unadjusted models but not in the fully-adjusted model. The fact that the relationship between the BSI group and high stress was no longer significant in the fully adjusted model indicates that the combination of covariates included in model D have a greater association with stress than does having a BSI injury. Controlling for level of education (i.e., possessing a university degree or above) and income bracket (i.e., high income) likely played a large role in eliminating the association between BSI and stress. These are intuitively linked with perceived life stress, as those with higher income are more likely to earn a greater income which often is indicative of having more occupation related control which is protective of high stress.[145] Low education and income are risk enhancing to stress. When we examined the difference in the association with high stress between the BSI and TBI group, we found no significant differences; hence those with a TBI and BSI had similar associations with high life stress.

7.1.5 Similarities between TBI and BSI Groups

The TBI and BSI groups demonstrated extraordinarily similarities amongst all of the mental health outcomes addressed in this thesis. One explanation for this is that pre-

injury factors may have been similar between these two groups, however, the demographic variables paints a dichotomization between these groups. The more likely explanation of these similarities amongst mental health findings lies in the similarity of the injuries (i.e., chronicity of injury).

7.1.6 Differences between TBI and the Combined Injury Groups

Amongst all of the mental health outcomes examined in this thesis the only instance where the TBI group and the Combined Injury Group differed was in terms of general mental health. The combined injury group demonstrated elevated odds of having poor or fair mental health relative to the non-injured group, this relationship was not significant when TBI replaced the Combined Injury Group. This instance was interesting as the absolute value of the difference amongst the Combined Injury Group was smaller than the TBI, yet only the Combined Injury Group demonstrated a statistically significant relationship. One explanation for this may be due to the rather small n of the TBI group and resulting minimized power to detect a difference relative to the larger Combined Injury Group. Another reason we may have observed this difference in response to the general mental health outcome might be due to inherent differences in the way respondents of the Combined Injury Group answered that question relative to the TBI group due to increased heterogeneity of the Combined Injury Group.

7.2 ASSOCIATIONS BETWEEN TBI AND SUBSTANCE USE AND RISK-TAKING FOLLOWING INJURY

Based on the substance use measures available in the data set (i.e., 2009-2010 CCHS), we looked at the associations between TBI and smoking, alcohol use and binge drinking, and illicit drug use. Cigarette smoking classified respondents into those that

were non-smokers and those that smoked. Secondly, drinking captured all respondents who did not drink alcohol, those that drink alcohol but don't binge, and those who binge drink. Finally, the use of illicit drugs captured those that reported using at least one illicit drug in the 12 months prior to interview. The illicit drugs captured were marijuana/ cannabis, ecstasy, cocaine/ crack, amphetamines, and hallucinogens/ PCP/ LSD.

We also included a risk-taking variable to assess whether differences existing between TBI, BSI and non-injured respondents in terms of their generally willingness to take risks, something that may help to explain both their injury status and their potentially elevated substance use and poor mental health rates. The variable capturing risk taking measured adherence to bicycle helmet use, separating respondents into those that don't cycle (i.e., lowest risk), those that cycle and always wear a helmet (i.e., medium risk) and those whom cycle and rarely wear a helmet (i.e., highest risk).

7.2.1 Associations with Cigarette Smoking

Descriptive analysis showed that the TBI and the non-injured groups had similar proportions of respondents who were smokers (19.6% and 20.0%, respectively) whereas slightly more of the BSI group smoked (25%). Regression analysis showed that those with a TBI did not differ from those without an injury in terms of cigarette smoking status. Conversely, we found that those with a BSI had significantly increased odds of smoking relative to both those with a TBI and those who were not injured. Considering the social coping hypothesis, one would expect that due to the documented changes in lifestyle among those whom suffered a TBI, there would be a heightened association with smoking.[146] However, the literature is unclear of the prevalence of cigarette smoking amongst those with a mild TBI[147] as most studies have focused on alcohol and

illicit drug use, not cigarette smoking. Considering that chronic cigarette smoking in the general population (i.e., non-clinical cohorts) is significantly associated with neurobiological and neurocognitive abnormalities,[148] and chronic cigarette smoking amongst those with a mild TBI results in worse verbal working memory performance, reduced speed of recovery in terms of processing speed and global neuro-cognition,[147] it is a positive sign that our study suggests that those with a mild TBI may not be smoking more than the non-injured general population.

7.2.2 Associations with Illicit Drug Use

Next we examined illicit drug use within the past year. Descriptive analysis demonstrated that those with a TBI had the highest proportion of past 12 month illicit drug use (12.5%), followed by the BSI (6.3%) and non- injured (4.7%) groups. Regressions uncovered significant differences in illicit drug use across injury groups that persisted in both unadjusted and adjusted models. Those with a TBI had significantly increased odds of using illicit drugs than those with a BSI (Unadjusted OR 2.12, 95% CI (0.98-4.58), $P<0.10$) and those who were not injured (Unadjusted OR 2.92, 95% CI (1.52-5.64); Adjusted OR 2.36, 95% CI (1.16-4.78)) within the past year. This finding, specifically, that those with a TBI are more likely to use illicit drugs than healthy controls is well corroborated in the literature. There is ample evidence of both elevated pre-injury and post-injury rates of illicit drug use/ problem use. For example, a 2004 study by Fann and colleagues found a 4.5 odds ratio of substance misuse within the first year following a TBI among persons with no prior mental illness or substance misuse related service utilization in the year prior to injury.[50]

The fact that those with a TBI are more likely than those with a BSI to use illicit drugs provides some support for the brain impairment hypothesis to substance use. If the root cause of illicit drug use seeking behaviour was to alleviate stressors caused by lifestyle adjustments following injury, one would expect similar associations between both the TBI and BSI groups, as both injury groups have a strong likelihood for necessary lifestyle adjustments. The fact that those with a TBI likely have suffered some degree of damage to the brain, if misclassification of TBI did not occur, and they have shown an association with illicit drug use, which has been shown to be a compensatory response to neural damage within the realms of the reward pathways,[149] provides evidence for the brain impairment hypothesis. However, it is important to be cognizant of the potentially heightened likelihood that the TBI group may be intrinsically more likely to partake in risk-taking behaviours. This may be a result of pre-fontal cortex injury which dampens dis-inhibitions,[83] or it may be due to risk-taking personality trait(s) that may have existed prior to injury and possibly contributed to injury. Regardless of the mechanism leading to illicit drug use, those living with a TBI are faced with abundant challenges; evidence from this thesis indicates that efforts are needed to alleviate the association between TBI and illicit drug use as we know illicit drug use has a plethora of consequences.

7.2.3 Associations with Alcohol Use and Binge Drinking

Finally, in terms of alcohol, 24.7% of the TBI group, 36.4% of the BSI group and 39% of the non-injured group were consumers of alcohol at a non- bingeing level. Confirming the descriptive findings, relative to the non-injured, those with a TBI were less likely to drink in all regression models except for the fully adjusted model, where there was no difference in the association between the non-injured and those with a TBI.

The BSI had significantly increased odds of drinking in all four models, relative to the non-injured group. Moreover, those with a TBI had significantly lower odds of drinking than those with a BSI.

However, in terms of the riskier index of binge drinking, those with a BSI had the greatest proportion of binge drinkers (48.3%) followed by the TBI (46.7%) and the non-injured (35.6%). Again, confirming the descriptive findings, relative to the non-injured group, those with a TBI were more likely to binge drink in every model except for the fully adjusted model. The full model demonstrated that those with a TBI and those who were not-injured had similar odds of binge drinking. Relative to those with a BSI, those with a TBI were more likely to binge drink.

These findings present an interesting case, whereby rates of drinking among those with a TBI were lower than the rates for non-injured controls. This finding contradicts existing literature which typically finds drinking to be higher in those with a TBI. However, despite a lower rate of drinking, those with a TBI binge drink more often than non-injured controls. The fact that those with a TBI are less likely to be drinkers but more likely to binge drink (although only in unadjusted or lightly adjusted models), does provide support that those with a TBI are utilizing heavy alcohol use as a means to suppress feelings that coincide with coping and/or to compensate for impaired functioning of neural reward pathways. This is supported by our findings of an elevated association between TBI and anxiety disorders; maybe it is more effective to reduce feelings of anxiety via heavier single dosages of alcohol rather smaller amounts.[150] Thus problem drinking, a more important measure than general alcohol use, was related to TBI status, at least in the unadjusted or partially adjusted models. The association diminished

after we controlled for a variety of variables that have been demonstrated to have an association with bingeing. For example, controlling for age and income are particularly important as adolescents and young adults are more likely to drink at hazardous levels as well as those of higher income. This leads one to question whether prior studies have sufficiently adjusted for variables that could confound or mediate this relationship. It is not always possible to adjust for a wide range of covariates because some data sets can be limited in the scope of measures available. For example, Ponsford and colleagues included a variety of important covariates such as age, gender, and education; however they did not include other important covariates such as income, and mental health status.[52] This can especially be a problem when researchers utilize clinical data sets, as these likely have limited socio-demographic measures, which are useful as control variables for alcohol use behaviour.

In terms of the brain impairment hypothesis, described earlier, we would expect that persons with a TBI would be more likely to be drinkers and binge more as this hypothesis stems on the premise that alcohol helps compensate for malfunctioning in the dopamine reward pathways of the brain,[82,151] therefore the increased likelihood of abstinence from drinking (i.e., TBI group) does not intuitively coincide with this hypothesis. However, the fact that those with a TBI binge drink more than those with a BSI injury whom themselves binge drink more than those without an injury suggests that there may be a difference in the motives behind binge drinking between these two groups, other than social coping adjustments. The elevated binge drinking of the TBI group could still be due to impaired brain functioning. The uncertainty is whether

impaired functioning of the reward pathway is better alleviated by heavy dosages of alcohol or not.

7.2.4 Associations with Risk-taking Behaviour

The last analyses looked at whether injury status was associated with a general willingness to take risks. Looking at the adherence to wearing a bicycle helmet whilst bicycling, while not an optimal measure this was used to proxy test for general risk-taking behaviour. If an injury group demonstrated significantly more risk-taking behaviour than the others then we would need to consider that association when interpreting any association between injury groups and the substance use outcomes. The TBI group had the greatest proportion of respondents (35.1%) that did not wear a helmet while bicycling, followed by the BSI (22.9%) and the non-injured group (20.3%). In terms of always wearing a helmet while bicycling the TBI group led the way with (25.3%) followed by the BSI group (21.3%) and the non-injured (17.6%). The remaining proportions of each group did not ride a bicycle. As mentioned earlier we have ranked each option (i.e., does not ride a bicycle, always wears a helmet, and rarely wears a helmet) in terms of the level of risk demonstrated; those that do not bicycle demonstrate the lowest risk-taking and those that ride a bicycle without a helmet demonstrates the greatest risk-taking.

Relative to the non-injured, those with a TBI were more likely to cycle whilst wearing a helmet than not cycle at all. Therefore the TBI group was more likely to be moderate risk takers. Again, relative to the non-injured, those with a TBI did not significantly differ in terms of not wearing a helmet while bicycling. Therefore the TBI group was not more likely to take higher level of risks than the non-injured. Next, relative

to those with a BSI, the TBI group was more likely to wear a helmet while cycling. Those with a TBI were just as likely to not wear a helmet as those with a BSI. Hence, those with a TBI were not more inclined to take the highest risk (i.e., cycling without a helmet). Collectively, these findings suggest that those with a TBI may be slightly more inclined to take risks than the non-injured population and the BSI population; however, this increased likelihood of risk-taking behaviour appears to diminish as the level of risk increases from moderate to severe risks.

Relating this back to substance use/misuse, the fact that there were limited differences in high risk taking between groups may indicate that any observed differences in substance use and mental health may be related to the injury status, and are not spurious and due to a common "cause" – being a risk taker. The take home message is that those with a TBI appear to demonstrate slightly more risk-taking behaviour than the non-injured and the BSI groups, but this may not be enough to warrant consideration as a global explanation for either injury status, or associations with substance use and mental health.

7.2.5 Differences between TBI and the Combined Injury Groups

Amongst all substance use outcomes examined in this thesis the only instance where the TBI group and the Combined Injury Group differed was in terms of binge drinking. The combined injury group demonstrated elevated odds binge drinking relative to the BSI group, this relationship was not significant when TBI replaced the Combined Injury Group. We may have observed this difference due to inherent differences in the way respondents of the Combined Injury Group answered that question relative to the TBI group due to increased heterogeneity of the Combined Injury Group.

7.3 DISCUSSION ON THE HEALTH UTILITIES INDEX

As mentioned the HUI is an index designed to measure health status. Considering the injury groups included in this thesis, heath status is an important factor to be considered, especially considering our less than ideal measures of injury severity. For example if one of the injury groups had significantly poorer health status than a comparison group this could influence the association with the outcome of interest in a variety of ways. The first thing that may occur if one group had very poor health status is a reduction in the effect size of the association with substance use outcomes as this group is physically unable to attain substances even if they yearning for them. If the difference in health status is less severe and the level of functioning is in the moderate range this could result in elevated associations with substance seeking behaviour as individuals would be able to access substances. These relationships hold true when one substitutes the mental health outcomes for the substance use outcomes.

In this thesis we utilized the global HUI index as a potential mediating variable, upon examination we found only 2 instances of evidence that this measure acted as a mediator. Firstly, the HUI may have mediated the relationship between the TBI group and smoking status with the BSI group as the referent. On the second occasion the HUI may have mediated the relationship between the Combined Head Injury Group and poor self-reported general mental health with the non-injured group as the referent.

It is crucial to consider the components of the HUI that encompass the global HUI rating and how individual components may affect the associations of interest in this thesis. The global HUI measure utilized in this thesis consisted of the following components: Vision, Hearing, Speech, Ambulation, Dexterity, Emotion, Cognition, and

Pain. For example if we consider the effects of the pain component on our outcomes of interest it is plausible that the pain component may be an excellent mediator variable as elevated sensations of pain likely increased the association between substance use and for the development of mental health problems. Examination of the individual components of the HUI may offer more instances of mediation than using the global rating as was done in this thesis.

7.4 EVIDENCE FOR THE SOCIAL COPING AND BRAIN IMPAIRMENT HYPOTHESES

Before summarizing the evidence for and against both the Brain Impairment hypothesis and the Social Coping hypothesis it is important to review the mechanisms involved. Following a TBI, there are a variety of potential lifestyle changes that can occur. Some examples include cessation in education, loss of occupation, reduced or removed parenting roles, and loss of friendships.[5,35] Similarly, survivors of TBI have to adjust to potential cognitive impairments that can come as a consequence to TBI such as poor/ slow problem solving, difficulty communicating, and poor working memory.[5,152] Due to these potential adverse events those with a TBI that use/ abuse substances may do so to alleviate some or all of the above mentioned stressors. Secondly, the brain impairment hypothesis is premised on a TBI causing a change in the functioning of the brain, particularly in the reward pathways of the brain. When this happens, one has difficulty achieving normal feelings of pleasure without some sort of compensation. In order to compensate for malfunctioning in the reward areas of the brain, those whom have suffered a TBI may seek substances as they have positive effects on the reward pathways.

In order to tease apart the Social Coping hypothesis from the Brain Impairment hypothesis, and vice-versa, we added the BSI injury group as a control. The BSI group was a necessary control group as the consequences of that spectrum of injuries can also lead to similar lifestyle consequences as those experienced by individuals with a TBI. Therefore, the major difference between the TBI and BSI injury groups is that those with a TBI are more likely to have impairments in the reward pathways of the brain. Therefore if the Brain Impairment hypothesis to substance use is supported we would see elevated rates of substance use/misuse for those with a TBI relative to those with a BSI as well as those without an injury. If the Social Coping hypothesis is supported we would find elevated rates of substance use/misuse among both the TBI and BSI groups relative to the non-injured group, as well as negligible difference in substance use/misuse rates between those with a TBI and those with a BSI. The third result that could occur is significantly greater substance use in the TBI group compared to the BSI and significantly greater substance use in the BSI group compared to the healthy control group, where there would be evidence for both the impaired brain functioning and social coping hypothesis.

If evidence exists for both the impaired brain function and the social coping hypothesis this suggests interdependence of these hypothesis. What this means is although these hypothesis may appear mutually exclusive, instead, they may be directly influencing one another.

In order to better display the evidence from this thesis in terms of providing support for the Impaired Brain Functioning and Social Coping Hypotheses to substance use, see table 7.1, which outlines the associations of interest for substance use and mental health, as well as the strength of the evidence for the associations, as a means to

differentiate between the proposed hypotheses. Evidence was deemed as strong if the association was significant in both unadjusted and fully adjusted models; marginal evidence was if the association was significant in only the unadjusted models or the association represented a trend towards significance (i.e., $P<0.1$).

In terms of drinking alcohol without bingeing behaviour, the evidence from this thesis does not support either the Brain Impairment or Social Coping hypotheses. With regard to binge drinking however, the evidence from this thesis does provide some support for the Brain Impairment hypothesis. It is necessary to be cognizant that two of three requirements were only marginally met for binge drinking to support the Brain Impairment hypothesis. In terms of illicit drug use, some support for the Brain Impairment hypothesis was met; however, similar to binge drinking, these findings should be interpreted with caution as two out of three requirements were only marginally met. Finally, evidence from our study in relation to smoking status does not provide evidence for either hypothesis as we did not differences in smoking status between those with a TBI and the non-injured group.

Considering the premise of the Social Coping hypothesis was built on the TBI and BSI group experiencing difficulties with lifestyle adjustment, we expected to see these adjustments demonstrated in our measures of mental health and the subsequent associations between injury type and poor mental health outcomes. In reality, evidence was quite limited for those with a TBI experiencing worse mental health than the non-injured controls. Having an anxiety disorder was the only mental health outcome that those with a TBI differed from the non-injured controls. In order to better interpret why this occurred, future studies should utilize a longitudinal data set that evaluates these

measures at multiple time points following injury, most importantly greater than 12 months following injury. This would allow us to more accurately assess evidence for the Social Coping hypothesis to substance use as this would allow the effects of lifestyle adjustments to be manifested in mental health measures. Perhaps feelings of anxiety/ having an anxiety disorder presents earlier than other mental health issues among those with a TBI. However, since we used a cross-sectional data set we can say that the evidence from this thesis indicates that the Impaired Brain Functioning hypothesis is marginally involved in elevated binge drinking and illicit drug use within 12 months following injury. In addition, there is marginal evidence for the social coping hypothesis as both injury groups showed elevated rates of binge drinking and illicit drug use relative to the non-injured group.

Table 7.1 Evaluation of presence and strength of evidence for the proposed mechanisms (Brain Impairment hypothesis and Social Coping hypothesis) between injury and substance use/ misuse stratified by substance use outcome

Association with:	**TBI vs. Non-injured**	**TB I vs. BSI**	**BSI vs. Non-injured**	**Evidence for:**
Drinking Alcohol	None	None	Strong	**Neither**
Binge Drinking	Marginal	Marginal	Strong	**Brain Impairment + Social Coping**
Illicit Drug Use	Strong	Marginal	Marginal	**Brain Impairment + Social Coping**
Smoking	None	None	Marginal	**Neither**

7.5 STRENGTHS AND LIMITATIONS

This thesis project must be considered in light of a number of important limitations, each of which should be carefully considered in order to increase the accuracy in the extrapolation of findings to future research and policy initiatives. First, the CCHS is an observational cross-sectional study. Therefore, it is impossible to make causal inferences. All data collected was done via retrospective self-report. Therefore, there is a heightened likelihood of recall bias. Considering the sensitive nature of the outcome variables in this study (i.e., substance use/ misuse and mental health) there is potential of under-reporting of substance use/ misuse. In addition there is potential for stigma associated with using substances whilst recovering from a TBI which could result in further under estimation; in other words the social desirability response bias may have been at play.[153] It has been demonstrated that the validity and reliability of self-report measures are dependent on a plethora of variables (e.g., sensitivity of data sought; specificity of validation criteria, and the time window of the report) and has shown to be neither valid or invalid but rather dependent on the personal characteristics of the respondent and the methods used by the data gatherer.[154] Biases such as and similar to the social desirability response bias stemming from self-report measures of alcohol consumption and other sensitive materials can be minimized by increasing the motivation of the respondent, simplifying the question procedure, clarifying understanding of the question, and making it clear to the respondent that the primary goal are accurate responses which can be attained by discussing and guaranteeing anonymity and confidentiality, both of which are done in this data set, the 2009-2010 CCHS.[154]

Second, the severity of head injuries was not clearly recorded in the survey; this study was forced to use a proxy measure of injury severity based on the amount of medical attention sought following the injury. Injury severity has a marked effect on biological sequelae in addition to psychosocial adjustment.[5] In addition, it is important to be aware that the most marginalized TBI survivors are likely unable to complete the CCHS therefore are underrepresented in the data set. Also, this study is unable to take into account the number of previous injuries experienced by respondents. For example, in the case of TBI, repetitive concussions have been shown to have more severe health consequences.[155] The lack of a repetitive injury measure may results in a conservative estimate of the association between injury and our outcome measures (i.e., substance use/ misuse and mental health).

Third, due to the cross-sectional design, this study is unable to assess the presence and/or intensity of substance use and mental health status prior to the injury. This study is only able to examine the presence and strength of association between substance use and mental health following the injury event among those who have experienced and survived TBI. Ideally, we would have used a longitudinal design as this would result in more accurate estimates as we would be able to account for pre-injury patterns and potentially calculate difference scores, as well as observe patterns over time. Unfortunately the measures for substance use, which are mostly based on frequency of use, are sub-optimal in providing insight into problematic use (i.e., dosage and psycho-social consequences). Hence, the findings of this thesis are meant to represent markers for potential problems or associations that may exist between TBI and substance use/ misuse and mental health outcomes.

Relatedly, the measure of binge drinking in the data set was defined as having 5 or more drinks in one drinking event. This definition is true for males; however the more commonly-established definition for binge drinking for females has a cut point of 4 or more drinks per drinking event.[156] Therefore our measure of binge drinking may underestimate the association between injury and problem drinking behaviours in women as we only captured more severe cases of binging in women. Unfortunately, we are unable to capture women who typically drink at the cut point of 4 drinks.

Fifth, we were unable to account for injuries that occurred more than 12 months from time of interview which would have an influence on our outcome measures and the strength of our 'non-injured' control group. A good example is the scenario where a respondent had multiple concussions in their youth but are responding that they did not suffer an injury as the CCHS inquires only about the prior 12 months. An individual such as this would be grouped as if they did not experience an event that would lead to brain impairment (i.e., concussion(s)) whereas they actually did experience an event or events that could have led to brain impairment. Relatedly, the injury questions in the data set asks about respondents' "most serious injury"; therefore, it is likely that cases of TBI will be missed in scenarios where an individual experienced multiple injuries which resulted in under-reporting of TBI. Hence the potential for misclassification within the non-injured group could result in conservative estimates as the groups (TBI and non-injured) would be inherently more similar to one another than intended.

As mentioned previously, the self-report nature and the specifics of the questions used to categorize those with a TBI naturally lends to the inclusion of individuals who may have experienced a very mild concussion, which as mentioned in the background

section is less likely to result in substantial lifestyle adjustments as compared to more severe TBI's. Also the sample size of the TBI group is relatively smaller than the other injury groups which may contribute to the lack of significant associations found amongst the mental health outcomes. In other words the TBI group may be under-powered.

Due to the nature of the data, we were unable to gather details on the presence or lack thereof of all psychiatric conditions and/or narcotic drug use, or other unmeasured confounders. However, we are able to account for depression and anxiety which are two of the most common comorbid psychiatric conditions to co-occur with substance use disorders.[157] Finally, the low number of individuals who had experienced a TBI suggests that the study may not be sufficiently powered to detect differences for some analyses.

Despite these limitations, this study possesses a variety of strengths. This thesis classified TBI based on self-report via a population based nationally representative sample which provides us with an accurate snap-shot of the Canadian population with a TBI. We used a self-report rather than a clinical diagnosis of TBI. Therefore we still captured those who have experienced a TBI, but we may have included those that had a severity of injury below the threshold of what would be picked up via a clinical assessment. This means that we likely captured a broad range of TBI that may have otherwise gone unreported; hence we have increased the generalizability of our findings. This provides a more accurate description of the association between TBI and substance use/misuse and mental health. A clinical diagnosis/ study of TBI and substance use/misuse as well as mental health are more frequently conducted in the literature, such as those mentioned in the background sections. Therefore, it is useful to undertake a different, underutilized approach such as was done here using a population data set with

self-report measures of injury. Without access to and subsequent implementation of good quality and an adequate number of control variables there is an increased likelihood of less accurate estimates. Due to the wide array of measures collected in the 2009-2010 CCHS, we were able to control for a large set of covariates that are likely confounders to the relationship between TBI and our outcomes of interest, which increases the accuracy of our estimates of association.

7.6 INTERPRETATIONS AND IMPLICATIONS

The prevalence of TBI is rising both within Canada and on a global scale. TBI has a significant impact on the younger population as it is one of the leading causes of death and morbidity. The consequences of TBI can be both short- and long-lived, with deficits in a variety of areas such as impaired cognition, neurological deficits, and personality and behaviour changes. Therefore, TBI is a growing concern from both a public health and a medical perspective. This is evidenced by increased education on the potential consequences of TBI on a short- and long-term scale as well as more stringent guidelines and procedures regarding screening for TBI in sport, for example.

The findings of this thesis contribute information to the scientific community on the mechanism between TBI and substance use/ misuse, which is an area that has scarcely been analyzed within a population health approach. We found marginal evidence for the Impaired Brain Functioning as well as the Social Coping hypothesis to substance use/ misuse. Although the research community has clearly established a variety of adverse consequences due to TBI, this study adds to the literature by showing that TBI is strongly connected to some unique outcomes around substance use and mental health. This thesis places a spotlight on the presence of both a significant association, in the

unadjusted model, as well as trending association in the full model with anxiety disorders within 12 months following injury as well as significantly elevated illicit drug use and binge drinking among those with a TBI relative to those without injury. Although we found evidence for some significant associations, we also had evidence contrary to the existing literature on a number of outcomes.

Nonetheless, the findings of this thesis indicate that public health policy should remain persistent with applying pressure and increasing awareness amongst healthcare and social workers for the benefits of continued follow-up of those with a TBI in order to reduce the potential for adverse consequences (i.e., future health conditions) as well as to reduce the likelihood of future injuries. In addition to healthcare and social workers this thesis provides evidence relevant for social support providers (i.e., family and friends). These individuals should be cognizant of the potential for challenges with substance use/ misuse and specific mental health problems in order to alleviate the likelihood of developing these adverse consequences of TBI. Relatedly, evidence from this thesis supports the need for programs to reduce binge drinking from an injury prevention perspective, as binge drinking was demonstrated to be strongly associated with TBI.

Future research should continue to employ self-report data at a population-level to be able to capture a broader range of head injuries, including those that fall into the milder injury categories who are less likely to seek medical attention (i.e., those that are more likely to be captured in clinical studies); most studies do not capture these individuals. In addition, future research should add a longitudinal approach which would allow for measures of pre-injury (baseline) substance use/misuse and mental health status, as well as examine how changes within- those outcome measures evolve at distinct

time cut-points following injury. Also, future research should include at least as many socio-demographic variables and other covariates as was done in this thesis as this provides a more accurate estimation between those with a TBI and substance use/ misuse and mental health.

This thesis has found that TBI is significantly associated with elevated rates of anxiety disorder relative to the non-injured population. Moving to substance use/ misuse, we found elevated rates of binge drinking and illicit drug use relative to the general population. Based on these findings this thesis found support for both the Brain Impairment and Social Coping hypotheses of substance use/ misuse. It is important to note that despite our TBI sample lying closer to the less severe end of the injury severity spectrum we still found concerning associations with mental health outcomes and substance use/misuse. Considering that milder forms of TBI, which is the most common severity level, is often under-reported, and is less likely to result in medical care, makes these findings especially valuable. This provides support for public health initiatives that should be aimed at having a downstream effect that will serve to improve the quality of life for those with a TBI by decreasing the consequence of poor mental health such as anxiety disorders and substance use/misuse, particularly problem drinking and illicit drug use.

Appendix A

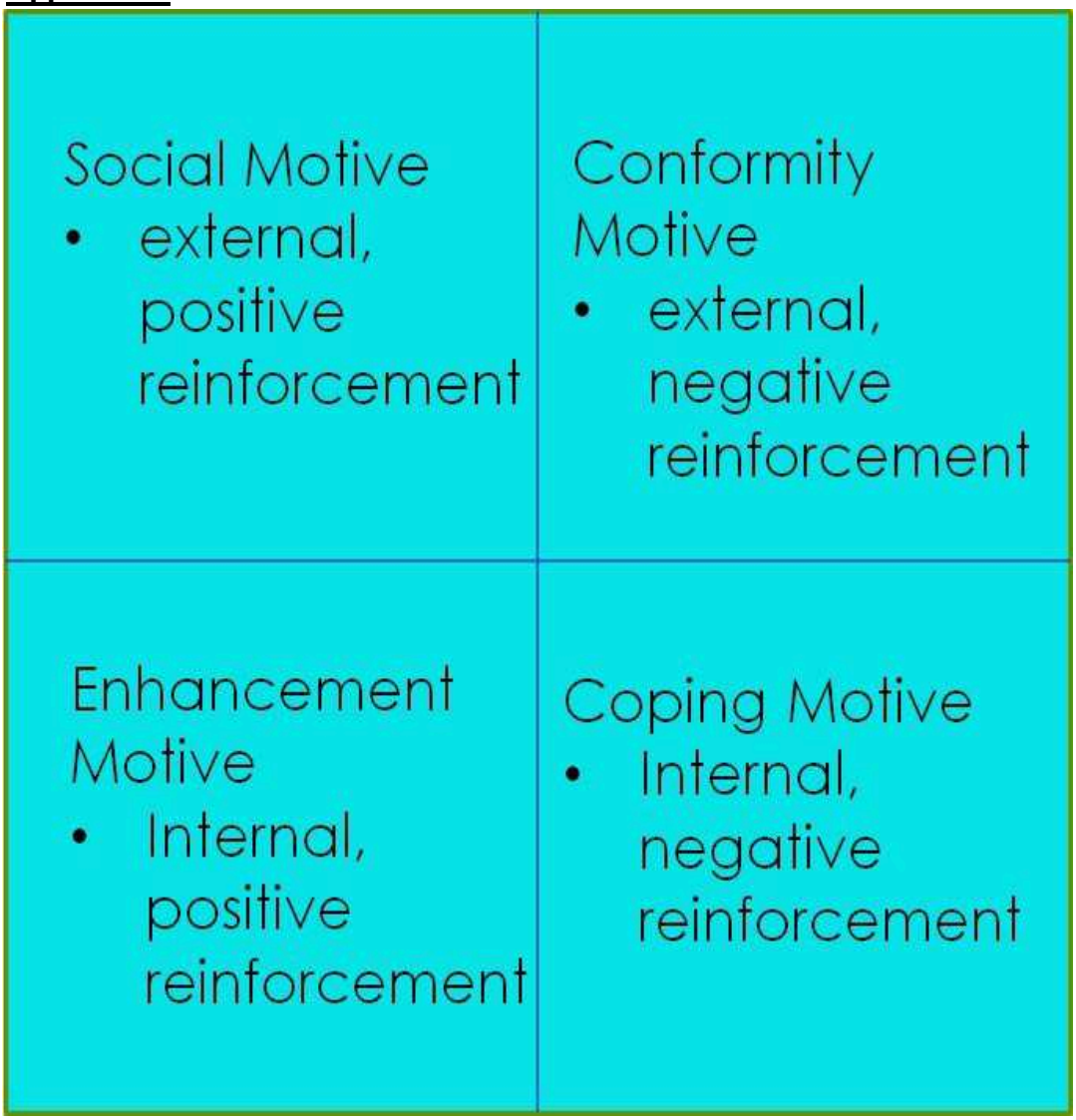

Figure A.1. The 2x2 matrix of proximal drinking motives as described by Cooper and colleagues (1994). This matrix describes both internal and external sources of reinforcement by positive and negative reinforcement and postulates a label for each combination

Appendix B

Table B.1. Exposure Variables

Variables	Coded Variable	Question	Response Options
Presence of injury	INJ_01	(Not counting repetitive strain injuries,) in the past 12 months, were you injured?	yes, no, don't know, and refusal
Injury type	INJ_05	What type of injury did you have? For example, a broken bone or burn.	multiple injuries (exc. minor inj.), broken or fractured bones, burn/ scald/ chemical burn, dislocation, sprain or strain (incl. torn lig.), cut/ puncture/ animal bite, scrape(s)/ bruise(s)/ blister(s), concussion or other brain injury, poisoning (exc. food pois, poison ivy), injury to internal organs, other, not applicable, don't know, refusal, not stated
Injury location	INJ_06	What part of the body was injured?	multiple sites, eyes, head, neck, shoulder/ upper arm, elbow/ lower arm, wrist, hand, hip, thigh, knee/ lower leg, ankle/ foot, upper back or upper spine, lower back or lower spine, chest (excl. back and spine), abdomen or pelvis (excl. back and spine), not applicable, don't know, refusal, not stated

Table B.2. Dependent Variables

Variables	Coded Variable	Description/ Question	Response Options
Drank alcohol in past 12 months	ALC_1	During the past 12 months, have you had a drink of beer, wine, liquor or any other alcoholic beverage?	yes, no, don't know, refusal, and not stated
'Binge' drinking	ALC_3	How often in the past 12 months have you had 5 or more drinks on one occasion?	never , less than once a month, once a month, 2 to 3 times a month, once a week, more than once a week, more than once a week, not applicable, don't know, refusal, and not stated
Cannabis use in past 12 months?	IDG_02	Have you used it in the past 12 months?	yes, no, not applicable, don't know, refusal, and not stated
Ecstacy use in past 12 months?	IDG_11	Have you used it in the past 12 months?	yes, no, not Applicable, and not stated
Cocaine use in past 12 months	IDG_05	Have you used it in the past 12 months?	yes, no, not applicable, and not stated
Amphetamine use in past 12 months?	IDG_08	Have you used it in the past 12 months?	yes, no, not applicable, and not stated
Hallucinogen, PCP and LSD use in past 12 months?	IDG_14	Have you used it in the past 12 months?	yes, no, not applicable, and not stated

Hard Drug Use in the past 12 months?	Derived	Based on responses to IDG_11, IDG_05, IDG_08 and IDG_14.	no, yes
Smoking Status	SMK_202	At the present time, do you smoke cigarettes daily, occasionally or not at all?	daily, occasionally, not at all, don't know, refusal and not stated
Perceived life stress	Gen_07	Thinking about the amount of stress in your life, would you say that most days are: (not at all stressful, not very stressful, a bit stressful, quite a bit stressful, or extremely stressful)?	not at all stressful, not very stressful, a bit stressful, quite a bit stressful, extremely stressful, don't know, and refusal
Self-perceived mental health	GEN_02B	In general, would you say your mental health is: (Excellent, Very good, Good, Fair, Poor)?	excellent, very good, good, fair, poor, don't know, refusal, and not stated
Self-reported mood disorder	CCC_280	Remember, we are interested in conditions diagnosed by a health professional. Do you have a mood disorder such as depression, bipolar disorder, mania or dysthymia?	yes, no, don't know, refusal, and not stated
Anxiety disorder	CCC_290	Do you have an anxiety disorder such as phobia, obsessive-compulsive disorder or a panic disorder?	yes, no, don't know, refusal, and not stated
Risk Marker (bicycle helmet wearing)	UPE_01	When riding a bicycle, how often do you wear a helmet?	always, most of the time, rarely, or never.

Table B.3. Covariates

Variable	Coded Variable	Question	Response Options
Treatment	INJ_13	Did you receive any medical attention for the injury (most serious injury) from a health professional in the 48 hours following the injury?	yes, no, not applicable, don't know, refusal, and not stated
Injury severity	Derived	Based on responses to INJ_13, INJ_14A, INJ_14B and INJ_15	mild injury, moderate/ severe injury
Age	DHH_AGE	Derived based on day of birth, month of birth, and year of birth. Continuous Variable.	Years: 12 -102
Sex	DHH_SEX	Interviewer: Enter the respondent's sex. If necessary, ask: Is respondent male or female?	Male, Female
Income	INCDHH	Variable groups the total household income from all sources.	No income, Less than $5000, $5000 to $9,999, $10000 to $14,999, $15000 to $19,999, $20,000 to $29,999 $30,000 to $39,999, $40,000 to $49,9999, $50,000 to $59,999, $60,000 to $69,999, $70,000 to $79,999, $80,000 to $89,999, $90,000 to $ 99,999, $100,000 or more, and not stated
Highest level of education	EDUDR10	Derived variable.	grade 8 or lower, grade 9-10, grade 11-13, secondary school graduate, some post-secondary, trades certificate or diploma, diploma/ certificate-college/ cegep, Univ. certificate below bachelor's level, bachelors

			degree, Univ. degree or cert. above bac. level, not stated
Marital status	DHH_MS	What is your marital status? Are you married, living common-law, widowed, separated, divorced, or single, never married?	married, common-law, widowed, separated, divorced, single/never married, don't know, and refusal
Cultural or racial origin	SDCDCGT	Determines whether the respondent is white or a visible minority (derived variable)	White, black, korean, filipino, japanese, chinese, south asian, southeast asian, arab, west asian, latin american, other racial or cultural origin, multiple racial/ cultural origins, not applicable, and not stated
Province of residence	GEO_PRV	Determines province of residence	
Perceived life stress	Gen_07	Thinking about the amount of stress in your life, would you say that most days are: (not at all stressful, not very stressful, a bit stressful, quite a bit stressful, or extremely stressful)?	not at all stressful, not very stressful, a bit stressful, quite a bit stressful, extremely stressful, don't know, and refusal
Self-perceived mental health	GEN_02B	In general, would you say your mental health is: (Excellent, Very good, Good, Fair, Poor)?	excellent, very good, good, fair, poor, don't know, refusal, and not stated
Injury Mechanism/ Location	INJ_08	Where did the injury happen know, refusal, and not stated	in a home or its surrounding area, residential institution, school/ college/ university, sports or athletics area of school, other sports or athletic areas, other institution, street/ highway/ sidewalk, commercial area, industrial or construction area, farm, countryside/ forest/ lake/ ocean, other, not applicable, don't know, refusal, and not

			stated

Table B.4. Potential Mediator Variables

Variable	Coded Variable	Question	Response Options
Health Utilities Index	HUIDHSI	Derived variable	Ranges from -0.335 to 1.0
Perceived life stress	Gen_07	Thinking about the amount of stress in your life, would you say that most days are: (not at all stressful, not very stressful, a bit stressful, quite a bit stressful, or extremely stressful)?	not at all stressful, not very stressful, a bit stressful, quite a bit stressful, extremely stressful, don't know, and refusal
Self-perceived mental health	GEN_02B	In general, would you say your mental health is: (Excellent, Very good, Good, Fair, Poor)?	excellent, very good, good, fair, poor, don't know, refusal, and not stated

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